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Clinical paper

Measuring disparities in out of hospital cardiac arrest outcomes in Chicago community areas ☆

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Abstract

Background: Advances in resuscitation science have improved survival rates after an out-of-hospital cardiac arrest (OHCA) in select geographies, but survival rates vary widely by community. The purpose of this study was to assess the variations in bystander interventions and subsequent OHCA outcomes by predominance of a race/ethnicity within community areas in a large city.

Methods: This is a retrospective cohort study of OHCA treated by Chicago Fire Department EMS from January 1st 2014 through December 31st 2021. Community areas were grouped into categories based on having a majority (>50%) of a race or ethnicity (i.e., predominantly White, Black, Hispanic, Integrated or Asian).

Results: Of the 13,778 OHCA cases meeting inclusion criteria, 62.1% were male, and 47.5% were from predominantly Black community areas, 17.9% from predominantly Hispanic community areas, 20.0% from White, and 14.0% from Integrated; the remaining 0.6% were from Asian community areas. Mean age was lowest (59.9 years) in Hispanic followed by Black (61.8 years) community areas compared to White (62.4 years) community areas. Cases from Black and Hispanic community areas had lower rates of shockable rhythms (12.6% and 14.9% versus 19.8%). Bystander cardiopulmonary resuscitation (CPR) and automated external defibrillator (AED) use was lowest in Black community areas. OHCA in Hispanic and Black community areas > 30% less likely to have favorable neurologic survival compared to White community areas. Females were more likely to survive to hospital admission across all community areas; however, neurologic survival in females was better only in White and Integrated community areas. Public location and shockable rhythm were significant predictors of favorable neurologic survival across all community area categories; AED use before EMS was a significant predictor in Black, Hispanic and Integrated community areas but not in White community areas. Bystander CPR was associated with favorable neurologic survival White (aOR = 1.40) and Integrated (aOR = 2.02) community areas, but there was no significant association in Black or Hispanic community areas.

Conclusion: Our study revealed significant variations in favorable OHCA characteristics across different community areas. While certain cardiac arrest features and modifiable factors play a significant role in some community areas, their effect may be less pronounced in other community areas.

Keywords: Cardiac arrest, Inequities, Epidemiology, bystander CPR, Survival

Introduction

More than 400,000 people in the United States experience an out-of-hospital cardiac arrest (OHCA) each year, resulting in a greater loss of productive years than for most other leading causes of death.[1] Advances in resuscitation science have improved survival rates in select geographies, but survival rates continue to vary by community and it is unclear if these advances have had equitable benefit. The lethality of OHCA in large urban centers and inequities by race/ethnicity has been extensively described.[2,3] Residents who live in community areas that are primarily Black, Hispanic, or low-income are more likely to have an OHCA and are less likely to survive.[4–6] Considering that half of the US population resides in large metropolitan areas and the proportion of non-White individuals in the US popula-

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tion is increasing, the persistent inequities in OHCA incidence and outcomes are a significant public health concern.

Chicago has one of the largest and most diverse populations in the US. Further, because Chicago is divided into 77 distinct community areas,[7] it is an ideal setting to test for relationships between a community area's race and ethnicity and OHCA characteristics and survival outcomes. The last published study describing variations in OHCA outcomes in Chicago by race and ethnicity (the Chicago CPR Project, 1987–1988) reported a threefold difference in survival in White compared to Black people (2.6% vs 0.8% survival) and bystander CPR rates that were 39% higher in White compared to Black people (25% vs 18% bystander CPR rates).[8] Moreover, patients with cardiac arrest in racially integrated community areas were most likely to be provided with bystander CPR, followed by predominantly white community areas, with the lowest rates of CPR provision in predominantly Black community areas.[9] Whether there were inequities in bystander CPR interventions and survival in Hispanics and other races/ethnicities at the individual or community area-level was not reported.

Measurement and reporting of community interventions and outcomes by race/ethnicity are vitally important to quality improvement programs in order to inform actionable interventions to mitigate inequities. We describe variations in bystander interventions, OHCA characteristics, and subsequent OHCA outcomes associated with predominant race/ethnicity in a community area. Understanding these associations will inform the development of models for community area risk stratification and inform community and systems-level interventions to improve OHCA outcomes.

Methods

Study design

This is a retrospective cohort study of non-traumatic cardiac arrests treated by Chicago Fire Department Emergency Medical Services from January 1st 2014 through December 31st 2021. The study adhered to the Strengthening and Reporting of Observational Studies in Epidemiology reporting guidelines for observational studies[10] and was approved by the Office for the Protection of Research Subjects of the University of Illinois at Chicago.

Setting and population

The City of Chicago is the third largest city in the United States, with a current population of 2,664,452. Chicago has the third largest urban Black population (29%)[11] and 5th largest Hispanic population in the US (29%).[12]

The study population included adults (aged $\geq$ 18 years) with OHCA. Cases were excluded from the analysis if resuscitation was not initiated, the patient had a do not resuscitate order, the arrest was witnessed by emergency medical services (EMS) personnel, the arrest occurred at a long-term care or health care facility, or the cause of the arrest was trauma. We also excluded OHCA that occurred at two major airports, because we thought that these would not be affected by community area characteristics.

Data sources

OHCA data were obtained from the Cardiac Arrest Registry to Enhance Survival (CARES), a prospective multicenter registry of non-traumatic cardiac arrests that involve persons who received resuscitative efforts, including CPR or defibrillation, by EMS.[13] Participating sites collect data from three sources that define the continuum of emergency cardiac care: 911 dispatch centers, EMS providers, and receiving hospitals. Individual race/ethnicity in CARES is assigned as reported by the patient, family, or healthcare provider based on the definitions of the US Office of Management and Budget. Predominance of race/ethnicity by community area was determined as follows. Chicago CARES data were geocoded to one of the city's 77 community areas based on the location where OHCA occurred. Next, predominance of race/ethnicity by community area was obtained using the Chicago Metropolitan Agency for Planning's data sourced from US Census Bureau's 2016–2020 American Community Survey.[14] We defined four categories for community areas based on having a majority (>50%) of a race or ethnicity: predominantly non-Hispanic White, predominantly non-Hispanic Black, predominantly Hispanic/Latino, predominantly Asian, or integrated (no single group has a > 50%). For simplicity, community area category are referred to by their predominant race or ethnicity (e.g., predominantly White community areas are referred to as White).

Statistical analysis

We compared OHCA incidence, prehospital characteristics, and survival outcomes between each community area category. Rates of prehospital characteristics (e.g., BCPR provision, presenting rhythm, and return of spontaneous circulation (ROSC)), as well as survival outcomes, (i.e., survival to hospital admission (STHA), survival to hospital discharge (STHD) and survival with functional neurologic outcome) in each group according to community area's main race/ethnicity were compared using the χ 2 test. Functional neurologic outcome was defined as cerebral performance category (CPC) of 1 or 2.[15] Multivariable logistic regression analysis was performed using generalized estimating equations (GEE) with logit link estimates to account for patient outcomes clustered within community areas. We assessed the association between patients' community area category with their survival outcomes while adjusting for confounders: age, sex, if OHCA was witnessed or not, location of arrest (public versus private), first monitored rhythm (shockable vs non-shockable), AED use, presumed cardiac etiology, and bystander CPR. We did not include race as a covariate in statistical modeling in order to avoid diverting attention from other factors critical to understanding disparities. We further assessed the association of prehospital characteristics with survival outcomes stratified by the patients' community area category.

Results

Characteristics of OHCA cases by community area category

CFD EMS treated 21,661 persons with non-traumatic OHCA from January 2014 to December 2021. For this analysis we included 13,778 cases after considering inclusion and exclusion criteria (see Fig. 1). Patient characteristics overall and by community area type are summarized in Table 1. The largest proportion of OHCA cases during the study period occurred in predominantly Black community areas (N = 6,544, 47.5%) and the lowest proportion occurred in predominantly Asian (N = 87, 0.6%) community areas. The mean and median age of OHCA was 61.8 and 62 years respectively with significant variation by community area type. Predominantly Black community areas saw a larger proportion of OHCA in women compared to overall city average (42.8% vs 37.9%).

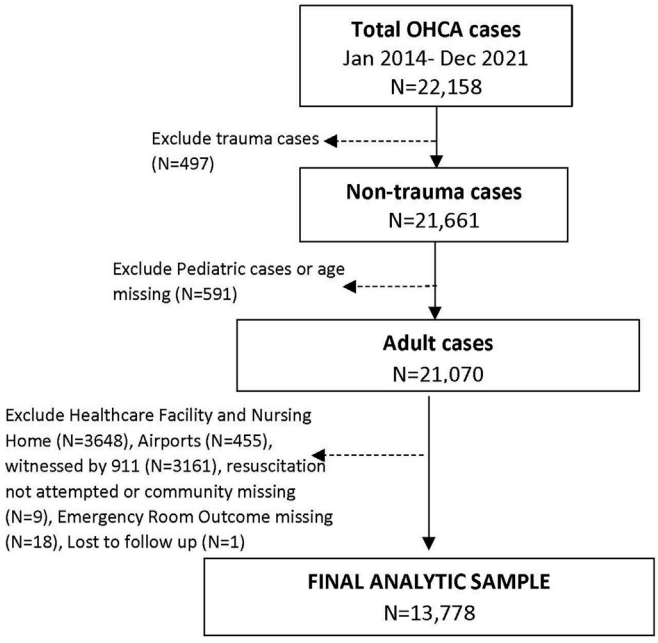

Fig. 1 – Consort diagram with inclusion/exclusions.

Significant differences ($P < 0.05$) were noted in the distribution of favorable OHCA characteristics by community area. Public location, presumed cardiac etiology, shockable rhythm, and witnessed arrest were higher than the city average in White, Asian, and Integrated community areas and lower than the city average in Black and Hispanic community areas. Black and Asian community areas had lower than city average rates of bystander CPR and AED use before EMS arrival. There were no significant differences in ROSC rates by community area (Table 1).

Survival outcomes by community area

Table 2 summarizes outcomes by community area category. Odds of STHA and STHD were lower for OHCA occurring in Black community areas compared to White community areas, but the differences disappeared after adjustment for age, sex, and OHCA characteristics. Similarly, odds of STHD in Hispanic community areas were lower than in White community areas, but differences disappeared after adjusting for demographic and OHCA characteristics. Odds of surviving with CPC 1–2 were lower in Black and Hispanic community areas even after adjusting for demographic variables and OHCA characteristics.

Survival disparities by age and sex

Tables 3–5 summarize STHA, STHD, and CPC 1–2 stratified by community area category. Females had better odds of STHA and STHD compared to males across all community areas except for Hispanic areas where there was no significant difference in STHD. Overall, survival with CPC 1–2 was significantly higher in females, however, no difference was seen when stratified by community area type.

Age had a significant association with STHA across all community area types; patients aged 75 and above had lower odds of STHA (Table 3) compared to the reference age group (ages 18–54). Compared to the reference age group (18–54 years) STHD in patients aged 75 and above was lower in White, Black, and Integrated community areas, but no significant difference was observed in Hispanic community areas (Table 4). Odds of CPC 1–2 was not significantly different across age groups in Black and Hispanic community areas (Table 5).

Community area effects

Within White community areas, Black patients had lower odds of STHA, STHD, and CPC 1–2 and Hispanics had lower odds of STHA compared to White patients. (Tables 3, 4, and 5).

Within Black community areas, odds of STHA were lower in Black and Other/Mixed/Unknown race and odds of CPC 1–2 were lower in Black patients, but no significant difference in odds of STHA, STHD, or CPC 1–2 were noted in Hispanics when compared to White patients (Tables 3, 4, and 5).

Within Hispanic community areas, odds of STHD and CPC 1–2 were better for Black compared to White patients (Tables 4 and 5). Hispanics who had an OHCA in Hispanic community areas had better odds of STHA compared to White individuals (Tables 3, 4, and 5) and there was a non-significant trend towards better odds of STHA, STHD, and CPC 1–2 in Other/Mixed/Unknown race (Tables 3, 4, and 5; wide confidence intervals overlap 1.00).

Within Integrated community areas, odds of STHA, STHD, and CPC 1–2 in Black and Hispanic individuals and odds of STHD and CPC 1–2 in Other/Mixed/Unknown race were not significantly different compared to White individuals (Tables 3–5).

Across all community area types, having an OHCA that was witnessed, in a public location, or presenting with a shockable rhythm was generally associated with higher odds of STHA, STHD, and CPC 1–2 (Tables 3–5).

The association of BCPR and AED use before EMS with survival outcomes varied across community areas. BCPR was associated with lower odds of STHA in Black community areas (Table 3). BCPR was not significantly associated with improved odds of STHD in White, Black, and Hispanic community areas, but odds were improved in Integrated community areas. BCPR was associated with

Table 1 – Basic demographics of out-of-hospital cardiac arrest patients, overall and by the community area (Predominantly Asian Community area included in the table).

	City of Chicago N=13,778 (100%)	White Community areas N=2748 (20.0%)	Black Community areas N=6544 (47.5%)	Hispanic Community areas N=2470 (17.9%)	Integrated* Community areas N=1929 (14.0%)	Asian Community area N=87 (0.6%)	P value
Age in Years							<0.001
Mean (SD)	61.8 (17.1)	62.4 (18.3)	61.8 (16.3)	59.9 (17.4)	62.5 (17.2)	68.8 (16.6)	
Median (IQR)	62.0 (50 – 74)	63.0 (51.0 – 77.0)	61.0 (51.0 – 73.0)	60.0 (49.0 – 72.0)	63.0 (51.0 – 75.0)	66.0 (56.0 – 85.0)	
Age group, N (%)							
18–54	4476 (32.5)	874 (31.8)	2070 (31.6)	915 (37.0)	603 (31.3)	14 (16.1)	<0.001
55–64	3296 (23.9)	561 (20.4)	1722 (26.3)	574 (23.2)	416 (21.6)	23 (26.4)	
65–74	2659 (19.3)	534 (19.4)	1245 (19.0)	451 (18.3)	411 (21.3)	18 (20.7)	
≥ 75	3347 (24.3)	779 (28.4)	1507 (23.0)	530 (21.5)	499 (25.9)	32 (36.8)	
Sex, N (%)							
Female	5216 (37.9)	871 (31.7)	2803 (42.8)	869 (35.2)	641 (33.2)	32 (36.8)	<0.001
Male	8561 (62.1)	1876 (68.3)	3741 (57.2)	1601 (64.8)	1288 (66.8)	55 (63.2)	
Missing	1	1					
Individual Race/Ethnicity, N (%)							
Asian**	332 (2.4)	125 (4.6)	8 (0.1)	35 (1.4)	118 (6.1)	46 (52.9)	<0.001
Black	7696 (55.9)	518 (18.8)	5931 (90.6)	698 (28.3)	529 (27.4)	20 (23.0)	
Hispanic	1855 (13.5)	350 (12.7)	161 (2.5)	1059 (42.9)	281 (14.6)	***	
Other	323 (2.3)	91 (3.3)	127 (1.9)	51 (2.1)	51 (2.6)		
White	3572 (25.9)	1664 (60.6)	317 (4.8)	627 (25.4)	950 (49.2)	14 (16.1)	
Public Location of Arrest, N (%)							
Yes	2960 (21.5)	843 (30.7)	1077 (16.5)	557 (22.6)	460 (23.8)	23 (26.4)	<0.001
No	10816 (78.5)	1904 (69.3)	5466 (83.5)	1913 (77.4)	1469 (76.2)	64 (73.6)	
Missing	2	1	1				
ROSC, N (%)							
Yes	4330 (31.4)	860 (31.3)	2017 (30.8)	823 (33.3)	605 (31.4)	25 (28.7)	0.237
No	9448 (68.6)	1888 (68.7)	4527 (69.2)	1647 (66.7)	1324 (68.6)	62 (71.3)	
Presumed Cardiac Etiology, N (%)							
Yes	11807 (85.7)	2392 (87.0)	5580 (85.3)	2077 (84.1)	1677 (86.9)	81 (93.1)	0.002
No	1971 (14.3)	356 (13.0)	964 (14.7)	393 (15.9)	252 (13.1)	6 (6.9)	
Shockable Rhythm, N(%)							
Yes	2081 (15.1)	543 (19.8)	822 (12.6)	368 (14.9)	332 (17.2)	16 (18.4)	<0.001
No	11697 (84.9)	2205 (80.2)	5722 (87.4)	2102 (85.1)	1597 (82.8)	71 (81.6)	
Witnessed Arrest, N (%)							
Yes	4983 (36.2)	1101 (40.1)	2229 (34.1)	884 (35.7)	731 (37.9)	38 (43.7)	<0.001
No	8795	1647 (59.9)	4315 (65.9)	1586 (64.2)	1198 (62.1)	49 (56.3)	

Table 2 – Association of Community area with Outcomes, crude and adjusted (accounting for clustering at community area level). Predominantly Asian community areas were excluded from this analysis.

	Outcome=STHA		
	Overall with Outcome N (%)	Crude OR (95% CI)	Adjusted[a] OR (95% CI)
Community area type			
White	708 (25.8%)	–REF–	–REF–
Black	1520 (23.2%)	**0.86 (0.75 – 0.99)**	0.96 (0.86—1.07)
Hispanic	621 (25.1%)	0.94 (0.81 – 1.10)	1.01 (0.89 – 1.15)
Integrated	483 (25.0%)	0.97 (0.82 – 1.14)	1.02 (0.91 – 1.14)
	Outcome=STHD		
Community area type			
White	252 (9.2%)	–REF–	–REF–
Black	438 (6.7%)	**0.70 (0.56 – 0.87)**	0.90 (0.74 – 1.11)
Hispanic	172 (7.0%)	**0.72 (0.54 – 0.95)**	0.80 (0.62 – 1.05)
Integrated	167 (8.7%)	0.91 (0.68 – 1.22)	1.02 (0.82 – 1.26)
	Outcome=CPC 1–2		
Community area type			
White	178 (6.5%)	–REF–	–REF–
Black	194 (3.0%)	**0.45 (0.33 – 0.62)**	**0.65 (0.49 – 0.86)**
Hispanic	97 (3.9%)	**0.58 (0.40 – 0.84)**	**0.69 (0.51 – 0.95)**
Integrated	109 (5.6%)	0.85 (0.60 – 1.20)	0.99 (0.74 – 1.32)
	Outcome = Utstein STHD		
Community area type			
White	117 (32.7%)	–REF–	–REF–
Black	104 (22.9%)	**0.64 (0.45–0.91)**	**0.65 (0.48–0.88)**
Hispanic	48 (23.0%)	0.63 (0.40–1.00)	**0.62 (0.41–0.94)**
Integrated	55 (27.9%)	0.80 (0.55–1.15)	0.77 (0.58–1.00)
	Outcome = Utstein CPC 1–2		
Community area type			
White	101 (28.2%)	–REF–	–REF–
Black	69 (15.2%)	**0.46 (0.31–0.69)**	**0.51 (0.37–0.71)**
Hispanic	33 (15.8%)	**0.48 (0.30–0.77)**	**0.49 (0.34–0.72)**
Integrated	44 (22.3%)	0.74 (0.52–1.06)	**0.67 (0.47–0.95)**

CPC indicates cerebral performance category; AED, automated external defibrillator; EMS, emergency medical services; STHA, survival to hospital admission; STHD, survival to hospital discharge.

[a] Adjusted for sex, age group, witnessed arrest, location of arrest, type of rhythm, AED used before EMS, presumed cardiac etiology and bystander CPR — Except for the Utstein STHD and Utstein CPC 1–2 models which were adjusted for sex, age group, location of arrest, AED used before EMS, presumed cardiac etiology and bystander CPR.

improved odds of CPC 1–2 in White and Integrated community areas, but not in Black or Hispanic community areas. Odds of STHD and CPC 1–2 were improved in Integrated community areas with AED use before EMS arrival (Table 4 and 5) as were odds of CPC 1–2 in Black and Hispanic community areas (Table 5).

Discussion

In this registry-based study, we found marked variations in OHCA survival outcomes by community area racial/ethnic composition. OHCA occurring in Black community areas are less likely to survive to hospital admission compared to White community areas. OHCA occurring in Black and Hispanic community areas are less likely to survive to hospital discharge and to survive with functional neurologic outcome (CPC 1–2) compared to those occurring in White community areas. On the other hand, Integrated community areas demonstrated survival outcomes comparable to White community areas. While some of the disparities can be attributed to differences in age, sex, cardiac arrest characteristics, and bystander response, a large portion of the inequities in survival with functional neurologic outcome remain unexplained. In fully adjusted models, OHCA from predominantly Black and Hispanic community areas were 31% and 35% respectively less likely to survive with functional neurologic outcome compared to White community areas. This study also revealed that OHCA survival outcomes in integrated areas are more equitable across individual-level race/ethnicity compared to predominantly White and predominantly Black community areas. A similar "protective effect" of integrated community areas was previously observed in Chicago by Iwashyna and colleagues (1999), where OHCA in racially Integrated community areas were more likely to receive bystander CPR compared to OHCA in predominantly Black or White community areas.[9]

Consistent with prior studies, we measured significant variations in favorable OHCA characteristics (public location, shockable rhythm, BCPR and use of AED before EMS); these were more fre-

Table 3 – Final Model Results for STHA – Overall^adjusted non-stratified results, and results stratified* by Community areas.

		Community area type*			
	City Overall^ aOR (95% CI)	White Community areas aOR (95% CI)	Black Community areas aOR (95% CI)	Hispanic Community areas aOR (95% CI)	Integrated Community areas aOR (95% CI)
Female					
Yes	**1.39 (1.29–1.51)**	**1.35 (1.18 – 1.55)**	**1.45 (1.29 – 1.64)**	**1.27 (1.02 – 1.58)**	**1.48 (1.20 – 1.83)**
No	–REF–	–REF–	–REF–	–REF–	–REF–
Age					
18–54	–REF–	–REF–	–REF–	–REF–	–REF–
55–64	1.09 (0.97–1.22)	1.06 (0.85 – 1.32)	1.10 (0.91 – 1.33)	1.06 (0.82 – 1.38)	1.14 (0.86 – 1.51)
65–74	1.04 (0.94–1.16)	**0.76 (0.62 – 0.93)**	1.07 (0.91 – 1.26)	1.21 (0.99 – 1.48)	1.30 (0.97 – 1.74)
75 and above	**0.71 (0.64–0.80)**	**0.60 (0.53 – 0.68)**	**0.76 (0.62 – 0.93)**	**0.78 (0.62 – 0.97)**	**0.70 (0.51 – 0.96)**
Individual Race/ Ethnicity					
White	–REF–	–REF–	–REF–	–REF–	–REF–
Black	**0.87 (0.78–0.98)**	**0.66 (0.56 – 0.76)**	**0.68 (0.50 – 0.91)**	1.17 (0.94 – 1.45)	1.10 (0.88 – 1.36)
Hispanic	1.02 (0.91–1.13)	**0.80 (0.66 – 0.97)**	0.95 (0.69 – 1.32)	**1.26 (1.06 – 1.51)**	1.13 (0.81 – 1.57)
Other/Mixed/ Unknown	0.94 (0.76–1.16)	0.86 (0.65 – 1.13)	**0.61 (0.43 – 0.86)**	1.12 (0.68 – 1.85)	**1.55 (1.17 – 2.05)**
Witnessed Arrest					
Yes	**2.11 (1.94–2.29)**	**2.10 (1.80 – 2.46)**	**2.22 (2.00 – 2.47)**	**1.80 (1.42 – 2.28)**	**2.12 (1.61 – 2.78)**
No	–REF–	–REF–	–REF–	–REF–	–REF–
Public Location					
Yes	**1.58 (1.44–1.72)**	**1.55 (1.30 – 1.85)**	**1.60 (1.40 – 1.84)**	**1.57 (1.25 – 1.97)**	**1.47 (1.15 – 1.88)**
No	–REF–	–REF–	–REF–	–REF–	–REF–
Shockable Rhythm					
Yes	**2.18 (1.97–2.41)**	**2.12 (1.68 – 2.68)**	**2.15 (1.84 – 2.52)**	**2.39 (1.90 – 3.00)**	**2.09 (1.71 – 2.56)**
No	–REF–	–REF–	–REF–	–REF–	–REF–
BCPR					
Yes	0.95 (0.85–1.06)	1.06 (0.86 – 1.31)	**0.85 (0.74 – 0.98)**	0.87 (0.66 – 1.14)	1.19 (0.93 – 1.51)
No	–REF–	–REF–	–REF–	–REF–	–REF–
AED use before EMS					
Yes	1.04 (0.93–1.16)	1.04 (0.86 – 1.27)	0.97 (0.81 – 1.16)	1.02 (0.84 – 1.23)	1.20 (0.90 – 1.60)
No	–REF–	–REF–	–REF–	–REF–	–REF–
Presumed Cardiac Etiology					
Yes	**0.55 (0.49–0.61)**	0.76 (0.54 – 1.07)	**0.48 (0.42 – 0.56)**	**0.55 (0.46 – 0.66)**	**0.59 (0.52 – 0.67)**
No	–REF–	–REF–	–REF–	–REF–	–REF–

^Overall results include all community areas

*stratified results exclude 1 community area that was predominantly AsianAED indicates automated external defibrillator; aOR, adjusted odds ratio; BCPR, bystander CPR; EMS, emergency medical services; STHA, survival to hospital admission

quently seen in White and Integrated community areas compared to Black and Hispanic community areas. Readers from outside of the United States may be surprised by the lower bystander CPR rates (overall 27%, witnessed cases 34%) compared to other industrial-

Table 4 – Final Model Results for STHD – Overall^adjusted non-stratified results, and adjusted results stratified* by Community areas.

		Community area type*			
	City Overall^ aOR (95% CI)	White Community areas aOR (95% CI)	Black Community areas aOR (95% CI)	Hispanic Community areas aOR (95% CI)	Integrated Community areas aOR (95% CI)
Female					
Yes	**1.44 (1.24 - 1.68)**	**1.34 (1.03 – 1.74)**	**1.54 (1.17 – 2.02)**	1.35 (0.87 – 2.09)	**1.53 (1.22 – 1.92)**
No	–REF–	–REF–	–REF–	–REF–	–REF–
Age					
18–54	–REF–	–REF–	–REF–	–REF–	–REF–
55–64	1.05 (0.90 - 1.23)	1.03 (0.74 – 1.44)	1.04 (0.80 – 1.35)	1.22 (0.91 – 1.63)	0.93 (0.66 – 1.29)
65–74	0.92 (0.78 - 1.08)	0.81 (0.59 – 1.11)	0.87 (0.68 – 1.12)	1.14 (0.82 – 1.59)	0.99 (0.65 – 1.50)
75 and above	**0.55 (0.44 - 0.68)**	**0.45 (0.31 – 0.65)**	**0.53 (0.40 – 0.72)**	1.05 (0.72 – 1.52)	**0.40 (0.20 – 0.78)**
Individual Race/ Ethnicity					
White	–REF–	–REF–	–REF–	–REF–	–REF–
Black	0.98 (0.80 - 1.20)	**0.62 (0.41 – 0.94)**	1.00 (0.65 – 1.53)	**1.65 (1.20 – 2.25)**	1.29 (0.70 – 2.38)
Hispanic	0.89 (0.71 - 1.13)	0.84 (0.56 – 1.25)	0.69 (0.39 – 1.22)	1.19 (0.82 – 1.73)	1.26 (0.94 – 1.70)
Other/Mixed/ Unknown	1.04 (0.76 - 1.41)	1.16 (0.76 – 1.76)	0.86 (0.36 – 2.06)	1.31 (0.66 – 2.62)	1.35 (0.75 – 2.42)
Witnessed Arrest					
Yes	**2.06 (1.82 - 2.34)**	**2.66 (2.09 – 3.38)**	**1.98 (1.64 – 2.38)**	**1.76 (1.50 – 2.06)**	**1.79 (1.20 – 2.65)**
No	–REF–	–REF–	–REF–	–REF–	–REF–
Public Location					
Yes	**1.81 (1.58 - 2.08)**	**1.87 (1.47 – 2.40)**	**1.82 (1.40 – 2.37)**	**1.71 (1.20 – 2.45)**	**1.62 (1.21 – 2.17)**
No	–REF–	–REF–	–REF–	–REF–	–REF–
Shockable Rhythm					
Yes	**4.75 (4.17 - 5.42)**	**5.06 (3.81 – 6.70)**	**4.84 (3.86 – 6.08)**	**4.59 (3.49 – 6.04)**	**4.34 (3.45 – 5.46)**
No	–REF–	–REF–	–REF–	–REF–	–REF–
BCPR					
Yes	1.13 (0.96 - 1.33)	1.16 (0.90 – 1.50)	1.01 (0.72 – 1.42)	0.97 (0.61 – 1.55)	**1.42 (1.17 – 1.73)**
No	–REF–	–REF–	–REF–	–REF–	–REF–
AED use before EMS					
Yes	**1.34 (1.12 - 1.60)**	1.02 (0.84 – 1.22)	1.20 (0.89 – 1.62)	1.49 (0.93 – 2.38)	**2.28 (1.90 – 2.74)**
No	–REF–	–REF–	–REF–	–REF–	–REF–
Presumed Cardiac Etiology					
Yes	**0.58 (0.49 - 0.69)**	**0.65 (0.44 – 0.96)**	**0.52 (0.42 – 0.63)**	0.70 (0.39 – 1.25)	**0.54 (0.37 – 0.81)**
No	–REF–	–REF–	–REF–	–REF–	–REF–

^Overall results include all community areas

*stratified results exclude 1 community area that was predominantly Asian.

AED indicates automated external defibrillator; aOR, adjusted odds ratio; BCPR, bystander CPR; EMS, emergency medical services; STHD, survival to hospital discharge.

ized nations. The bystander CPR rate reported in this study is the overall rate for the period between 2014 and 2021. We also exclude cases from nursing homes, healthcare facilities and from international airports where bystander CPR rates tend to be much higher. Bystander CPR rates have increased in Chicago over the years and recently surpassed the national bystander CPR rate in the 2023 CARES annual report (43.9% vs 41.2%).[16,17] While this is progress, bystander rates continue to be lower than in countries like Denmark, Sweden, and Norway, with rates approaching 70%.[18] The reasons for these differences are multifactorial. Previous work by US colleagues have identified disparities in CPR training,[19] delays in recognition,[20,21] fear of performing CPR incorrectly[22], fear of legal

Table 5 – Final Model Results for CPC – Overall^adjusted non-stratified results, and adjusted results stratified* by community area type.

		Community area type*			
	Overall^aOR (95% CI)	White Community areasaOR (95% CI)	Black Community areasaOR (95% CI)	Hispanic Community areasaOR (95% CI)	Integrated Community areasaOR (95% CI)
Female					
Yes	**1.29 (1.06 - 1.57)**	1.26 (0.92 – 1.73)	1.20 (0.86 – 1.68)	1.53 (0.83 – 2.82)	1.28 (1.00 – 1.64)
No	–REF–	–REF–	–REF–	–REF–	–REF–
Age					
18–54	–REF–	–REF–	–REF–	–REF–	–REF–
55–64	1.04 (0.83 - 1.29)	1.01 (0.68 – 1.51)	1.09 (0.72 – 1.64)	1.09 (0.66 – 1.81)	0.89 (0.58 – 1.37)
65–74	0.83 (0.64 - 1.08)	**0.66 (0.46 – 0.94)**	0.76 (0.44 – 1.33)	1.22 (0.77 – 1.93)	0.94 (0.52 – 1.68)
75 and above	**0.46 (0.33 - 0.65)**	**0.32 (0.17 – 0.61)**	0.59 (0.34 – 1.03)	0.69 (0.33 – 1.44)	**0.37 (0.19 – 0.73)**
Individual Race/Ethnicity					
White	–REF–	–REF–	–REF–	–REF–	–REF–
Black	**0.68 (0.53 - 0.86)**	**0.46 (0.28 – 0.76)**	**0.51 (0.31 – 0.83)**	**1.51 (1.04 – 2.21)**	1.03 (0.64 – 1.65)
Hispanic	0.83 (0.62 - 1.11)	1.04 (0.67 – 1.60)	0.49 (0.21 – 1.15)	1.24 (0.67 – 2.28)	1.15 (0.71 – 1.84)
Other/Mixed/ Unknown	0.85 (0.56 - 1.28)	1.27 (0.69 – 2.32)	0.34 (0.11 – 1.05)	1.20 (0.52 – 2.73)	1.03 (0.50 – 2.13)
Witnessed Arrest					
Yes	**1.91 (1.56 - 2.33)**	**2.57 (1.84 – 3.59)**	**1.69 (1.30 – 2.20)**	**1.91 (1.26 – 2.89)**	1.46 (0.82 – 2.58)
No	–REF–	–REF–	–REF–	–REF–	–REF–
Public Location					
Yes	**1.99 (1.70 - 2.32)**	**2.43 (1.83 – 3.23)**	**1.64 (1.18 – 2.28)**	**1.84 (1.17 – 2.92)**	**1.77 (1.29 – 2.43)**
No	–REF–	–REF–	–REF–	–REF–	–REF–
Shockable Rhythm					
Yes	**7.55 (6.28 - 9.09)**	**8.08 (5.66 - 11.53)**	**8.95 (6.55 – 12.23)**	**5.28 (3.35 – 8.31)**	**6.55 (5.01 – 8.55)**
No	–REF–	–REF–	–REF–	–REF–	–REF–
BCPR					
Yes	**1.36 (1.14 - 1.62)**	**1.40 (1.08 – 1.84)**	1.21 (0.95 – 1.53)	0.82 (0.43 – 1.59)	**2.02 (1.44 – 2.85)**
No	–REF–	–REF–	–REF–	–REF–	–REF–
AED use before EMS					
Yes	**1.58 (1.30 - 1.92)**	1.15 (0.88 – 1.49)	**1.48 (1.05 – 2.07)**	**2.45 (1.60 – 3.76)**	**1.95 (1.33 – 2.86)**
No	–REF–	–REF–	–REF–	–REF–	–REF–
Presumed Cardiac Etiology					
Yes	**0.59 (0.46 - 0.76)**	**0.48 (0.31 – 0.76)**	**0.48 (0.34 – 0.69)**	0.84 (0.44 – 1.58)	0.74(0.52 – 1.07)
No	–REF–	–REF–	–REF–	–REF–	–REF–

^Overall results include all community areas

*stratified results exclude 1 community area that was predominantly Asian.

AED indicates automated external defibrillator; aOR, adjusted odds ratio; BCPR, bystander CPR; CPC, cerebral performance category; EMS, emergency medical services.

consequences and concerns about racial profiling[23] as barriers to performing CPR. These barriers can be overcome. Chicago has already demonstrated success at increasing bystander CPR rates through a combination approach that addresses both awareness (through community CPR programs) and real-time guidance (by implementing dispatch-assisted CPR).[24,25]

Although BCPR is an intervention shown to double to triple OHCA survival in previous studies,[26,27] it had a variable effect in community areas with differing demographic composition. BCPR was associated with improved odds of STHA and STHD in Integrated community areas and odds of CPC 1–2 in White and Integrated community areas but was not associated with improved survival outcomes in Black and Hispanic community areas. Work to identify other unmeasured inequities in the cardiac arrest system of care is vital in order mitigate inequities in outcomes.

Conversely, AED use was associated with improved odds of STHD only in Integrated communities and was associated with improved odds of CPC 1–2 in Black, Hispanic, and Integrated communities, but not White communities. Given the survival advantage afforded by the use of AEDs, it is important to address inequities in use of AEDs. The underlying cause for variations in use of AED before EMS by community area is not completely understood. It is possible that, as has been observed in other geographic regions,[28,29] community areas with larger concentrations of minoritized racial and ethnic groups have less AEDs available for public use. Another explanation could be lower rates of training in AED use among Black and Hispanic people.[30,31]

Hispanic community areas also appear to have a "protective effect" in our study for Hispanic and Black people with OHCA. Odds of survival are not significantly different for individuals of Other race/ethnicity compared to White individuals whereas Black individuals have higher odds of STHD and CPC 1–2 and Hispanic individuals have higher odds of STHA compared to White people in Hispanic areas. Interestingly Hispanic people have better odds of STHA and similar odds of STHD or CPC 1–2 compared to White people within Hispanic community areas. On the other hand, Black people compared to White people with OHCA had lower odds of STHA and CPC 1–2 in White and Black community areas and lower odds of STHD in White community areas.

Whether these disparities in outcomes by individual race/ethnicity across community areas are a result of comorbidities or inequities in the provision of post resuscitation care deserves further investigation. It is possible that inequities are driven by receiving hospital performance. Previous studies have noted that Hispanic and Black people are less likely to be cared for at higher-performing hospitals and adjusting for receiving hospital bridged inequities in OHCA outcomes.[32] Interhospital variability in survival outcomes has been documented previously in Chicago.[33] Inequities may also be a result of other unmeasured differences in care driven by language discordance, implicit biases, or unequal distribution of clinical resources influencing post resuscitation care.[34] Female sex had improved STHA, STHD, and neurological survival overall. These findings are consistent with previous analysis done at the national level.[35] This difference in survival outcomes by sex warrants further exploration of the interplay between sex and other modifiable factors.

Survival by age group of 75 and above was significantly lower and progressively worsened for each outcome of STHA, STHD, and CPC for White community areas. A similar trend was noted for this oldest age group for other community area types as well, however, the association of age group for the later outcomes of STHD and CPC was not present for the Black and Hispanic strata. This may be due to the much smaller sample size of Black (3.0%) and Hispanics (3.9%) that had a CPC outcome.

Our sample's mean age of 61.8 is similar to the national mean age of 62.2 in 2023.[17] However, over the past decade, the mean age has declined, both locally and nationally.[36] The overall proportion of females (38%) in our sample is identical with the CARES national proportion of females with OHCA that were treated by EMS in 2022. Yet, on a granular level we see a significantly higher proportion of females with OHCA in Black community areas which may be due to the high risk factor burden.[37,38] The true incidence and distribution of OHCA remains uncertain as OHCAs not treated by EMS are not captured by the CARES registry. Exploring other national registries to define OHCA incidence and then stratification by age, sex, race/ethnicity would allow for a better understanding of the distribution of disease burden by these demographic features.

To achieve equity in OHCA, quality improvement programs must consider the specific characteristics of each setting and ensure that interventions align with the community's needs. A significant limitation of many existing quality improvement programs for OHCA is their reliance on a trial-and-error approach. Communities with lower survival rates often implement strategies that have been successful elsewhere, but these efforts frequently yield disappointing results. As an example, in this study we observed that bystander CPR had a variable effect on survival outcomes by community area in Chicago. This is not to say that efforts to increase bystander CPR are not effective, but that other contributing factors need to be addressed too. Continued analysis of disaggregated data by community area can inform tailored, community-level quality interventions to mitigate cardiac arrest inequities.

Limitations: There are several limitations to our study that should be mentioned. First, the observational nature of our study allows us to draw associations between specific community areas/ethnicities and OHCA outcomes, however, direct causality remains unanswered. Our study is limited to the City of Chicago with a single EMS provider agency, thus limiting generalizability of our study results. Another limitation is how CARES categorizes race/ethnicity. Healthcare providers or family members might perceive a person's race/ethnicity differently than how the individual identifies. This can lead to misclassification, as someone's racial or ethnic identity may not align with how others categorize them. Some patients treated on the border of Chicago may have been cared for by suburban EMS agencies and were therefore not captured in our study. However, having a single EMS agency removes possible confounding due to variations in care across multiple EMS agencies. While all patients were transported to hospitals designated as cardiac arrest receiving hospitals with similar capabilities, our study did not assess or compare the care given at these hospitals including cardiac catheterization and targeted temperature management which may have affected survival to hospital discharge and neurologic outcomes. Another limitation is that we were not able to stratify for CPR quality data which could have influenced outcomes. Moreover, the results of this study present associations averaged over an 8-year time period, hence, it may not be reflective of patterns or trends over time.

Conclusion

Our study revealed significant variation in the association of bystander interventions and OHCA survival outcomes across different community areas. While bystander interventions (BCPR and AED use) play a significant role in certain community areas, their effect may be less pronounced in other community areas. Future research should assess the interaction of community area and hospital-based care and their impact on survival.

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CRediT authorship contribution statement

Marina Del Rios: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Shaveta Khosla:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis. **Joseph Weber:** Writing – review & editing, Writing – original draft, Methodology, Investigation. **Pavitra Kotini-Shah:** Writing – review & editing, Methodology, Investigation. **Katie Tataris:** Writing – review & editing, Data curation. **Eddie Markul:** Writing – review & editing, Data curation. **Terry Vanden Hoek:** Writing – review & editing, Supervision, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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