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Retrospective cross sectional analysis of demographic disparities in outcomes of CPR performed by EMS providers in the United States

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Abstract

Objective: To investigate demographic disparities in prehospital cardiopulmonary resuscitation (CPR) initiation and successful outcomes of patients with out-of-hospital cardiac arrest (OHCA) treated by emergency medical services (EMS) providers.

Methods: We analyzed the National Emergency Medical Service Information Systems (NEMSIS) 2017 database, analyzing patient gender, age and race against CPR initiation and Return of Spontaneous Circulation (ROSC). The analysis was performed for a subset of patients who received bystander interventions (n = 3,362), then repeated for the whole cohort of patients (n = 5,833).

Results: Within the subgroup of patients that received CPR or AED application prior to the arrival of the paramedics, a logistic regression for CPR initiation rates as a function of race, gender and age reported the following adjusted odds ratios: African American (AA) to White 0.570 (95%CI [0.419, 0.775]), Hispanic to White 0.735 (95%CI [0.470, 1.150]); female to male 0.768 (95%CI [0.598, 0.986]); senior to adult 0.708 (95%CI [0.545, 0.920). Similarly, a logistic regression of ROSC as a function of race, gender and age reported the following adjusted odds ratios: AA to White 0.652 (95%CI [0.533, 0.797]) Hispanic to White 1.018 (95%CI [0.783, 1.323]); female to male 0.887 (95%CI [0.767, 1.025]); senior to adult 0.817 (95%CI [0.709, 0.940]). Similar trends existed in the entire cohort of patients.

Conclusions: These results suggest that there are discrepancies in patient care during cardiopulmonary arrest performed by EMS for OHCA, inviting further exploration of healthcare differences in the prehospital EMS approach to OHCA.

Keywords

EMS, cardiopulmonary resuscitation, health disparities, prehospital

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Introduction

Background

Disparities in healthcare quality have already been established as a major issue within the healthcare system.[1,2] Multiple patient characteristics have been shown to affect health outcomes, including race/ethnicity, age, gender, weight, disability, drug use, and mental illness, among others.[3–7] Previous research on racial health disparities in CVD has shown that it is the

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leading cause of life expectancy differences between racial groups, with African Americans having a 2–3 times higher likelihood of dying from heart disease as compared to Whites.[8] Gender disparities research has shown that across the past two decades, the prevalence of myocardial infarction (MI) increased in females aged 35–54, while male prevalence of MI in the same age group declined.[9] A 2013 meta-analysis also indicated that females had lower rates of adherence to statin therapy, a potentially life-saving CVD intervention, compared to their male counterparts.[10] It has also long been known that aging has deleterious effects on baseline cardiovascular health, with CVD being the leading cause of death in adults over 65.[11]

Goals of this investigation

Healthcare disparities in the inpatient and outpatient settings have garnered justifiably significant attention in the medical literature. However, there exist gaps in the literature as it pertains to whether similar disparities are present in patients treated in the prehospital setting. Lewis et al. published one of the few studies addressing this gap, using national EMS data from 2010–2013 to demonstrate that women were less likely than men to receive aspirin and lights and sirens transport in the workup of chest pain, and were also less likely to receive resuscitation in out-of-hospital cardiac arrest (OHCA).[12] Following this line of inquiry, our primary objective was to examine for the presence of disparities on the basis of patient age, gender, and race in prehospital CPR and outcomes of patients with OHCA. The secondary objective of our study is to cultivate further lines of inquiry into this field and to promote positive change, should our results suggest healthcare disparities in this setting. We hypothesized that EMS provider CPR initiation and outcomes would be poorer for women, racial minority groups, and patients over the age of 65.

Methods

Data source

Data was analyzed from the 2017 NEMSIS database, version 3, a voluntary, national registry of EMS activations funded by the National Highway Traffic and Safety Administration.[13] NEMSIS is a compilation of standardized EMS patient care reports submitted by state repositories from local EMS agencies in participating states. At the time of data extraction, 37 states and territories were fully contributing data to NEMSIS; on average, a majority of EMS agencies within a participating state report EMS activation data. In 2017, 15 states (Delaware, Hawaii, Idaho, Louisiana, Maryland, Michigan, Mississippi, Missouri, New Hampshire, New York, North Carolina, North Dakota, Ohio, Tennessee, and West Virginia) were not contributing data to NEMSIS. Of note, NEMSIS variables eArrest.01 (presence of cardiac arrest), eArrest.02 (cardiac arrest etiology), and eArrest.03 (whether or not CPR was attempted) are components of the Utstein cardiac arrest criteria.[14]

Inclusion/exclusion process

For the purposes of this study, patients were included who suffered a cardiac arrest as determined by EMS personnel on scene. The inclusion and exclusion process is shown in Figure 1. The NEMSIS 2017 database included 79,07,829 cases; selection for only patients who suffered cardiac arrest yielded 68,322 cases. In order to establish a more homogenous patient population, only those with cardiac arrest of presumed cardiac etiology were included. Cardiac arrest etiology was documented as variable eArrest.02 (Data Dictionary defined as "indication of the etiology or cause of the cardiac arrest"), and entries were included when the value was coded as 30,02,001 representing Cardiac (Presumed) etiology. Doing so excluded traumatic and external causes of cardiac arrest that may influence the decision to initiate CPR (e.g., obvious signs of death, scene/provider safety, or access to patients). Patients with ages under 40 were excluded, as manifestations of acquired CVD commonly do not appear until the fifth decade of life.[15] Patients over the age of 100 were excluded as a relatively arbitrary cutoff point, as the vast majority of data points lay beneath this value. Age was stratified into two groups, 40 to 64 years old (adults) and 65 to 100 years old (seniors), as CVD is the leading cause of death in patients aged $\geq$65.[11] Data was initially examined for Native American/Alaska Native, Asian, or Native Hawaiian/Pacific Islander patients but was ultimately excluded from the statistical analysis due to a low n (these racial groups collectively comprised 3.3% of the final n). Cases where CPR was discontinued due to a discovered DNR, medical control order, or inability to perform were excluded due to extrinsic effects on OHCA workup. Due to the fact that bystander CPR or AED application may affect patient outcomes before EMS arrival, we analyzed this subgroup of patients first, and the whole cohort after to assess for differences.

At all stages, any cases that had missing values or incomplete chart entry (encounters with one or more data items essential to analysis containing blank or aberrant N/A values) were excluded. Duplicate values, where the same patient could possess multiple patient care report (PCR) entries if they received a combination of resuscitation methods in one encounter

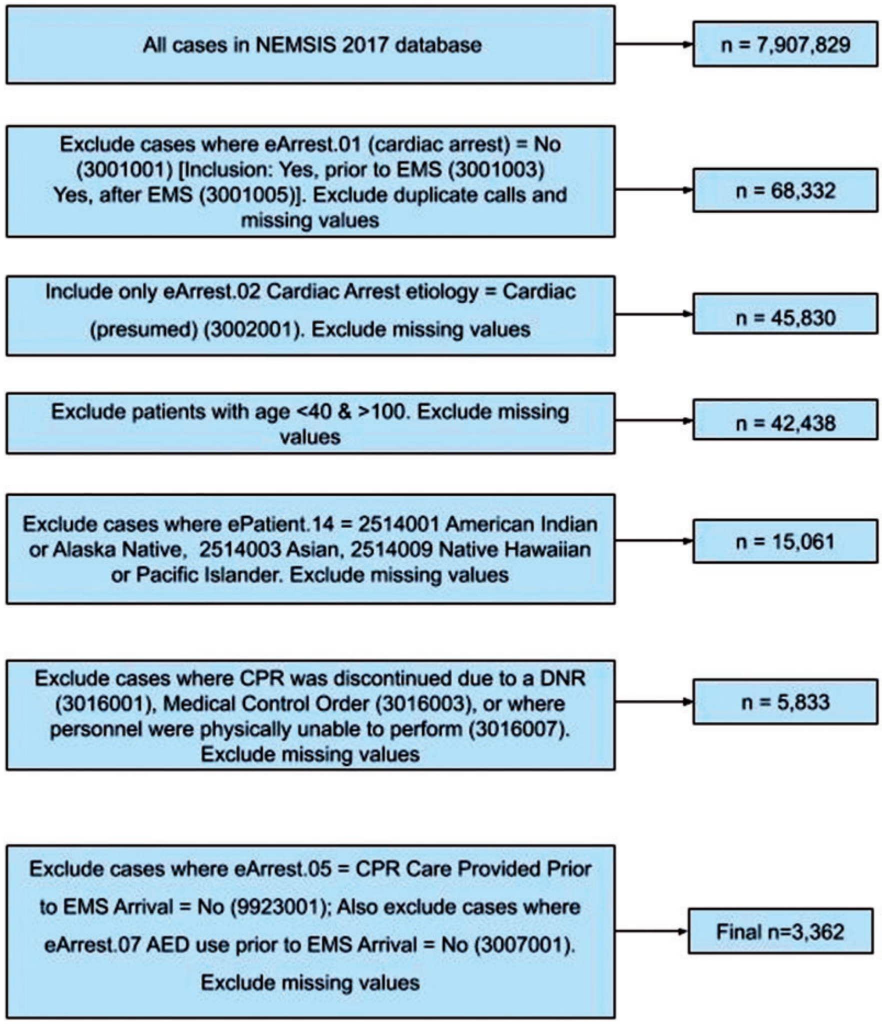

Figure 1. Inclusion and exclusion criteria flowchart with associated *n*.

(e.g., a patient who received compressions and ventilation would have two separate PCR entries for these interventions) were excluded. Duplicate patient "activations" (where cooperating agencies submitted separate charts for the same patient workup) were merged. The variables analyzed in this study were based on the judgment of the individual charting EMS provider. After exclusions, there remained a final *n* of 5,833 and out of that 3,362 received CPR and/or AED application.

Statistical analysis process and variables measured

IBM SPSS Version 25 was used to perform the following statistical analysis: t-tests, Chi square, and logistic regressions. Confidence interval of proportions was obtained by bootstrapping (1,000 samples). A p-value <0.05 was considered significant. The independent variables gathered are as follows: Gender, Race, and Age. Values for patient race were documented as variable ePatient.14 (Data Dictionary defined as "patient's race"); values included for this study were Black or African American (code: 25,14,005), Hispanic/Latino (code: 25,14,007), or White (code: 25,14,011). Age was examined as patients age 40–64 and age 65–100, as previously described.

The dependent variables gathered were initiation of resuscitation and ROSC. Initiation of resuscitation was defined as any positive value for variable eArrest.03 (Data Dictionary defined as "Indication of an attempt to resuscitate the patient who is in cardiac arrest"). Positive values were represented by entries that included Attempted Defibrillation (code: 30,03,001), Attempted Ventilation (code: 30,03,003), and/or Initiated Chest Compressions (code: 30,03,005). ROSC was defined by the variable eArrest.16 (Data Dictionary defined as "the reason that CPR or the resuscitation efforts were discontinued") where Return of spontaneous circulation (pulse or BP noted) was the documented reason for termination of resuscitative efforts (code: 30,16,011).

Results

Data from patients with bystander initiated CPR or AED application

Initiation of CPR. Table 1(A) shows the initiation rate of CPR for males and females. This subgroup presented a significant difference favoring males (females 90.0%, males 92.4%, difference −2.4%, 95%CI [−4.4, −0.3]). While broken down by race only the White population continued to show a statistically significance favoring males (White females 90.7%, White males 93.2%, difference −2.5, 95%CI [−4.7, −0.2]), Hispanics presented a non significant difference (Hispanic females 87.7%, Hispanic males 91.6%, difference −3.9%, 95%CI [−12.2, 4.4]), and AA exhibited almost the same ratio (AA females 87.6%, AA males 87.7%, difference 0.1%, 95%CI [−6.0, 5.8]; Figure 2(a)).

Table 1(B) shows the initiation of CPR as a function of age. Younger population exhibited a significant difference in their favor (adults 93.0%, seniors 90.6%, difference 2.4%, 95%CI [0.5, 4.3]). This difference was still significant for the AA population (AA adults 91.3%, AA seniors 84.3%, difference 7%, 95%CI [1.3, 12.7]), Hispanic population exhibit a lower and non significant difference (Hispanic adults 92.5%, Hispanic seniors 84.3%, difference 4.2%, 95%CI [-3.1, 11.5]), and White patients showed even a smaller and non-significant difference (White adults 93.5%, White seniors 91.8%, difference 1.7%, 95%CI [-0.3, 3.7]; Figure 2(b)).

Table 1(C) depicts the results of the logistic regression using covariates race, gender and age. White, male, and adult was used as reference. The model produced the following adjusted odds ratio for race: AA to White 0.570 95%CI [0.419, 0.775] ($p < 0.001$), Hispanic to White 0.735 95%CI [0.470, 1.150] ($p = 0.178$), female compared to male 0.768 95%CI [0.598, 0.986] ($p < 0.05$), and seniors compared to adults 0.708 95% CI [0.545, 0.920] ($p < 0.05$).

Table 2 compares the CPR initiation and ROSC rates between the subgroup that received bystander CPR and the whole cohort, as a function of race. Table 2(A) shows the CPR initiation rates corresponding to the subgroup that received bystander intervention. AA showed the lowest proportion (87.7%, 95% CI [84.8, 90.5]) followed by the Hispanic population

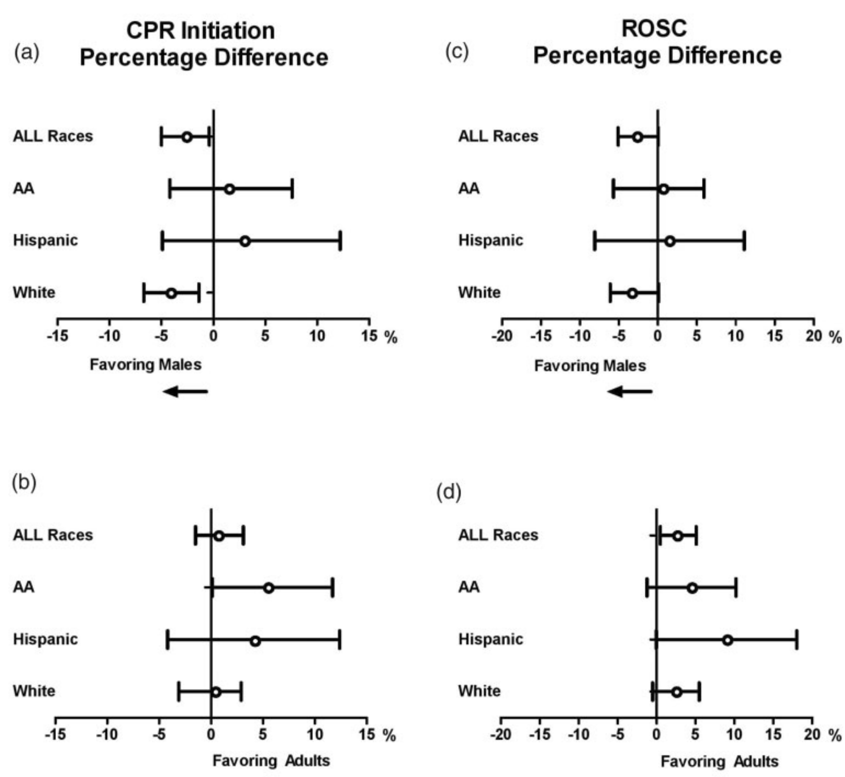

Figure 2. Percentage differences in individuals that receive bystander CPR or AED. Panel (a) differences in CPR initiation according to gender. Panel (b) differences in CPR initiation according to age. Panel (c) differences in ROSC according to gender. Panel (d) differences in ROSC according to age. Total subgroup = 3362; AA = 495, Hispanic = 248; White = 2619.

Table 1. (A) CPR initiation rates for the subgroup that received bystander CPR or AED as a function of gender. (B) CPR initiation rates for the same subgroup as a function of age. Total values and race distribution. (*) Denotes statistical significance, $p < 0.05$. (C) Logistic regression with Race, Gender, and Age as covariates. White, Male, and Adults were used as reference. The adjusted odds ratio for AA compared to White was 0.57 ($p < 0.0001$), Hispanic compared to White was 0.735 (not significant). Adjusted odds ratio for gender was 0.768 ($p < 0.05$) for females compared to males. Adjusted odds ratio for age was 0.708 ($p < 0.05$) for seniors compared to adults.

(A)	CPR initiation vs. gender					
	Female ($n = 1145$)	95%CI	Male ($n = 2217$)	95%CI	Difference	95%CI
Total	90.0%	[88.1, 91.6]	92.4%	[91.3, 93.4]	−2.4%	[−4.4, −0.3] (*)
AA	87.6%		87.7%		0.1%	[−6.0, 5.8]
Hispanic	87.7%		91.6%		−3.9%	[−12.2, 4.4]
White	90.7%		93.2%		−2.5%	[−4.7, −0.2] (*)
(B)	CPR initiation vs. age					
	Adults ($n = 1309$)	95%CI	Seniors ($n = 2053$)	95%CI		95%CI
Total	93.0%	[91.6, 94.3]	90.6%	[89.3, 91.9]	2.4%	[0.5, 4.3] (*)
AA	91.3%		84.3%		7%	[1.3, 12.7] (*)
Hispanic	92.5%		88.3%		4.2%	[−3.1, 11.5]
White	93.5%		91.8%		1.7%	[−0.3, 3.7]
(C)	Logistic regression					
		B	SE	Significance	Exp(*B*)	95%CI
Race	White			0.001	1	
	AA	−0.563	0.157	0.000	0.570	[0.419, 0.775]
	Hispanic	−0.307	0.228	0.178	0.735	[0.470, 1.150]
Gender		−0.264	0.134	0.038	0.768	[0.598, 0.986]
Age		−0.345	0.127	0.010	0.708	[0.545, 0.920]

(90.3%, 95%CI [86.7, 93.5]), and finally White patients (92.4%, 95%CI [91.4, 93.4]). These values came out to be statistically significant, $p = 0.02$.

The percentage of the population that received bystander CPR prior to EMS arrival also differed by race: AA 51.7% (95%CI [48.6, 54.9]), Hispanic 56.1% (95%CI [51.5, 60.7]) and White 59.0% (95%CI [57.6, 60.5]), $p < 0.001$. Table 2(C) shows a logistic regression for the probability of receiving bystander CPR as a function of race, gender and age. AA compared to White patients have an adjusted odds ratio of 0.740 (95%CI [0.642, 0.852]), Hispanic compared to White 0.875 (95%CI [0.718, 1.067]), females have an adjusted odds ratio of 0.865 (95%CI [0.776, 0.965]), and seniors compared to adults 0.903 (95%CI [0.810, 1.01]).

Success of resuscitation. Table 3(A) displays the rate of success as a function of gender. Male population showed a difference in their favor, but not significant (females 41.2%, males 44.7%, difference -3.5%, 95% CI [-7.0, 0.005]), AA females presented a better outcome than AA males but not significant (AA females 36.3%, AA males 34.4%, difference 1.9%, 95%CI [-6.7, 10.5]). Hispanic and White patients exhibited a non-significant higher rate of success for males (hispanic females 42.0%, hispanic males 47.9%, difference -5.9%, 95%CI [-18.9, 7.2]; White females 42.3%, White males 46.2%, difference -3.9%, 95%CI [-7.9, 0.1]; Figure 2(c)).

Table 3(B) presents the same analysis according to age. As expected, younger patients exhibit a statistically significant greater rate of success (adults 46.3%, seniors 41.8%, difference 4.5%, 95%CI [1.1, 7.9]). For all races the same pattern is observed, being statistically significant only for the White population, (AA adults 39.0%, AA seniors 31.5%, difference 7.5%, 95%CI [-0.9, 15.9]; Hispanic adults 51.7%, Hispanic seniors 40.6%, difference 11.1%, 95%CI [-1.2, 23.4]; White adults 47.5%, White seniors 43.4%, difference 4.1%, 95%CI [0.1, 8.0]); Figure 2(d)).

Table 2(A) reports the rate of successful ROSC as a function of race. ROSC values also differed

Table 2. (A) CPR initiation and ROSC rates as a function of race from the population that received bystander CPR or AED. (B) CPR initiation and ROSC rates for the whole cohort. Patients that received bystander help showed a higher rate of ROSC. (*) Denotes $p < 0.001$ (#) $p = 0.02$. (C) Logistic equation of probability of being helped as a function of Race, Gender, and Age. White, Male and Adult was used as reference. The adjusted odds ratio for AA compared to White was 0.740 ($p < 0.001$), for Hispanic the adjusted odds ratio is 0.875 ($p > 0.05$). For gender, females have an adjusted odds ratio of 0.865 ($p < 0.001$) and age has an adjusted odds ratio of 0.903 although not significant ($p > 0.05$).

(A)	Previous bystander CPR or AED cohort					
	AA ($n = 495$)	95% CI	Hispanic ($n = 248$)	95% CI	White ($n = 2619$)	95% CI
CPR initiation (#)	87.7%	[84.8, 90.5]	90.3%	[86.7, 93.5]	92.4%	[91.4, 93.4]
ROSC(*)	35.2%	[31.1, 39.2]	46.0%	[39.9, 52.0%]	44.9%	[43.0, 46.7]
(B)	Total cohort					
	AA ($n = 956$)		Hispanic ($n = 442$)		White ($n = 4435$)	
CPR initiation(*)	69.8%	[67.0, 72.8]	73.1%	[69.2, 76.8]	75.9%	[74.6, 77.2]
ROSC (*)	29.2%	[26.7, 32.0]	37.8%	[33.7, 41.6]	38.3	[36.8, 39.9]
Percentage helped by bystander (*)	51.7%	[48.6, 54.9]	56.1%	[51.5, 60.7]	59.0%	[57.6, 60.5]
(C)	Logistic regression					
		B	SE	Significance	Exp(*B*)	95%CI
Race	White			0.000	1	
	AA	−0.302	0.072	0.000	0.740	[0.642, 0.852]
	Hispanic	−0.133	0.101	0.187	0.875	[0.718, 1.067]
Gender		−0.144	0.056	0.009	0.865	[0.776, 0.965]
Age		−0.102	0.055	0.066	0.903	[0.810, 1.01]

Table 3. (A) ROSC rates as a function of gender in the subgroup that received bystander CPR or AED. (B) ROSC rates as a function of Age, same subgroup. Total values and race distribution. (*) Denotes statistical significance, $p < 0.05$. (C) Logistic regression of ROSC outcome with Race, Gender, and Age as covariates. Compared to white, AA has an adjusted odds ratio of 0.652 ($p < 0.001$). Hispanic people show an adjusted odds ratio of 1.018 but not significant. Gender also does not exhibit a significant adjusted odds ratio (0.887) with $p > 0.05$. Finally age has an adjusted odds ratio of 0.817 (senior compared to adults) with $p < 0.05$.

(A)	ROSC vs. gender					
	Female ($n = 1145$)	95%CI	Male ($n = 2217$)	95%CI	Difference	95%CI
Total	41.2%	[38.3, 44.1]	44.7%	[42.8, 46.9]	−3.5%	[−7.0, 0.005]
AA	36.3%		34.4%		1.9%	[−6.7, 10.5]
Hispanic	42.0%		47.9%		−5.9%	[−18.9, 7.2]
White	42.3%		46.2%		−3.9%	[−7.9, 0.1]
(B)	ROSC vs. age					
	Adults ($n = 1309$)	95%CI	Seniors ($n = 2053$)	95%CI		95%CI
Total	46.3%	[43.5, 49.0]	41.8%	[39.7, 43.9]	4.5%	[1.1, 7.9] (*)
AA	39.0%		31.5%		7.5%	[−0.9, 15.9]
Hispanic	51.7%		40.6%		11.1%	[−1.2, 23.4]
White	47.5%		43.4%		4.1%	[0.1, 8.0] (*)
(C)	Logistic regression					
		B	SE	Significance	Exp(*B*)	95%CI
Race	White			0.000	1	
	AA	−0.428	0.103	0.000	0.652	[0.533, 0.797]
	Hispanic	0.018	0.134	0.895	1.018	[0.783, 1.323]
Gender		−0.120	0.074	0.105	0.887	[0.767, 1.025]
Age		−0.203	0.064	0.005	0.817	[0.709, 0.940]

Table 4. (A) CPR initiation rates as a function of gender for the whole cohort. (B) CPR initiation rates as a function of Age. Total values and race distribution. (*) Denotes statistical significance, $p < 0.05$. (C) Logistic regression with Race, Gender, and Age as covariates. AA has an adjusted odds ratio of 0.730 when compared to White, $p < 0.001$. Hispanic people exhibit an adjusted odds ratio of 0.853 when compared to White, although not significant ($p = 0.160$). Gender has an adjusted odds ratio of 0.878 of females compared to males ($p < 0.05$) and age has an adjusted odds ratio of 0.945 but not significant ($p = 0.367$).

(A)	CPR initiation vs. gender					
	Female ($n = 2078$)	95%CI	Male ($n = 3755$)	95%CI	Difference	95%CI
Total	73.0%	[71.0, 75.1]	75.7%	[74.4, 77.2]	−2.7%	[−5.0, −0.4] (*)
AA	70.8%		69.1%		1.7%	[−4.2, 7.6]
Hispanic	75.5%		71.9%		3.6%	[−4.9, 12.2]
White	73.3%		77.4%		−4.1%	[−6.7, −1.4] (*)
(B)	CPR initiation vs. age					
	Adults ($n = 2220$)	95%CI	Seniors ($n = 3613$)	95%CI		95%CI
Total	75.2%	[73.2, 76.9]	74.4%	[73.0, 75.9]	0.8%	[−1.5, 3.1]
AA	72.8%		66.9%		5.9%	[0.12, 11.7] (*)
Hispanic	75.4%		71.2%		4.2%	[−4.2, 12.4]
White	75.9%		76.0%		0.1%	[−3.1, 2.9%]
(C)	Logistic regression					
		B	SE	Significance	Exp(*B*)	95%CI
Race	White			0.000	1	
	AA	−0.314	0.079	0.000	0.730	[0.625, 0.853]
	Hispanic	−0.159	0.113	0.160	0.853	[0.684, 1.065]
Gender		−0.130	0.063	0.039	0.878	[0.777, 0.993]
Age		−0.057	0.063	0.367	0.945	[0.835, 1.069]

Table 5. (A) ROSC rates as a function of gender for the whole cohort. (B) ROSC rates as a function of age. Total values and race distribution. (*) Denotes statistical significance, $p < 0.05$. (C) Logistic regression of ROSC as a function of Race, Gender, and Age. AA compared to White exhibits an adjusted odds ratio of 0.654 ($p < 0.001$). Hispanic people compared to White have an adjusted odds ratio of 0.953, although not significant. Gender also has a non-significant adjusted odds ratio of 0.920 ($p = 0.144$) but age shows a significant odds ratio of 0.871 ($p = 0.014$).

(A)	ROSC vs. gender					
	Female ($n = 2078$)	95%CI	Male ($n = 3755$)	95%CI	Difference	95%CI
Total	35.2%	[33.2, 37.1]	37.7%	[36.1, 39.3]	−2.5%	[−5.1, 0.06]
AA	29.2%		29.1%		0.1%	[−5.7, 5.9]
Hispanic	38.8%		37.3%		1.5%	[−8.1, 11.1]
White	36.3%		39.4%		−3.1%	[−6.1, 0.13]
(B)	ROSC vs. age					
	Adults ($n = 2220$)	95%CI	Seniors ($n = 3613$)	95%CI		95%CI
Total	38.4%	[36.4, 40.5]	35.8%	[34.3, 37.3]	2.6%	[0.5, 5.1] (*)
AA	31.5%		27.0%		4.5%	[−1.2, 10.2]
Hispanic	42.7%		33.7%		9%	[−0.03, 18.0]
White	39.9%		37.4%		2.5%	[−0.5, 5.5%]
(C)	Logistic regression					
		B	SE	Significance	Exp(*B*)	95%CI
Race	White			0.000	1	
	AA	−0.425	0.078	0.000	0.654	[0.561, 0.762]
	Hispanic	−0.038	0.103	0.716	0.963	[0.787, 1.179]
Gender		−0.084	0.057	0.144	0.920	[0.822, 1.029]
Age		−0.139	0.056	0.014	0.871	[0.779, 0.972]

significantly among the three races: AA exhibited the lowest proportion (35.2%, 95%CI [31.1, 39.2]) followed by White patients (44.9%, 95%CI [43.0, 46.7]) and Hispanic showed the highest (46.0%, 95%CI [39.9, 52]).

Analysis of the whole cohort. Overall a similar pattern was observed in the whole cohort; differences included findings that proportions of CPR initiation and rate of success were lower, (CPR initiation 74.7% for the whole cohort, 91.6% for the subgroup that received CPR or AED application, ROSC 36.8% for the whole cohort, 43.5% for the for subgroup that received CPR or AED application).

Initiation of CPR. Table 4(A) shows the proportion of CPR initiation by EMS personnel according to gender. Overall there is a significant difference: females 73%, males 75.7%, difference -2.7%, (95%CI [-5.0, -0.4]). When accounting for race this difference remains significant only for White patients (White female 73.3%, White male 77.4%, difference -4.1%, 95%CI [-6.7, -1.4]), for the hispanic population the difference is reversed and non-significant (hispanic females 75.5%, hispanic males 71.9%, difference 3.6%, 95% CI [-4.9, 12,2]), and a similar trend is observed in AA (AA females 70.8%, AA males 69.1%, difference 1.7%, 95%CI [-4.2, 7.6]; Figure 3(a)).

Table 4(B) shows the CPR initiation rates according to age (adults vs seniors). There was no difference between the two groups (adults 75.2%, seniors 74.4%, difference 0.8%, 95%CI [-1.5, 3.1]). When broken down by race, AA exhibits a significant difference favoring the younger population (AA adults 72.8%, seniors 66.9%, difference 5.9%, 95%CI [0.12, 11.7]), Hispanics also shown a similar difference but not significant (Hispanic adults 75.4%, seniors 71.2%, difference 4.2%, 95%CI [-4.2, 12.4]), while adults and seniors from the White population presented almost the same proportion (White adults 75.9%, seniors 76.0%, difference 0.1%, 95%CI [-3.1, 2.9]; Figure 3(b)).

Table 2(B) presents the same analysis as presented in Table 2(A) but for the whole cohort. Similarly statistically significant differences are observed. AA exhibited the lowest CPR initiation rate 69.8% (95%CI [67.0, 72.8]), followed by Hispanic 73.1% (95%CI [69.2, 76.8]) and then White 75.9% (95%CI [74.6, 77.2]) ($p < 0.001$).

Table 4(C) presents the logistic regression of CPR initiation as function of race, gender and age. AA have

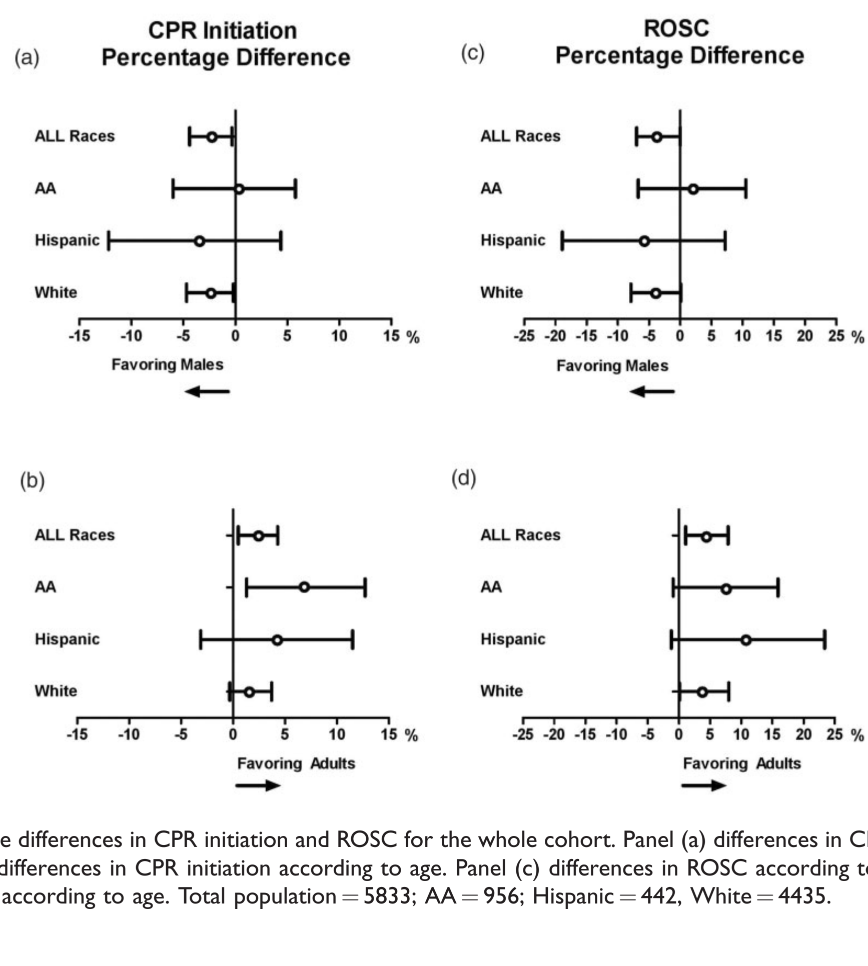

Figure 3. Percentage differences in CPR initiation and ROSC for the whole cohort. Panel (a) differences in CPR initiation according to gender. Panel (b) differences in CPR initiation according to age. Panel (c) differences in ROSC according to gender. Panel (d) differences in ROSC according to age. Total population = 5833; AA = 956; Hispanic = 442, White = 4435.

an adjusted odds ratio of 0.730 compared to white (95%CI [0.625, 0.853]), and Hispanic 0.853 (95%CI [0.684, 1.065]), females have 0.878 (95%CI [0.777, 0.993]), and seniors 0.945 (95%CI [0.835, 1.069]).

Success of resuscitation. Table 5(A) shows the differences in ROSC for the whole cohort as a function of gender. The rate of success is higher but not significant in males than females (females 35.2%, males 37.7%, difference -2.5%, 95%CI [-5.1, 0.06]). When broken by races none of the differences are significant but, similar to the initiation of CPR, White females had a lower rate than males (White females 36.3%, White males 39.4%, difference -3.1%, 95%CI [-6.1, 0.13]), AA showed almost no difference (AA females 29.2%, AA males 29.1%, difference 0.1%, 95%CI [-5.7, 5.9]), and Hispanic (similar to the CPR initiation rates) showed a slight but not significant higher success for females (Hispanic females 38.8%, Hispanic males 37.3%, difference 1.5%, 95% CI [-8.1, 11.1]; Figure 3(c)).

Table 5(B) shows the proportions of ROSC in accordance to age. As expected, the younger population exhibited a higher rate of success (adults 38.4%, seniors 35.8%, difference 2.6%, 95%CI [0.5, 5.1]). Each race group presented the same pattern although no statistically significant. The highest difference between adults and seniors was shown in the Hispanic population (Hispanic adults 42.7%, Hispanic seniors 33.7%, difference 9%, 95%CI [-0.03, 18.0]) follow by AA (AA adults 31.5%, AA seniors 27.0%, difference 4%, 95% CI [-1.2, 10.2]) and then White patients (White adults 39.9%, White seniors 37.4%, difference 2.5%, 95%CI [-0.5, 5.5%]; Figure 3(d)).

Table 2(B) illustrates the rate of success according to race. The lowest value was presented by AA (29.2%, 95%CI [26.7, 32.0]) followed by the Hispanic population (37.8%, 95%CI [33.7, 41.6]) and then White patients (38.3%, 95%CI [36.8, 39.9]). These differences came out to be statistically significant, $p < 0.001$.

Table 5(C) presents the logistic regression of ROSC for the whole cohort as a function of race, gender and age. AA has an adjusted odds ratio of 0.654 compared to White (95%CI [0.561, 0.762]), Hispanic 0.953 (95% CI [0.787, 1.179]), females compared to males present an adjusted odds ratio of 0.920 (95%CI [0.822, 1.029] and seniors to adults 0.872 (95%CI [0.779, 0.972]).

Discussion

Our data suggests that initiation and success rates of prehospital healthcare provider-initiated CPR in African American patients are lower when compared to the rates seen in other races. These findings are consistent with previous publications, indicating disparities in healthcare quality and access within the African American community. This discrepancy in CPR outcomes between different races may be attributable to numerous factors, including socioeconomic differences, increased severity of cardiovascular disease among minorities, and potential healthcare provider bias.

The existence of poorer outcomes from cardiovascular and cerebrovascular disease in African Americans compared with other races has been supported by the body of pre-existing literature. Rates of death due to stroke and ischemic heart disease have consistently remained highest amongst African Americans.[16,17] When compared with non-Hispanic Whites, non-Hispanic African Americans also have higher rates of avoidable deaths from CVD, with social and economic factors clearly having a strong negative impact.[18] Taking this into account, the decreased rates of EMS provider CPR and successful ROSC demonstrated in our data present an additional metric presenting poorer outcomes in CVD in African Americans.

It would certainly be possible that the decreased rates of CPR initiation and ROSC seen in African American patients in the present study could be attributable to these aforementioned discrepancies in baseline cardiovascular health. Patients with more poorly managed CVD have higher rates of mortality from their disease.[17] Therefore, the futility of CPR efforts could be explained, at least in part, by these more advanced disease states seen in patients with certain demographic features.

The American Heart Association (AHA) has identified certain factors believed to play a role in determining disparities in CVD outcomes. These include but are not limited to geographic location, education, wealth, and access to preventative care.[17] That being said, rurality of a patient's location plays a role in access to healthcare resources, both in terms of access to preventative care, as well as on-scene response times (i.e., time elapsed from initial 9-1-1 call to EMS personnel arrival on-scene). A prolonged EMS response time has the potential to negatively influence patient outcomes in OHCA.[19] However, the extent to which this plays a role in contributing to disparities seen between racial groups is unclear, as a lesser proportion of African Americans and other racial minorities live in rural areas as compared to urban areas (18% vs 40%, respectively).[20]

We present differences in rates of EMS provider-initiated CPR and successful ROSC when examining various racial groups in patients suffering from OHCA. When only looking at patients who received bystander CPR prior to EMS arrival, African Americans had a lower rate of EMS CPR (87.7% vs 92.4%, $p = 0.02$; odds ratio 0.57, $p < 0.0001$) and ROSC (35.2% vs 44.9%, $p < 0.001$; odds ratio 0.65, $p < 0.001$) when compared to Caucasians. For the whole cohort, African Americans still had a lower rate of EMS CPR (69.8% vs 75.9%, $p < 0.001$; odds ratio 0.73, $p < 0.001$) and ROSC (29.2% vs 38.3%, $p < 0.001$; odds ratio 0.65, $p < 0.001$) when compared to Caucasians. Despite the limitations of our study (as discussed below), we find these differences to be not only statistically significant, but clinically and culturally significant as well. These findings would certainly benefit from future studies that endeavor to track these rates and changes over time. While CVD remains the number one cause of death among all patients in the United States, there must be more work done to ensure the closing of the gap between racial groups in treatment and outcomes of CVD. This requires examination of all clinical environments, including prehospital and inpatient/outpatient venues.

Epidemiology

The distribution of calls for cardiac arrest based on race differs from US Census data by race presented in Figure 4.[21] Comparison of this data is complicated by a number of factors, such as the self-reported race/ethnicity used in the US Census data versus EMS provider documented race in the NEMSIS database. In NEMSIS documentation, EMS providers "assign" an assumptive race to each patient based upon situational factors such as skin color, name, language spoken by family members at the scene, prevalence in the local communities, etc. This issue would certainly apply to the present study, as patients in cardiac arrest are not able to self-report their race/ethnicity, and family members, if present, are likely not to be asked to provide this information at the scene. For example, Paramedics or EMTs may perceive a patient to be White or African American, based upon skin tone, when that patient may actually be of Hispanic/Latino heritage. This difference in patient race reporting could partially account for the higher-than-expected percentages of cardiac arrest calls for White and African American patients and the lower-than-expected percentage seen in cardiac arrest calls for Hispanic patients.

There may be additional factors involved, as this data is consistent with previous studies that have found Hispanics to be less likely to call 9-1-1 during medical emergencies.[22] The exact reason for this is difficult to account for, as this likely entails multiple complex issues, including but not limited to language barriers, mistrust of law enforcement, and misinformation about health concerns.

The greater percentage of cardiac arrest calls for African American patients than would be predicted based on US Census data aligns with studies mentioned earlier in this paper that suggest poorer cardiovascular health and outcomes amongst African Americans.[18]

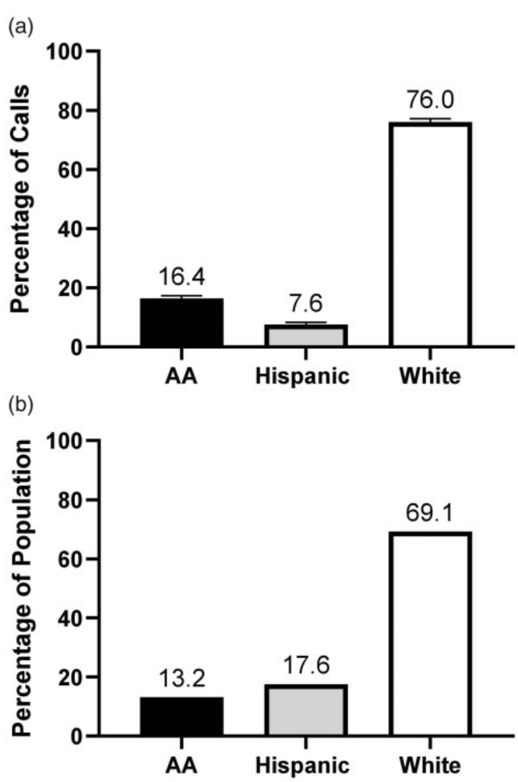

Figure 4. (a) The 9-1-1 calls for cardiac arrest in 2017, broken down as a function of race; (b) 2010 US Census data, represented as a percentage by race.

Importance of bystander CPR

Although not one of the questions initially posed by our investigations, the percentage of the population that received bystander CPR prior to EMS arrival also differed by race. The findings presented in this paper serve as a strong reminder of the importance of minimizing the time from which a patient is first found down to first chest compressions or AED application, as this has strong correlations to ROSC and long term neurologic outcome.[23] Bystander intervention is vital to increasing the chances of meaningful survival in these patients, and additional studies have shown that bystander support decreases for African Americans and patients residing in counties with lower socioeconomic status.[24]

Limitations

The relevant limitations of the NEMSIS database are addressed by the database owners, and can be classified as followed:[25] As the database is powered by electively submitted data, it is possible that the data overrepresents agencies that have funding or manpower to employ NEMSIS-compliant electronic medical records and submit said data. This potentially underrepresents states or agencies without such resources. As listed previously, 15 states were not submitting data in 2017, and the involvement of further states in the NEMSIS database since that time will provide not only a larger n, but a more robust representation of the United States. Additionally, as a result of differences in submission practices, the database may be influenced by selection bias and information bias. In this case, selection bias refers to agency or state level differences in inclusion criteria that lead to different numbers or types of patients being submitted as data. Information bias could present as states or agencies not having a universal data entry template; this lack of uniformity may result in interagency discrepancies of available data and impede comparison between said states and agencies. These limitations could not be adjusted for, as these are inherent limitations in the data collection process.

Review of the dataset revealed poor consistency in charting the variable "initial monitored rhythm", which resulted in compromised statistical significance. It is understood that the initial monitored rhythm, such as whether the patient was found to be in ventricular fibrillation or pulseless electrical activity, is strongly correlated to ROSC and long-term neurological outcome. As NEMSIS continues to expand in call volume, and submitting agencies refine their data entry process, further research can be directed toward examining how this variable interacts with the findings presented in this research.

As mentioned in the discussion, the rurality of patient location has implications on access to healthcare resources, both in terms of access to preventative care, as well as on-scene response times. With this in mind, the authors of this paper had the intention to include rurality/urbanicity and EMS response times in the analysis. Regrettably, this information was not available in the version of the NEMSIS database utilized in this study (version 3, 2017). Previous versions of the NEMSIS database did include this vital information, and future studies on disparities in prehospital care would surely benefit from the inclusion of this data to help provide a more holistic picture.

The authors also acknowledge that ROSC is a nonideal metric for measuring patient outcomes from OHCA resuscitative efforts. The data provided by the NEMSIS database is limited to only what is charted during the course of a patient's prehospital care. The NEMSIS database does not have access to further information once transfer of care to the destination facility has occurred. The tracking of individual patient outcomes would be impossible due to de-identification of patient data and inability to correspond an individual's prehospital charting with subsequent hospital records. The ability to assess for more meaningful measures of patient outcomes, such as long-term survival, neurologic status, or return to baseline function, following EMS provider treatment of OHCA would provide valuable information.

Conclusion

This research draws upon the landscape of previous studies regarding healthcare disparities in the hospital setting and seeks to add to the relatively scarce studies of this topic in prehospital settings by examining how initiation and success of cardiopulmonary resuscitation may differ by patient demographics. We encourage future investigators to continue to explore this burgeoning field of inquiry.

In all healthcare settings the goal should be appropriate and successful treatment of all patients, regardless of age, gender, race, or any other identifiable demographic features. All healthcare providers, irrespective of training level, can influence patient outcomes and must be held accountable for adverse events that occur based upon factors within their control. This includes, but is not limited to, identifying any potential bias that may be influencing patient care.

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Contributionship

TH, TW, JP, and MR conceived the study and its design. TW and JP procured the NEMSIS data. JP, AF, and CW performed statistical analysis. TH, TW, and JP wrote the manuscript. HG provided content suggestions. TH, TW, and HG performed grammatical editing. TH and TW performed formatting. TH and TW take responsibility for the article as a whole.

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