Circulation

ORIGINAL RESEARCH ARTICLE

Race-Based Differences in ST-Segment–Elevation Myocardial Infarction Process Metrics and Mortality From 2015 Through 2021: An Analysis of 178 062 Patients From the American Heart Association Get With The Guidelines–Coronary Artery Disease Registry

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BACKGROUND: Systems of care have been developed across the United States to standardize care processes and improve outcomes in patients with ST-segment–elevation myocardial infarction (STEMI). The effect of contemporary STEMI systems of care on racial and ethnic disparities in achievement of time-to-treatment goals and mortality in STEMI is uncertain.

METHODS: We analyzed 178 062 patients with STEMI (52 293 women and 125 769 men) enrolled in the American Heart Association Get With The Guidelines–Coronary Artery Disease registry between January 1, 2015, and December 31, 2021. Patients were stratified into and outcomes compared among 3 racial and ethnic groups: non-Hispanic White, Hispanic White, and Black. The primary outcomes were the proportions of patients achieving the following STEMI process metrics: prehospital ECG obtained by emergency medical services; hospital arrival to ECG obtained within 10 minutes for patients not transported by emergency medical services; arrival-to–percutaneous coronary intervention time within 90 minutes; and first medical contact–to-device time within 90 minutes. A secondary outcome was in-hospital mortality. Analyses were performed separately in women and men, and all outcomes were adjusted for age, comorbidities, acuity of presentation, insurance status, and socioeconomic status measured by social vulnerability index based on patients' county of residence.

RESULTS: Compared with non-Hispanic White patients with STEMI, Hispanic White patients and Black patients had lower odds of receiving a prehospital ECG and achieving targets for door-to-ECG, door-to-device, and first medical contact–to-device times. These racial disparities in treatment goals were observed in both women and men, and persisted in most cases after multivariable adjustment. Compared with non-Hispanic White women, Hispanic White women had higher adjusted in-hospital mortality (odds ratio, 1.39 [95% CI, 1.12–1.72]), whereas Black women did not (odds ratio, 0.88 [95% CI, 0.74–1.03]). Compared with non-Hispanic White men, adjusted in-hospital mortality was similar in Hispanic White men (odds ratio, 0.99 [95% CI, 0.82–1.18]) and Black men (odds ratio, 0.96 [95% CI, 0.85–1.09]).

CONCLUSIONS: Race- or ethnicity-based disparities persist in STEMI process metrics in both women and men, and mortality differences are observed in Hispanic White compared with non-Hispanic White women. Further research is essential to evolve systems of care to mitigate racial differences in STEMI outcomes.

Key Words: ethnicity ■ healthcare disparities ■ mortality ■ racial groups ■ ST elevation myocardial infarction

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This manuscript was sent to Michael Kurz, Guest Editor, for review by expert referees, editorial decision, and final disposition.
Supplemental Material is available at https://www.ahajournals.org/doi/suppl/10.1161/CIRCULATIONAHA.123.065512.
For Sources of Funding and Disclosures, see page 239.

Circulation is available at www.ahajournals.org/journal/circ

Clinical Perspective

What Is New?

- In a large US-based ST-segment–elevation myocardial infarction (STEMI) systems-of-care registry, Hispanic White or Black patients had lower odds of meeting time-to-diagnosis or treatment goals compared with non-Hispanic White patients.
- In-hospital mortality was higher in Hispanic White women compared with non-Hispanic White women. No significant race- or ethnicity-based mortality differences were found in men.

What Are the Clinical Implications?

- Important race- or ethnicity-based disparities persist in STEMI systems-of-care metrics and in mortality after STEMI.
- More research is essential for STEMI systems of care to evolve so that race- or ethnicity-based disparities in STEMI outcomes can be mitigated.

Nonstandard Abbreviations and Acronyms

AHA	American Heart Association
ED	emergency department
EMS	emergency medical services
FMC	first medical contact
GEE	generalized estimating equation
GWTG-CAD	Get With The Guidelines–Coronary Artery Disease
NSTEMI	non–ST-segment–elevation myocardial infarction
OR	odds ratio
PCI	percutaneous coronary intervention
STEMI	ST-segment–elevation myocardial infarction
SVI	social vulnerability index

A generation of science directly links prompt reperfusion therapy to survival and better quality of life after ST-segment–elevation myocardial infarction (STEMI). Recognizing that the achievement of timely reperfusion therapy requires seamless teamwork among emergency medical services (EMS) and hospital personnel, STEMI systems of care have coalesced throughout the United States,[1] and aggressive goals for first medical contact (FMC)-to-device times have been established for patients presenting with STEMI to receiving and referring centers.[1–3] The establishment of STEMI systems of care has been successful at reducing treatment times in patients with STEMI overall.[4] However, it is less clear whether these STEMI systems of care have also been effective at reducing longstanding race- or ethnicity-based disparities in cardiovascular outcomes.[5–14] Previous studies reporting disparities in STEMI outcomes[11,13,15,16] were largely conducted before the era of STEMI systems of care, the establishment of which has given rise to several additional process metrics that evaluate the effectiveness of the collaboration between EMS and hospital partners. Expanded performance metrics, including performance of an ECG before hospital arrival and time from FMC to percutaneous coronary intervention (PCI), provide an opportunity to document the effects of systems of care on disparities in contemporary patients with STEMI.

The American Heart Association (AHA) Get With The Guidelines–Coronary Artery Disease registry (GWTG-CAD) is a large program that enrolls patients admitted with STEMI to 1 of >700 participating hospitals across the United States. We examined whether race- or ethnicity-based disparities persist in guideline-driven time metrics to diagnosis and revascularization, including FMC-to-PCI time and door-to-device time, as well as in-hospital mortality. We hypothesized that compared with non-Hispanic White patients, Hispanic White and Black patients would have lower likelihood of achieving key STEMI process metrics and a higher likelihood of in-hospital death after adjusting for age, comorbidities, acuity of presentation, insurance status, and socioeconomic status.

METHODS

Data Sources and Collection: GWTG-CAD Cohort

The AHA GWTG-CAD registry is a voluntary quality improvement program in the United States that has been described previously.[4,17] Participating hospitals upload clinical data of consecutive patients admitted with STEMI or non-STEMI (NSTEMI). Program information and data elements collected in the case report form are available at https://www.heart.org/en/professional/quality-improvement. Data were used primarily at local sites for quality improvement; therefore, sites were granted a waiver of informed consent under the common rule. The data collection and coordination for GWTG programs are managed by IQVIA. Deidentified data from the AHA GWTG-CAD registry are available through the AHA Precision Medicine Platform. Requests to access the data should be made by contacting AHA as instructed at https://www.heart.org/en/professional/quality-improvement/quality-research-and-publications/hospital-level-research.

Study Population

The study population includes all patients between 18 and 100 years of age admitted to one of the GWTG-CAD hospitals from January 1, 2015, to December 31, 2021 (Figure 1). A principal final or discharge diagnosis of STEMI or STEMI equivalent was defined as STEMI of the anterior wall, inferior wall, other sites, or unspecified site. Patients diagnosed with STEMI and discharged from the hospital with valid data for sex, race or ethnicity, and disposition status were included in the study.

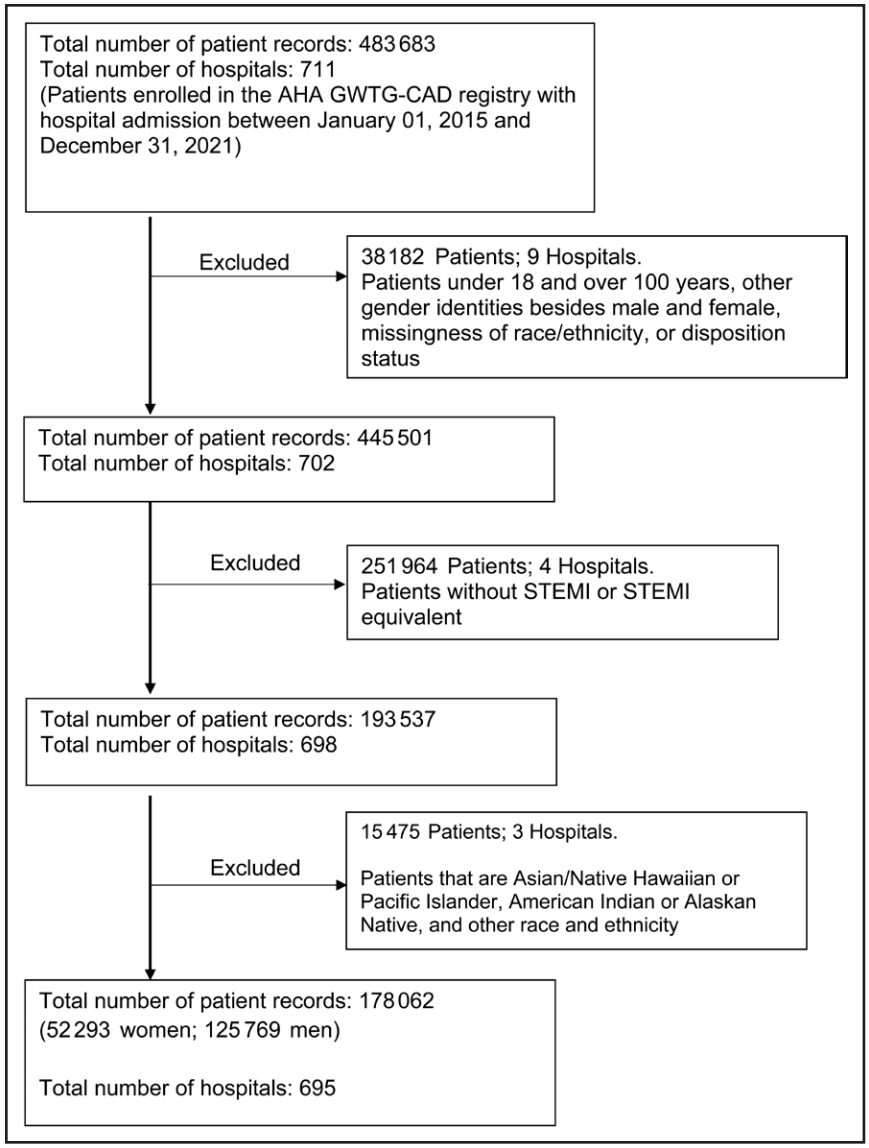

Figure 1. Patient selection flow diagram.
AHA indicates American Heart Association; GWTG-CVD, Get With The Guidelines–Coronary Artery Disease; and STEMI, ST-segment–elevation myocardial infarction.

Ascertainment of Race and Ethnicity and Study Outcomes

At participating hospitals, race and ethnicity data were entered into the GWTG-CAD registry, usually on the basis of race and ethnicity data from the electronic medical record (which, in turn, could be reported by patients or family members or entered by hospital staff without consulting patients or family members). The GWTG-CAD registry documents each patient as belonging to 1 of 6 race groups (only one option per patient can be selected): White, Black, Asian, American Indian or Alaska Native, Native Hawaiian or Pacific Islander, or unable to determine. Hispanic ethnicity is collected separately from race and was entered for each patient as "yes" or "no/unable to determine." Nearly all patients entered into the registry as being of Hispanic ethnicity were also entered as White (ie, there were practically no patients entered into the registry as Hispanic Black). In addition, the numbers of American Indian or Alaskan Native, Native Hawaiian or Pacific Islander, or Asian patients with STEMI were deemed too few to provide meaningful race-specific STEMI outcomes data. Therefore, for the purposes of this analysis, we categorized patients into 3 mutually exclusive race and ethnicity groups: non-Hispanic White, Hispanic White, and Black. All comparisons by race and ethnic groups were performed separately in women and men.

The primary study outcomes included the following STEMI systems of care metrics: arrival to ECG for walk-in patients or for EMS-transported patients for whom a prehospital ECG was not obtained; door-to-device time; FMC-to-PCI time for EMS-transported patients; and rate of obtaining a prehospital ECG before hospital arrival (for EMS-transported patients). Additional metrics explored included door-to-fibrinolysis time, door-in to door-out time, emergency department (ED) length of stay, and FMC-to-catheterization laboratory activation. The secondary outcome for study analyses was in-hospital all-cause mortality.

Statistical Analysis

Baseline characteristics were tabulated separately for women and in men and stratified into the 3 race or ethnicity groups: non-Hispanic White (reference group), Hispanic White, or Black. Descriptive statistics are represented as percentages for

categorical variables and medians (with interquartile range) for continuous variables. Socioeconomic status was estimated on the basis of the social vulnerability index (SVI) using the Centers for Disease Control and Prevention Geospatial Research, Analysis, and Services Program database.[18] SVI combines data from the US Census Bureau on multiple variables that capture information on socioeconomic status, housing composition, language, and housing type. These factors are then used to generate a nationwide ranking of counties, with higher numbers representing higher vulnerability. For our analysis, we cross-walked individual patient zip codes to outlined county-level SVI for each patient in the registry. This method has been applied previously in registry analyses on cardiovascular disease.[19]

In analyses separated by sex, the rates of achievement of the following 4 primary outcomes were compared among the 3 race and ethnic groups (with non-Hispanic White as the reference group): rate of prehospital ECG obtained among patients transported by EMS; arrival to ECG within 10 minutes if no prehospital ECG was obtained; arrival to PCI within 90 minutes; and FMC-to-PCI time within 90 minutes for EMS-transported patients. Additional analyses compared by race and ethnic groups (again separately in women and men) were the achievement of 4 additional time-to-treatment STEMI metrics: ED length of stay ≤30 minutes; FMC-to-cardiac catheterization laboratory activation within 20 minutes; door-to-fibrinolysis within 30 minutes; and door-in to door-out time within 30 minutes.

For all 4 primary outcomes, the additional time-to-treatment metrics and in-hospital mortality, generalized estimating equations (GEEs) were used to calculate odds ratios (ORs), accounting for within-hospital clustering, using robust sandwich estimators for the variance. Four models were fitted, including unadjusted, age-adjusted, multivariable-adjusted (adjusting for age, clinical status on presentation, and underlying comorbidities), and extended multivariable-adjusted (adjusting for age, clinical status on presentation, underlying comorbidities, insurance, and SVI). Variances of these equations were calculated using sandwich estimates. Elements of clinical status on presentation factored into adjusted models included cardiac arrest before arrival, cardiogenic shock on presentation, heart failure on presentation, heart rate on presentation, and systolic blood pressure on presentation. Underlying comorbidities factored into adjusted models included known history of diabetes, peripheral artery disease, hypertension, myocardial infarction or cerebrovascular disease, baseline serum creatinine level, baseline left ventricular ejection fraction, previous PCI, previous coronary artery bypass grafting, and smoking status. Additional sensitivity analysis using unadjusted GEE models was performed to explore the effect of hospital characteristics, including teaching hospital status, critical care access status, and size, on race- or ethnicity-based differences in attainment of time-based process metrics.

For multivariable analysis (including process metrics and survival models), inclusion was limited to patients admitted between January 1, 2019, and December 31, 2021, as the capture of crucial covariates, including cardiac arrest before arrival, heart failure on FMC, and cardiogenic shock on arrival, was incomplete (with a high degree of missingness of these covariates) before 2019. Missingness in continuous variables was managed by single imputation of the median value. Missingness in categorical variables was managed by imputation of the mode, application of K-nearest neighbors imputer, or multiple imputation by chained equations. All study results were generated separately for men and women. Statistical significance was assessed at $\alpha<0.05$. Data analysis was performed using the open-source software R (version 4.2.0; R Foundation for Statistical Computing) and Python (3.7.16) by the AHA Data Science Analytics team.

RESULTS

Patient Baseline Characteristics and Hospital Characteristics

A total of 178 062 patients, including 52 293 (29.4%) women and 125 769 (70.6%) men, were admitted to 626 GWTG-CAD hospitals between January 1, 2015, and December 31, 2021. Baseline patient demographic characteristics, medical history, transportation mode, and clinical condition on FMC are shown for both sexes (Table 1). Among women (Table 1), 79.9% were identified as non-Hispanic White, 5.7% as Hispanic White, and 14.4% as Black. Average age at presentation with STEMI was significantly lower for Black women (61 years) or Hispanic White women (65 years) compared with non-Hispanic White women (67 years). Compared with non-Hispanic White women, Hispanic White women had higher rates of diabetes and end-stage kidney disease requiring dialysis, and were less likely to be transported by EMS to the hospital. Compared with non-Hispanic White women, Black women had higher rates of comorbid conditions, including cerebrovascular disease, diabetes, need for dialysis, hypertension, and active or previous tobacco use. SVI was lowest (ie, socioeconomic status was highest) in non-Hispanic White women. Among men (Table 1), 81.9% were identified as non-Hispanic White, 7.2% as Hispanic White, and 10.9% as Black. Average age at presentation with STEMI was significantly lower for Black men (58 years) or Hispanic White men (58 years) compared with non-Hispanic White men (62 years). Compared with non-Hispanic White men, Hispanic White men had higher rates of diabetes. Compared with non-Hispanic White men, Black men had higher rates of cerebrovascular disease, diabetes, and hypertension, and were more likely to be active or previous smokers. SVI was lowest in non-Hispanic White men.

Prehospital Care and In-Hospital Treatment

Among both women and men, Hispanic White patients were less likely to receive prehospital ECGs and to undergo EMS prehospital (field) activation of the cardiac catheterization laboratory for STEMI (Table 1). Non-Hispanic White patients were more likely to be referred to a cardiac rehabilitation program at hospital discharge. Care was similar across race and ethnic groups in many time-independent indices of in-hospital care, including rates of performance of primary PCI for STEMI during hospitalization

Table 1. Baseline Characteristics

Characteristics	Women				Men			
	Non-Hispanic White	Hispanic White	Black	Overall	Non-Hispanic White	Hispanic White	Black	Overall
No. (% of overall)	41 810 (80.0)	2967 (5.6)	7516 (14.3)	52 293	102 994 (81.9)	9087 (7.2)	13 688 (10.9)	125 769
Age, y	67 (19)	65 (19)*	61 (18)*	66 (19)	62 (16)	58 (15)*	58 (16)*	61 (16)
Medical history								
Cerebrovascular disease	5.8	4.9	8.4*	6.1	4.1	3.0*	5.9*	4.2
Diabetes	18.3	32.9*	28.1*	20.5	15.6	22.6*	20.9*	16.7
Currently on dialysis	0.7	2.3*	2.4*	1.0	0.4	1.4*	1.7*	0.7
Hypertension	43.1	46.8*	53.0*	44.7	39.7	37.6*	47.2*	40.4
Heart failure	4.4	4.3	7.0*	4.8	3.2	3.3	5.4*	3.4
Peripheral artery disease	3.6	3.4	4.4*	3.7	3	2.1*	3.3	2.9
Previous MI	7.6	7.8	9.8*	7.9	9.9	7.3*	10.8*	9.8
Previous CABG	2.1	2.6	2.0	2.1	3.3	2.0*	2.3*	3.1
Previous PCI	8.7	9	9.6	8.8	11.6	8.6*	11.8*	11.4
Active or previous smoking	37.2	24.7*	39.9*	36.9	37.8	32.9*	46.7*	38.4
Presenting patient characteristics								
Cardiac arrest before arrival	3.2	3	3.6	3.3	4.0	3.5*	4.4*	4.0
Heart failure on FMC	5.6	5.5	6.8*	5.8	4.6	4.5	6.0*	4.7
Cardiogenic shock on FMC	5.0	5.1	5.2	5.0	4.3	4.4	4.8*	4.4
Heart rate	80 (30)	80 (29)	81 (28)*	80 (29)	79 (28)	80 (29)*	80 (29)*	79 (28)
Systolic blood pressure	142 (47)	141 (50)	143 (49)*	142 (47)	145 (44)	144 (46)	144 (46)	145 (44)
Initial serum creatinine	0.9 (0.4)	0.9 (0.5)	0.9 (0.4)*	0.9 (0.4)	1.1 (0.4)	1.0 (0.4)*	1.2 (0.4)*	1.1 (0.4)
Documented LVEF, %								
<30	8.1	9.6*	9.8	8.4	8.5	9.9*	12.2*	9.0
30–39	13.6	15.2*	13.3	13.6	13.8	16.4*	14.4*	14.0
40–49	20.7	21.7	18.3	20.4	23.4	24.5*	20.6*	23.1
50–59	29.3	26.8*	28.7	29.1	31.6	29.0*	28.7*	31.1
60–69	18.6	17.4	20.1*	18.8	15	13.7*	15.9*	15
>70	0.9	1.2	1.2*	0.9	0.5	0.4	0.7*	0.5
Transportation mode to first facility								
EMS: air	1.3	0.5*	0.6*	1.2	1.5	0.6*	0.6*	1.3
EMS: ground ambulance	50.2	47.6*	56.4*	50.9	44.5	42.9*	53.0*	45.3
Walk-in	23.0	30.2*	23.6	23.5	27.5	34.9*	25.9*	27.8
Transferred from another facility	23.2	19.9*	17.6*	22.2	24.3	20.4*	18.5*	23.4
Prehospital care								
Prehospital ECG obtained (EMS only)	86.4	79.8*	82.1*	85.3	87.9	83.2*	85.1*	87.3
Percent catheterization laboratory activations that were prehospital	49.9	42.2*	41.7*	48.3	49	40.9*	44.1*	47.9
Reperfusion therapy in STEMI								
Thrombolytics	1.2	1.1	0.7*	1.1	1.1	0.9	0.8*	1.0
PCI	85.4	84.7	85.1	85.3	89.1	90.0*	86.5*	88.9
PCI indication (% of PCI from row above)								
Primary PCI for STEMI	89.9	96.3*	91.2*	90.7	91.4	91.5	92.7*	91.5
PCI (stable after thrombolysis)	1.3	0.9	0.8*	1.2	1.3	1.1	0.7*	1.2
PCI (unstable >12 hours symptom onset)	2.9	2.4	3.5*	3	2.2	2.4	2.6*	2.2

(*Continued*)

Table 1. Continued

Characteristics	Women				Men			
	Non-Hispanic White	Hispanic White	Black	Overall	Non-Hispanic White	Hispanic White	Black	Overall
PCI (stable > 12 hours of symptom onset)	1.3	1.8	1.5	1.4	1.1	1.5*	1.1	1.1
Rescue PCI (after failed thrombolysis)	2	0.9*	0.8*	1.7	2.3	1.5*	1.0*	2.1
Other	0.4	0.1*	0.3	0.4	0.3	0.3	0.4	0.3
No PCI and no thrombolysis	10.4	12.6*	11.2*	10.6	7.3	7.6	10.2*	7.7
Hospitalization								
LVEF assessed this admission	68.6	74.2*	70.4*	69.2	69.2	73.9*	70.8*	69.7
CABG this admission	3.8	3.8	2.0*	2.7	3.9	4.5*	2.6*	3.8
Cardiac rehabilitation referral	68	61.1*	66.6*	67.4	72.5	65.6*	67.5*	71.5
Medications prescribed at discharge								
ACE inhibitors	38.8	41.3*	39.4	39.1	46.3	52.5*	45.7	46.7
ARB	15.3	16	19.1*	15.9	14.1	12.8*	15.6*	14.2
Aspirin	79.1	78.8	80.2*	79.2	83.4	85.0*	81.8*	83.4
Beta-blocker	76.6	75.3	77.9*	76.7	80.4	81.6*	79.3*	80.4
Clopidogrel	34.6	39.0*	35.1	34.9	31.6	39.9*	34.3*	32.5
Prasugrel	6.7	4.5*	6.3	6.5	10.1	7.1*	8.9*	9.8
Ticagrelor	37.3	34.0*	37.8	37.1	50.0	36.5*	37.5*	40.3
Prasugrel or ticagrelor	43.9	38.3*	44.1	43.6	51.0	43.6*	46.3*	50.0
P2Y12 inhibitor	78.2	77.2	78.9	78.2	82.3	83.1	80.1*	82.1
Statin	78.4	79	80.8*	78.8	83.3	85.5*	82.6*	83.4
PCSK9 inhibitor	0.2	0.1	0.2	0.2	0.2	0.1	0.1*	0.2
Insurance								
Medicare	32.9	27.3*	25.4*	31.5	23	15.9*	17.4*	21.9
Medicaid	4.8	10.5*	10.1*	5.9	4.5	9.6*	10.3*	5.5
Federal insurance (VA/CHAMPVA/Tricare)	0.3	0.1	0.3	0.3	1.1	0.5*	1.4*	1.1
Private	18.8	15.6*	17.5*	18.4	25.6	21.9*	20.6*	24.8
Self-pay/no insurance	3.2	8.0*	5.0*	3.7	4.6	11.8*	8.4*	5.5
Other/not documented	0.3	0.7*	0.4*	0.3	0.4	0.9*	0.9*	0.5
Social vulnerability index	0.48 (0.40)	0.68 (0.31)*	0.66 (0.33)*	0.52 (0.38)	0.47 (0.40)	0.68 (0.33)*	0.63 (0.35)*	0.52 (0.39)

Values are n (%), median (interquartile range), or percentage. ACE indicates angiotensin-converting enzyme; ARB, angiotensin receptor blocker; CABG, coronary artery bypass graft surgery; CHAMPVA, Civilian Health and Medical Program of the Department of Veterans Affairs; EMS, emergency medical services; FMC, first medical contact; LVEF, left ventricular ejection fraction; MI, myocardial infarction; PCI, percutaneous coronary intervention; and STEMI, ST-segment–elevation myocardial infarction.

*$P<0.05$ compared with non-Hispanic White (reference group).

and prescription of guideline-directed medications at the time of discharge. Notable differences include lower rates of discharge on newer-generation P2Y12 platelet inhibitors (prasugrel or ticagrelor) for Hispanic White patients and lower rates of discharge on aspirin, beta-blockers, or newer-generation P2Y12 platelet inhibitors for Black men.

Race- and Ethnicity-Based Variations in STEMI Process Metrics

Timed process metrics in STEMI care are shown for women and men (Table 2; Figure 2A through 2D; Figure S1A through S1D). In both women and men, several process metrics were less likely to be achieved among Hispanic White or Black patients compared with non-Hispanic White patients, including prehospital ECG among EMS-treated patients (Figure 2A), door-to-ECG time ≤10 minutes (Figure 2B), door-to-device time ≤90 minutes (Figure 2C), FMC-to-PCI time within 90 minutes (Figure 2D), ED length of stay ≤30 minutes (Figure S1A), and FMC-to-catheterization laboratory time ≤20 minutes (Figure S1B). Compared with non-Hispanic White patients, Hispanic White or Black patients were less likely to be treated within recommended door-to-fibrinolysis times ≤30 minutes (Figure S1C). For patients with STEMI who were transferred from

Table 2. STEMI Process Metrics

Process metrics	Women				Men			
	Non-Hispanic White	Hispanic White	Black	Overall	Non-Hispanic White	Hispanic White	Black	Overall
Total n (% of overall)	41 810 (80.0)	2967 (5.6)	7516 (14.3)	52 293	102 994 (81.9)	9087 (7.2)	13 688 (10.9)	125 769
Time to ECG								
No.	12 276	1135	2400	15 811	32 601	3479	4407	40 487
Arrival to ECG ≤10 minutes if no prehospital ECG, %	65.8	58.2*	59.1*	64.2	76.2	70.2*	66.1*	74.6
ED length of stay								
No.	28 523	2238	5521	36 282	69 775	6948	9859	86 582
Median minutes (IQR)	37 (39)	40 (42)*	42 (48)*	38 (41)	34 (34)	37 (36)*	39 (40)*	35 (34)
≤30 minutes, %	39.8	35.9*	32.8*	38.5	43.4	40.6*	37.0*	42.5
Door-to-device time								
No.	34 747	2445	6200	43 392	89 444	8000	11 548	108 992
Median minutes (IQR)	57 (41)	64 (43)*	65 (46)*	58 (43)	54 (39)	60 (39)*	62 (41)*	56 (40)
≤90 minutes, %	82.4	77.5*	74.3*	80.9	85.4	82.5*	79.6*	84.6
FMC-to-catheterization laboratory activation (nontransferred, EMS)								
No.	11 137	778	2108	14 023	25 642	2177	3725	31 544
Median minutes (IQR)	28 (27)	30 (28)	31 (31)*	29 (27)	25 (25)	26 (24)	27 (26)*	26 (25)
≤20 minutes, %	33.2	29.7	26.1*	31.9	39	36.0*	33.6*	38.2
EMS FMC-to-PCI time								
No.	18 061	1153	3531	22 745	41 364	3343	6125	50 832
Median minutes (IQR)	92 (42)	93 (41)	98 (47)*	93 (43)	86 (39)	86 (38)	91 (42)*	87 (39)
≤90 minutes, %	48.8	46.8	40.6*	47.4	56.5	56.6	49.6*	55.7
≤120 minutes; direct presenters with transport time ≥45 minutes, %	1.9	1.0*	0.5*	1.7	2.0	1.3*	0.9*	1.8
≤120 minutes for transfers-in, %	1.2	0.9	0.8*	1.1	1.4	1.0	1.1	1.3
Door-to-fibrinolysis time								
No.	497	24	59	580	1143	82	136	1361
Median minutes (IQR)	36 (43)	67 (47)	44 (49)	36 (45)	33 (39)	52 (61)*	41 (62)*	34 (43)
≤30 minutes, %	42.1	20.8	35.6	40.5	45.5	28.1*	36.0*	43.5
Door-in to door-out time								
No.	8987	488	1189	10 664	23 362	1557	2268	27 187
Median minutes (IQR)	62 (61)	69 (74)*	73 (83)*	63 (63)	55 (50)	60 (54)*	66 (69)*	56 (52)
≤30 minutes, %	10.8	7.6*	7.3*	10.2	13.8	11.3*	9.3*	13.3
≤45 minutes, %	30.8	23.8*	23.0*	29.6	37.0	32.9*	27.3*	36.0

ED indicates emergency department; EMS, emergency medical services; FMC, first medical contact; IQR, interquartile range; PCI, percutaneous coronary intervention; and STEMI, ST-segment–elevation myocardial infarction.

*$P<0.05$ compared with non-Hispanic White (reference group).

STEMI-referring to STEMI-receiving centers, the proportion of patients transferred within guideline-recommended door-in to door-out time was lower for Hispanic White or Black patients (Figure S1D).

In unadjusted GEE models, odds of achieving guideline-recommended FMC-to-PCI times were lower for Black patients compared with non-Hispanic White patients ($P<0.01$; Table 3). In addition, Hispanic White or Black patients had lower odds of being treated within guideline-recommended time intervals for arrival to ECG and door-to-device time compared with non-Hispanic White women and men ($P<0.01$; Table 3). Hispanic White or Black patients also had lower odds of a prehospital ECG being obtained by EMS. All associations remained statistically significant in multivariable GEE models accounting for age, comorbidities, acuity of presentation, insurance status, and socioeconomic status (all $P<0.05$).

Effects of Hospital Characteristics

Key characteristics of GWTG-CAD hospitals included in the study are summarized in Table S1A and S1B. There was no association between race or ethnicity

and treatment at a 24-hour PCI-capable center. Black patients were more likely than patients from other racial or ethnic groups to undergo treatment at a teaching hospital and were most likely to undergo treatment at large hospitals with ≥500 beds. Sensitivity analyses were performed to explore the effect of hospital characteristics on race- or ethnicity-based differences in attainment of time-based process metrics (Table S2A and S2B). Unadjusted GEE models demonstrated similar race or ethnicity disparities in the achievement of process metrics across strata of teaching hospital status, critical care access status, and hospital size (Table S2A and S2B).

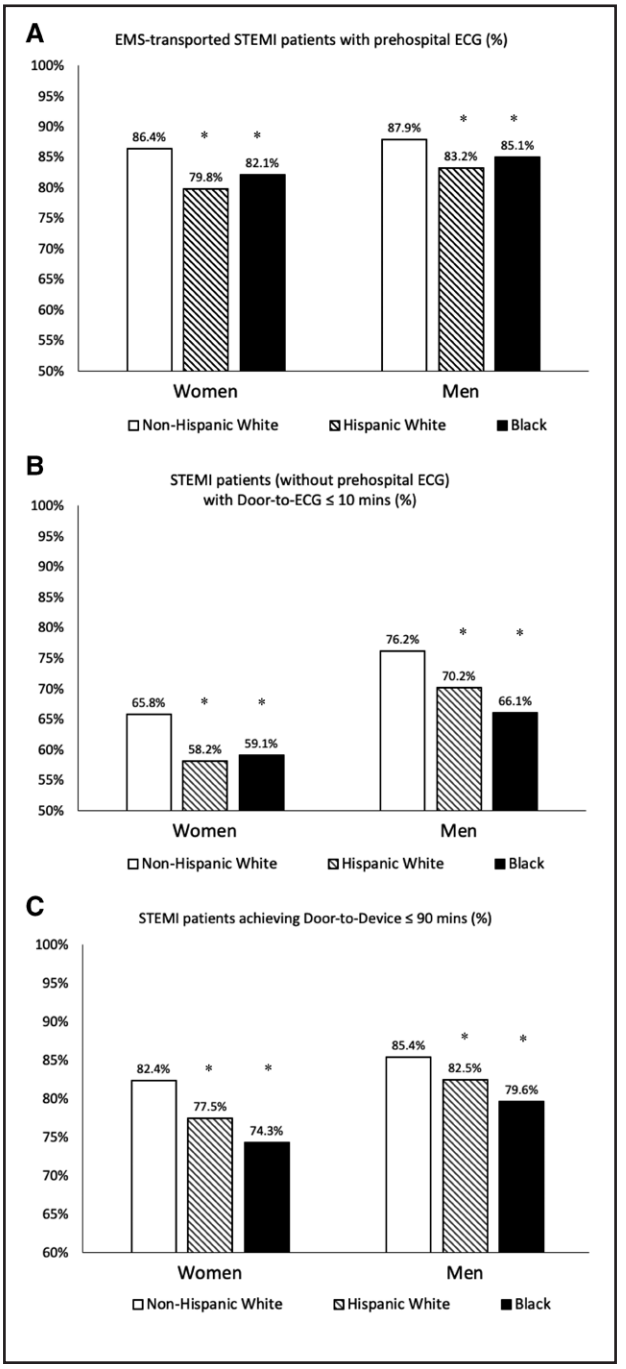

Figure 2. Rate of attainment of STEMI process (timed) metrics stratified by race and ethnicity and sex.
A, Emergency medical services (EMS)–transported patients with ST-segment–elevation myocardial infarction (STEMI) with prehospital ECG obtained. **B**, Door-to-ECG time within 10 minutes in patients with STEMI without prehospital ECG. **C**, Door-to-device time ≤90 minutes. **D**, First medical contact (FMC) to percutaneous coronary intervention (PCI) ≤90 minutes. *P<0.05 when comparing race or ethnic group with reference group of non-Hispanic White (within the same sex group).

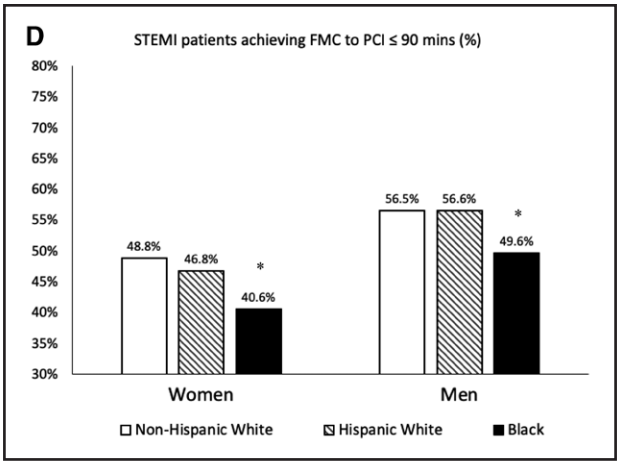

Figure 2 Continued.

In-Hospital Mortality

In-hospital mortality was analyzed in 95 738 patients (28 353 women and 67 385 men) admitted between January 1, 2019, and December 31, 2021 (capture of crucial covariates was incomplete before 2019). The unadjusted in-hospital mortality rate for the entire study cohort was 6.6%, with significant differences across race and ethnicity groups (Table 4). Univariable GEE models demonstrated higher odds of in-hospital death among Hispanic White compared with non-Hispanic White women (OR, 1.31 [95% CI, 1.10–1.57]; P<0.01). These higher odds persisted after adjustment for age, underlying comorbidities, acuity of presentation, insurance status, and SVI (OR, 1.39 [95% CI, 1.12–1.72]; P<0.01; Table 4). Age-adjusted models demonstrated a slightly higher rate of in-hospital mortality in Black women, but these associations were attenuated and not significant after adjustment for comorbidities, insurance, and socioeconomic status (P=0.10; Table 4). In men, unadjusted GEE models did not demonstrate statistically significant associations between race or ethnicity and likelihood of in-hospital death. Age-adjusted models demonstrated a higher rate of in-hospital death in Black or Hispanic White men (P<0.01). These differences did not persist after further adjustment for comorbidities, acuity of presentation, insurance status, and SVI (P>0.05; Table 4).

Table 3. Models for STEMI Process Metrics: GEE With Hospital as Clustering Variable

Models for STEMI process metrics	Women								Men							
	Unadjusted		Adjusted for age		Adjusted for age and medical condition*		Adjusted for age, medical condition, insurance, and SVI†		Unadjusted		Adjusted for age		Adjusted for age and medical condition*		Adjusted for age, medical condition, insurance, and SVI†	
Arrival to ECG ≤10 minutes if no prehospital ECG																
Non-Hispanic White	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Hispanic White	0.75 (0.62–0.90)	0.0023	0.74 (0.61–0.89)	0.0013	0.77 (0.64–0.93)	0.0070	0.77 (0.64–0.93)	0.0064	0.69 (0.61–0.79)	<0.0001	0.68 (0.60–0.77)	<0.0001	0.70 (0.61–0.80)	<0.0001	0.72 (0.63–0.82)	<0.0001
Black	0.80 (0.70–0.92)	0.0012	0.75 (0.65–0.86)	<0.0001	0.79 (0.69–0.90)	0.0007	0.80 (0.70–0.93)	0.0025	0.64 (0.57–0.71)	<0.0001	0.62 (0.55–0.69)	<0.0001	0.64 (0.57–0.71)	<0.0001	0.66 (0.59–0.74)	<0.0001
Door-to-device time ≤90 minutes																
Non-Hispanic White	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Hispanic White	0.76 (0.65–0.90)	0.0009	0.76 (0.64–0.89)	0.0006	0.77 (0.66–0.91)	0.0018	0.78 (0.66–0.93)	0.0047	0.82 (0.72–0.94)	0.0037	0.80 (0.70–0.92)	0.0012	0.81 (0.70–0.93)	0.0033	0.82 (0.71–0.95)	0.0097
Black	0.65 (0.57–0.73)	<0.0001	0.63 (0.56–0.71)	<0.0001	0.65 (0.57–0.73)	<0.0001	0.66 (0.58–0.74)	<0.0001	0.67 (0.61–0.73)	<0.0001	0.65 (0.59–0.71)	<0.0001	0.66 (0.61–0.73)	<0.0001	0.68 (0.62–0.74)	<0.0001
EMS FMC-to-PCI time ≤90 minutes																
Non-Hispanic White	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Hispanic White	0.96 (0.79–1.17)	0.70	0.93 (0.76–1.14)	0.47	0.94 (0.77–1.16)	0.56	0.99 (0.81–1.21)	0.93	1.12 (0.98–1.28)	0.095	1.07 (0.93–1.22)	0.36	1.08 (0.94–1.25)	0.28	1.15 (1.00–1.32)	0.056
Black	0.73 (0.63–0.84)	<0.0001	0.67 (0.58–0.77)	<0.0001	0.67 (0.58–0.77)	<0.0001	0.69 (0.60–0.80)	<0.0001	0.78 (0.70–0.87)	<0.0001	0.72 (0.65–0.80)	<0.0001	0.72 (0.65–0.80)	<0.0001	0.77 (0.65–0.80)	<0.0001
Prehospital ECG obtained (EMS only)																
Non-Hispanic White	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Hispanic White	0.64 (0.44–0.93)	0.0198	0.62 (0.43–0.91)	0.0144	0.61 (0.42–0.90)	0.0126	0.66 (0.44–0.97)	0.0353	0.65 (0.47–0.89)	0.0083	0.64 (0.46–0.88)	0.0068	0.62 (0.44–0.88)	0.0067	0.65 (0.46–0.93)	0.0183
Black	0.73 (0.61–0.87)	0.0003	0.70 (0.58–0.83)	<0.0001	0.70 (0.59–0.84)	0.0001	0.74 (0.62–0.88)	0.0008	0.79 (0.69–0.91)	0.0014	0.77 (0.67–0.89)	0.0005	0.77 (0.66–0.89)	0.0006	0.81 (0.70–0.94)	0.0059

EMS indicates emergency medical services; FMC, first medical contact; GEE, generalized estimating equation; PCI, percutaneous coronary intervention; Ref, reference group for model statistics; STEMI, ST-segment–elevation myocardial infarction; and SVI, social vulnerability index.

*Medical condition variables: diabetes, cardiac arrest before arrival, heart failure on FMC, and cardiogenic shock on FMC.

†SVI based on zip code.

DISCUSSION

STEMI systems of care have revolutionized the management of STEMI in the United States,[4] but whether contemporary systems of care have mitigated previously well-documented race-based disparities in STEMI outcomes[7,11,12,15,20] is uncertain. This analysis included 178 062 patients hospitalized with STEMI between 2015 and 2021 and demonstrated that important race- or ethnicity-based disparities persist in STEMI outcomes. In analyses performed separately in women and men, Hispanic White and Black patients had lower odds of having a prehospital ECG obtained and achieving several time-sensitive process metrics (including door-to-ECG, arrival-to-PCI, and FMC-to-PCI times), even after adjustment for acuity of illness on presentation, comorbid conditions, insurance status, and socioeconomic status as measured by the SVI. Furthermore, sensitivity analyses stratified by hospital type (bed capacity, teaching status, and critical access status) did not demonstrate meaningful variations in race- or ethnicity-based disparities in achievement of timed STEMI process metrics. For the outcome of in-hospital mortality, Hispanic White women (but not Black women) had higher adjusted odds of in-hospital death compared with non-Hispanic White women. There were no differences in adjusted mortality rate in Hispanic White or Black men compared with non-Hispanic White men.

Table 4. STEMI In-Hospital Mortality Rates and Mortality Models (Using GEE With Hospitals as Clustering Variable)

Groups	Raw mortality rate, %	Unadjusted		Adjusted for age		Adjusted for age and medical condition*		Adjusted for age, medical condition, insurance, and SVI†	
		OR (95% CI)	*P* value	OR (95% CI)	*P* value	OR (95% CI)	*P* value	OR (95% CI)	*P* value
Women									
Non-Hispanic White	9.1	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Hispanic White	11.6	1.31 (1.10–1.57)	0.0032	1.47 (1.24–1.74)	<0.0001	1.49 (1.21–1.83)	0.0002	1.39 (1.12–1.72)	0.0029
Black	8.5	0.93 (0.82–1.06)	0.27	1.18 (1.03–1.34)	0.0160	0.91 (0.78–1.07)	0.26	0.88 (0.74–1.03)	0.104
Men									
Non-Hispanic White	5.8	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Hispanic White	5.9	1.02 (0.88–1.17)	0.8300	1.19 (1.03–1.37)	0.0207	1.12 (0.94–1.34)	0.21	0.99 (0.82–1.18)	0.88
Black	6.2	1.08 (0.97–1.21)	0.15	1.36 (1.22–1.52)	<0.0001	1.04 (0.92–1.18)	0.50	0.96 (0.85–1.09)	0.51

GEE indicates generalized estimating equation; OR, odds ratio; Ref, reference group for model statistics; STEMI, ST-segment–elevation myocardial infarction; and SVI, social vulnerability index.

*Medical condition variables: cardiac arrest before arrival, cardiogenic shock on presentation, heart failure on presentation, heart rate on presentation, systolic blood pressure on presentation, diabetes, peripheral artery disease, hypertension, myocardial infarction, cerebrovascular disease, baseline serum creatinine, baseline left ventricular ejection fraction, previous percutaneous coronary intervention, previous coronary artery bypass grafting, and smoking status.

†SVI based on zip code.

Two previous GWTG-CAD analyses published in 2010 and 2013 demonstrated longer door-to-balloon times and lower odds of achieving guideline STEMI door-to-balloon time metrics for Black or Hispanic patients compared with non-Hispanic White patients.[21,22] Our study adds to the existing literature by demonstrating disparities in the attainment of an expanded set of STEMI systems of care quality metrics, including during the prehospital phase of care (eg, EMC with documented FMC time), in a contemporary and larger patient population and adjusting for insurance status and SVI. In the previously mentioned 2013 door-to-balloon study by Cavender et al,[21] adjusted analyses suggested that race- or ethnicity-based disparities were not evident in women. In addition, the 2010 study by Cohen et al[22] reported temporal improvements in the attainment of composite measures of evidence-based STEMI care across all race and ethnic groups. In contrast, our analysis revealed significant and persistent race- or ethnicity-based differences in STEMI process metrics in both women and men and in in-hospital mortality in Hispanic women compared with non-Hispanic White women. Taken together, these new findings suggest stagnation in previous progress toward eliminating race- or ethnicity-based disparities in STEMI care.

Previous studies have suggested that differences in insurance status or socioeconomic measures may partially or fully explain observed racial disparities in STEMI outcomes.[10,12,21,23–25] Our study showed attenuation of age-adjusted mortality differences after further adjustment for clinical factors, insurance status, and SVI in Black and Hispanic White men compared with non-Hispanic White men and in Black women compared with non-Hispanic White women. However, mortality differences persisted in Hispanic White women compared with non-Hispanic White women, and race disparities in both women and men persisted in nearly all process metrics even after adjustment for clinical factors, insurance status, and SVI. Variations in treatment recommendations made by individual providers on the basis of patient race have been reported, even in the setting of identical clinical presentations.[26,27] Therefore, it is tempting to conclude that racial bias within STEMI systems of care might explain observed disparities in STEMI outcomes in our study. However, although Hispanic White and Black women and men were less likely to meet time-to-treatment goals in our study, they were more likely to achieve other STEMI performance measures (eg, left ventricular ejection fraction assessed during STEMI admission) or as likely to achieve other measures (overall rate of PCI, rate of discharge of several recommended medication classes) compared with non-Hispanic White patients.

Robustly designed interventions to improve system-level performance on STEMI metrics have not been uniformly effective across the spectra of race and ethnicity and sex.[25,28] An analysis of data from 23 809 patients enrolled in the STEMI Systems Accelerator Project from 2012 through 2014 explored the effect of interventions to optimize implementation of systems of STEMI care across multiple regions.[28] The authors reported improvements in the attainment of guideline targets for FMC-to-device times for men (but not women) and for White (but not Black) patients. These analyses did not include

Hispanic White patients and were not rigorously adjusted for insurance status and SVI. Nevertheless, findings like these highlight the need for dedicated interventions that are specifically aimed at improving the quality of STEMI care for marginalized groups of patients.

This study has important limitations. Limited English-language proficiency (a variable not captured in the GWTG-CAD registry) has been reported to contribute to worse outcomes in patients with STEMI and in other emergency conditions.[29,30] In addition, mistrust of the US health care system by non-White individuals (also not collected) may lead to delays in providing consent or participating in shared decision-making for procedures.[26,31] Large-scale registries (such as the GWTG-CAD registry) that are powered to discern differences in outcomes in process and hard outcomes (such as death) are often lacking in data elements that probe into these important race-specific barriers to equitable care. Solutions may include embedding within these registries the opportunity for selected centers to participate in additional data collection elements specific to racial disparities in a subset of patients. Ascertainment of race and ethnicity recorded in electronic medical records reflects patient self-identified race and ethnicity in many but not all cases, and often does not completely or accurately classify individuals who belong to more than one racial group. As a socioeconomic measure, we used SVI, which assesses vulnerability at the census-tract level; however, this may not provide adequate granularity to comprehensively represent each individual patient's level of educational attainment, income, or other unique circumstances. The analysis only included hospitals that voluntarily participate in the GWTG-CAD program, and therefore may not be representative of STEMI care in all parts of the United States.

In conclusion, this study found that significant race- or ethnicity-based disparities persist in contemporary STEMI systems of care in the achievement of time-to-treatment goals, process metrics, and in in-hospital mortality. Associations were evident in both male and female populations, and persisted despite rigorous adjustment for acuity of presentation, comorbidities, insurance, and SVI. Reasons for these disparities are complex and likely multifactorial. STEMI systems of care can evolve to embed research specifically designed to probe into the underpinnings of racial disparities, which is an essential step before these disparities can be eliminated.

ARTICLE INFORMATION

Received May 7, 2023; accepted June 13, 2023.

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Sources of Funding

This analysis was funded by an American Heart Association young investigators grant awarded to Drs Fernandes and Osho.

Disclosures

None.

Supplemental Material

Tables S1 and S2
Figure S1

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