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Persistent Racial and Sex Disparities in Outcomes After Coronary Artery Bypass Surgery:

A Retrospective Clinical Registry Review in the Drug-eluting Stent Era

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Abstract

Objective: The purpose of this study was to assess the temporal trends in 30-day mortality by race group for patients undergoing coronary artery bypass grafting (CABG) between 2011 and 2018 and to investigate the effect of race and sex on postoperative outcomes after CABG.

Summary Background Data: Cardiovascular diseases remain a leading cause of death in the United States with studies demonstrating increased morbidity and mortality for black and female patients undergoing surgery. In the post drug-eluting stent era, studies of racial disparities CABG are outdated.

Methods: We performed a retrospective analysis of the Society for Thoracic Surgeons database for patients undergoing CABG between 2011 and 2018. Primary outcome was 30-day mortality. Secondary outcomes included postoperative length of stay, surgical site infection, sepsis, pneumonia, stroke, reoperation, reintervention, early extubation, and readmission.

Results: The study population was comprised of 1,042,506 patients who underwent isolated CABG between 2011 and 2018. Among all races, Black patients had higher rates of preoperative comorbidities. Compared with White patients, Black patients had higher overall mortality (2.76% vs 2.19%, $P < 0.001$). On univariable regression, Black patients had higher rates of death, infection, pneumonia, and postoperative stroke compared to White patients. On multivariable regression, Black patients had higher odds of 30-day mortality compared to white patients [odds ratio (OR) = 1.11, 95% confidence interval (CI) 1.05–1.18]. Similarly, female patients had higher odds of death compared to males (OR = 1.26, 95% CI 1.21–1.30).

Conclusions: In the modern era, racial and sex disparities in mortality and postoperative morbidity after coronary bypass surgery persist with Black patients and female patients consistently experiencing worse outcomes than White male patients. Although there may be

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unknown or underappreciated biological mechanisms at play, future research should focus on socioeconomic, cultural, and multilevel factors.

Keywords

CABG; coronary artery bypass; disparities; sex; mortality; race

Cardiovascular diseases remain a leading cause of death in the United States and globally.¹ Life-saving interventions continue to evolve to improve mortality, yet equitable access to diagnostic and effective treatments like angioplasty, stents, and surgery, especially coronary artery bypass grafting (CABG), continues to be problematic for certain groups. In addition, many studies have demonstrated that morbidity and mortality for Black patients undergoing CABG is higher when compared to other groups.^{2–4} National clinical registries with validated risk-adjustment methodologies like the Society for Thoracic Surgeons (STS) national database provide valuable sources of data to evaluate these disparities. Hartz et al demonstrated that race and sex were both independent risk factors of adverse outcomes following CABG.⁵ Research has demonstrated that Black race is consistently found to be an independent predictor of mortality for CABG for all but the highest-risk patients.⁶

Others have examined the role of various factors and how they relate to racial disparities in cardiac surgery and CABG. For example, Khera et al offered a fishbone diagram to demonstrate root causes of higher mortality in Black patients, illustrating core factors such as biological differences, socioeconomic factors, differences in hospital quality, baseline health status, cultural differences, and poor provider quality.⁷ Similarly, Rangrass et al suggested that even after controlling for socioeconomic status and hospital quality—which explained >50% of their observed disparity—non-white patients still had a higher mortality among patients undergoing CABG.⁸ Additional investigators have suggested that Black patients seek treatment for other cardiovascular care, such as heart transplantation, at lower-quality centers with higher-risk adjusted mortality.⁹ Furthermore, the impact of inadequate insurance coverage, absence of adequate medication coverage, or public insurance might be contributing to Black patients' poor outcomes or being treated at lower-quality programs.¹⁰

The current landscape of racial and sex disparities in health care, in particular CABG, is overdue for a contemporary update, particularly in the post-drug-eluting stent (DES) and Affordable Care Act (ACA) era. We hypothesized that racial and sex disparities persist despite improvements in general access—for example, adoption of the ACA—and guideline-directed care over shorter periods of follow-up (ie, 5 years). The goal of this study was 2-fold: to assess the temporal trends in 30-day mortality by race group after CABG; and investigate the effect of race and sex on postoperative outcomes after CABG in the DES era.

METHODS

Data Source

We performed a retrospective analysis of the STS database for Adult Cardiac Surgery for patients undergoing CABG between 2011 and 2018. The STS database is the largest database of thoracic surgery in the world, and it captures detailed information on

patients undergoing cardiac surgery most typically by surgeons in a group practice or at academic hospitals.¹¹ Although the database itself encompasses the spectrum of cardiac surgery operations (CABG, aortic, mitral, tricuspid valve procedures, aortic procedures, arrhythmia procedures, and so on), this study was limited to patients undergoing isolated CABG. The database itself collects multiple data points including standard demographic information (age, race, sex, height, weight, among others), as well as multiple data points on preoperative, operative, and postoperative factors. The database includes participation of approximately 3,800 surgeons and anesthesiologists, and previous research suggests penetrance of approximately 95% of all coronary artery bypass operations that are captured by Centers for Medicare and Medicaid Services.¹¹ Importantly, the database is a clinical registry, distinct from other databases that are more administrative in nature (eg, utilizing only claims data), and is supported by clinically trained staff to abstract and input clinical data. Race is based on patient or family self-report. The STS also has a predicted risk score calculator to predict morbidity and mortality.¹²

Inclusion Criteria

Beginning with version 2.73 of the STS database, we included patients who underwent isolated CABG between 2011 and 2018. We chose to start with 2011 as the beginning date because this was the beginning of version 2.73 and approximately 10 years after introduction of DESs.

Exclusion Criteria

We excluded patients or centers that report data from a non-US site, as this project is primarily concerned with disparities in the United States. Patients with missing data on race were also excluded.

Primary and Secondary Study Outcomes

Primary exposure for this review was race (categorized as White, Black, Black+, Other), where Black+ indicates a patient who reported Black race and an additional racial category (eg, Black + White, Black + Asian). Primary outcome was 30-day mortality. Secondary outcomes included postoperative length of stay, surgical site infection, sepsis, pneumonia, stroke, reoperation, reintervention, early extubation, and readmission.

Statistical Analyses

Baseline characteristics between racial groups were compared. Specifically, categorical data were expressed as whole number (n) and percentages and compared by χ^2 analysis. Given a focus on race, pair-wise comparisons were made for categorical variables (eg, Black vs White, Black vs Black+, Black vs other). A global *P* value has been reported unless otherwise indicated. Continuous data were expressed as means with associated 95% confidence intervals (CIs). To compare continuous variables, analysis of variance was performed followed by Tukey test. Univariable and multivariable logistic regression were performed to assess whether demographic and preoperative factors were associated with post-operative outcomes. Specifically, our model accounted for age, sex, body mass index, insurance status, presence of hypertension, diabetes, peripheral vascular disease (PVD),

history of stroke, cerebral vascular disease, history of heart failure, chronic lung disease, end-stage renal disease, number of diseased vessels, previous coronary intervention and/or coronary bypass, status of case, hematocrit, platelets, and predicted mortality. Similarly, we used an interaction model to assess for the relationship between race and sex, adjusted for insurance status and predicted mortality. Univariable and multivariable analyses were presented as odds ratios (OR) and corresponding 95% CIs. For multivariable analysis, clustering by center was accounted for by utilizing cluster-correlated robust variance. Missing data for baseline characteristics have been detailed in Table 1. Missing data were excluded from Table 2 results and observations with missing data were dropped from regression models.

Lastly, we examined trends in predicted and observed 30-day mortality over time by race and sex using observed to expected mortality (O:E) ratios. We determined the observed death rate by race and sex groupings in each year, and predicted mortality is a calculated score provided by the STS database. All analyses were performed using Stata version 14 or Stata version 16 (StataCorp, College Station, TX). Ninety-five percent CIs and a *P* value of <0.05 were used to determine statistical significance. The study was reviewed and acknowledged by the Johns Hopkins Medicine Institutional Review Board.

RESULTS

Baseline Patient Characteristics

A total of 1,042,506 patients met inclusion criteria after excluding 25,954 patients without race data available. Of those included in the analysis, 884,606 (84.85%) were White, 79,871 (7.66%) were Black, 1,736 (0.17%) were Black+, and 76,293 (7.32%) were classified as “Other,” which includes those patients who reported Asian, Native-American, or other race categories. For the total study sample, the mean age was 65.11 years (SD = 10.27) with a range of 19 to 90 years. Males comprised 74.9% of the study population, and females accounted for 25.1%. Patient demographic and clinical characteristics are shown in Table 1.

Comorbidities were measured and compared across racial groups, and Black patients were more likely to have hypertension (n = 75,355, 94.4%) compared to all other groups (White: n = 778,650, 88.0%; Black+: n = 1581, 91.1%; other: n = 67,849, 88.9%; all *P* < 0.001). Additionally, Black patients were more likely to have a history of stroke (n = 9,355, 11.7%) compared to other groups (White: n = 61,568, 7.0%, *P* < 0.001; Black+: n = 170, 9.8%, *P* = 0.003; Other: n = 5,861, 7.7%, *P* < 0.001) and more likely to have history of chronic lung disease (n = 20,775, 26.0%) compared to other races (White: n = 221,093, 25.0%; Black+: n = 319, 18.4%; Other: n = 13,996, 18.4%, all *P* < 0.001). Similar to hypertension and stroke, Black patients were also more likely to have end-stage renal disease (ESRD) (n = 6,861, 8.6%) and chronic heart failure (n = 19,964, 25.0%) compared to all other races [ESRD, White: n = 19,102, 2.2%; Black+: n = 109, 6.3%; Other: n = 4,699, 6.2%, pair-wise comparisons largest *P* value < 0.001; congestive heart failure (CHF), White: n = 163,451, 18.5%; Black+: n = 373, 21.5%; Other: 17,127, 22.5%, pair-wise comparisons largest *P* = 0.001]. Black patients had the highest predicted morbidity (19.7%) when compared to all other groups (pair-wise comparisons largest *P* < 0.001). Lastly, Black patients had higher STS calculated predicted risk of mortality (2.42%) compared to White patients

(2.03%, $P < 0.001$) and Other patients (2.18%, $P < 0.001$), but no significant difference in predicted mortality risk was observed when compared to Black+ patients (2.24%, $P = 0.177$). Additional demographic and clinical factors including missing data are displayed in Table 1.

Postoperative Outcomes

Postoperative outcomes were observed to vary by race category of the patient. Descriptively, Black patients were more likely to die (Black: $n = 2,065$, 2.76%) when compared to White patients (White: $n = 18,040$, 2.19%, $P < 0.001$) and Other (Other: $n = 1,638$, 2.33%, $P < 0.001$) with no significant difference when compared to Black+ patients (Black+: $n = 39$, 2.33%, $P = 0.278$). Blacks had slightly longer postoperative lengths of stay (7.79 days, 95% CI 7.75–7.84) than all other groups, although the CI overlapped with the Black+ group (7.60 days, 95% CI 7.27–7.94). Similarly, Black patients were more likely than White and Other race patients to have a surgical site infection (Black: $n = 1,332$, 1.67% vs White: $n = 11,548$, 1.31%, $P < 0.001$; vs Other: $n = 977$, 1.28%, $P < 0.001$), but there was no significant difference when compared to the Black+ group ($n = 37$, 2.15%, $P = 0.073$). Additionally, Black patients had higher rates of sepsis ($n = 1,006$, 1.26%) when compared to White patients ($n = 7,004$, 0.79%, $P < 0.001$) and Other race patients ($n = 853$, 1.12%, $P < 0.001$), but no significant difference was observed when compared to the Black+ group ($n = 14$, 0.81%, $P = 0.094$). When compared to White patients and Other race patients, Black patients were also more likely to have pneumonia (Black: $n = 2,571$, 3.23% vs White: $n = 22,424$, 2.54%, $P < 0.001$; vs. Other: $n = 2,091$, 2.75%, $P < 0.001$), but there was no significant difference when compared to Black+ patients ($n = 50$, 2.89%, $P = 0.43$). On pair-wise comparison to White and Other race patients, Black patients also had higher rates of postoperative stroke and prolonged ventilation (all $P < 0.001$ for pair-wise comparison between Black vs White and Black vs Other race). Results are further detailed in Table 2.

Univariable Analysis

To associate patient and clinical characteristics with adverse outcomes, ORs were determined using logistic regression. In univariable analysis, race was significantly associated with higher odds of 30-day mortality among Black patients compared to white (OR = 1.27, 95% CI 1.20–1.34). Similarly, female patients had a higher odds of 30-day mortality when compared to male patients (OR = 1.68, 95% CI 1.63–1.73). For secondary outcomes, Black patients had a higher odds of surgical site infection (OR = 1.28, 95% CI 1.19–1.38), sepsis (OR = 1.60, 95% CI 1.48–1.73), and stroke (OR = 1.66, 95% CI 1.56–1.77) compared to White patients. Black+ patients also had a higher odds of surgical site infection (OR = 1.66, 95% CI 1.14–2.41) compared to White patients. Additionally, all race categories had higher odds of pneumonia compared to White patients with Black patients having the highest odds (OR = 1.28, 95% CI 1.19–1.38). Age was associated with higher odds of mortality across age categories. Results are further detailed in Table 3.

Multivariable Analysis

On multivariable analysis, Black patients had a higher odds of death compared to Whites (OR = 1.11, 95% CI 1.05–1.18). Similarly, female patients had higher odds of death compared to males (OR = 1.26, 95% CI 1.21–1.30). Among all patients, PVD (OR = 1.36,

95% CI 1.31–1.41), history of stroke (OR = 1.14, 95% CI 1.07–1.20), and CHF (OR = 1.63, 95% CI 1.57–1.70) were all significantly associated with higher odds of death. Age remained significantly associated with odds of death after adjustment. Similarly, all strata of chronic lung disease were associated with higher odds of death: mild, OR = 1.13, 95% CI 1.07 to 1.19; moderate, OR = 1.43, 95% CI 1.34 to 1.53; severe, OR = 1.73, 95% CI 1.62 to 1.84. On multivariable analysis, case status was associated with 30-day mortality. Urgent cases had a higher odds of death compared to elective (OR = 1.40, 95% CI 1.34–1.46). Emergent case status was also associated with higher odds of death (OR = 3.76, 95% CI 3.53–3.99) when compared to elective cases. Salvage cases had the highest odds of death compared to elective cases (OR = 15.72, 95% CI 13.26–18.65). Results are further detailed in Table 3.

Race/Sex Interactions and Temporal Trends

The above results were complemented by performing an interaction model with race and sex, adjusted for insurance status, and predicted mortality score. The odds of death among White females compared to White males was significant (OR = 1.34, 95% CI 1.29–1.39). The odds of death among Black females to Black males was not significant (OR = 0.99, 95% CI 0.91–1.09). The odds of death among Black males compared to White males was also significantly higher (OR = 1.31, 95% CI 1.22–1.42). The odds of death among Black females compared to White males was also significant (OR = 1.31, 95% CI 1.21–1.41). Finally, the odds of death among Black females compared to White females was not significant (OR = 0.97, 95% CI 0.90–1.05).

Lastly, we investigated temporal trends in O:E by race and sex (Exhibit 1). The panels suggest some level of concordance in gender trend (Panel B), some level of disparity by race from 2011 through 2016 (Panel C), and heterogeneity by race-sex groupings throughout the study period (Panel D).

DISCUSSION

Disparities in outcomes continue to be a significant challenge in the modern health care environment. It is unfortunate that the current COVID-19 pandemic illuminates the well-established inequities and disparities here in the United States and around the world.^{13,14} It is timely, then, to report our findings of persistent racial and sex disparities in postoperative outcomes after CABG.

The purpose of this study was to investigate racial and sex disparities in outcomes after CABG in the era of modern cardiovascular care including DESs. Specifically, we sought to assess the trends in 30-day mortality by race-sex groupings after CABG and investigate the effect of race and sex on postoperative outcomes. Broadly, our study suggests that Black patients had higher proportions of comorbidities (eg, hypertension) than other study populations with correspondingly worse postoperative outcomes. Globally, Black patients on both univariable and multivariable regression adjusted for multiple demographic and clinical characteristics had persistently worse outcomes when compared to White males. Despite controlling for variables such as insurance, sex, case status, and clinical comorbidities, Black patients still had an 11% higher odds of 30-day mortality when compared to White patients,

and this is notably in a setting with lower or equal proportions of emergent or salvage cases. Furthermore, female patients had an even higher odds of death when compared to male patients and this remained the case despite adjustment.

Results of this study are consistent with other findings in the literature on outcomes after cardiac surgery among minority populations. Burton et al¹⁵ demonstrated that Black patients had higher proportions of adverse comorbidities, and this study also suggested higher odds of post-operative morbidity. Our study is consistent with these findings given the higher rates of death, readmission, infection, and stroke. Similarly, two recent studies of Medicare patients suggested that female patients and Black patients had higher rates of mortality—a finding that our study also confirms with our data from the largest, clinically robust database of >1 million patients.^{16,17}

Several explanations for higher mortality in female and racial minorities have been proposed in the literature and could provide context to our findings. These factors include more difficult anatomy (eg, smaller coronary vasculature), slower adoption of multiple arterial vascularization in women, socioeconomic factors (eg, being single, unemployed), and quality of cardiac surgical centers.^{18–21} Considering this, we also sought to explore an interaction between race and sex beyond their individual contributions to our model. Through our interaction model, our results suggest that all other groups (White females, Black males, Black females) do worse when compared to White males. Notably though, Black females do not appear to have higher odds of 30-day mortality when compared to White females or Black males. Although previous research has demonstrated that Black patients are more likely to have hypertension, diabetes, and heart failure, it has also suggested Black patients are more likely to be younger.⁶ Our interaction model suggests that being female and Black may lead to an equal odds of death (as opposed to an increased odds) when compared to the individual odds of death of being female or Black using White males as the reference group. These results provide additional findings compared to previously published reports of race, sex, and interactions.⁵

Finally, additional research suggests that the Affordable Care Act enacted in 2010 may have provided increased access to cardiac surgery.²² Similarly, a large body of evidence has evaluated cardiac outcomes after the introduction of DES.^{23–26} Studies demonstrated changes in CABG referrals of cardiac catheterization patients and use of DES in an expanded patient population with left main coronary artery disease. Others have proposed that the introduction of DES did not modify the comparison of CABG to percutaneous intervention with respect to cardiac outcomes.^{27,28} It is unclear how the evolution of DES has impacted these findings and outcomes in diverse, minority patient populations. Results of our study appear to demonstrate some heterogeneity in O:E trends without apparent major change in overall disparities by race and sex over the last 8 years. Chaudhary et al proposed that universal access to healthcare may lessen racial disparities, but other research has suggested that postoperative care for Black patients may still be suboptimal.^{29,30} Nevertheless, using a state-wide database, Mazzeffi et al³¹ suggested that Black patients may do better than others postoperatively, a finding that differs from our national investigation. This study investigated data from Maryland which, as proposed by the authors, has an all-payer system that equitably reimburses hospitals, suggesting some

uninsured or underinsured patients might have improved access to care. The proportion of uninsured nonelderly patients in Maryland is lower than the national average: 7.1% versus 10.2%.³¹ More studies using large, robust clinical registries are needed to appreciate how socioeconomic and state-level factors may be contributing to poor health outcomes among minority patients. Similarly, we suggest that additional research should focus on multilevel modeling of these hospital, community, and local factors, as some research has previously suggested hospital-level factors can significantly contribute to outcomes.^{2,32} A research focus on these factors might help influence policy in the current era of surgical care.

Limitations

The findings of this study must be interpreted considering several limitations. First, as the data are abstracted from a clinical registry, we cannot underestimate some disadvantages to large databases, such as surveillance bias and misclassification.³³ Similarly, despite the size of this database, more granular or qualitative context on socioeconomic factors would be helpful but are not readily available. Moreover, data definitions and calculations (eg, predicted mortality) change over time, and it is not always possible to fully compare cases across the study period. For example, in the STS Database, the definition for readmission changed from 30 days after procedure to 30 days after discharge, and this opens the door for residual bias. It is important to note that in our study we did not have robust data to address socioeconomic status for this patient population, and we were unable to fully adjust for SES beyond utilizing public health insurance (eg, Medicaid vs. commercial) as a surrogate. In future investigations, clinical and health services research should target specific sociocultural factors and health systems variables that may influence limitations in access to care or other important physician or patient variables.^{34,35} The STS has plans to acquire National Death Index data to correlate long term outcomes and other socioeconomic factors to improve their database. Ongoing research in this contemporary era is necessary, as disparities are not static and a continued effort to address them may uncover new and necessary findings to help reduce the burden for those who have been historically impacted in extraordinary ways.^{36,37}

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Panel A

Panel B

Panel C

Panel D

Abbreviation: O:E = observed to expected

Exhibit 1.
Observed to expected mortality.

TABLE 1.

Baseline Demographic and Clinical Characteristics of Patients, Stratified by Race

	White	Black	Black+	Other	P *
Total no. of patients	884,606	79,871	1,736	76,293	
Mean age, y (SE)	65.5 (0.01)	62.3 (0.04)	63.2 (0.2)	63.4 (0.04)	0.001
Sex					<0.001
Female, n (%)	212,106 (24.0)	31,251 (39.1)	515 (29.7)	17,776 (23.3)	
Male, n (%)	672,232 (76.0)	48,588 (60.8)	1,221 (70.3)	58,491 (76.7)	
Hispanic ethnicity (%)	5.2	1.0	44.1	27.1	<0.001
Body mass index, mean, kg/m ² (SE)	30.1 (.006)	30.5 (.02)	29.4 (0.1)	28.1 (0.02)	<0.001
Medical history					
Hypertension					<0.001
Yes	778,650 (88.0)	75,355 (94.4)	1,581 (91.1)	67,849 (88.9)	
No	104,801 (11.9)	4,420 (5.5)	153 (8.8)	8,345 (10.9)	
Unknown/missing	1,155 (0.1)	96 (0.1)	2 (0.1)	99 (0.1)	
Diabetes					0.111
Yes	399,891 (45.2)	46,528 (58.3)	1,011 (58.2)	46,429 (60.9)	
No	483,456 (54.7)	33,225 (41.6)	719 (41.4)	29,753 (39.0)	
Unknown/missing	1,259 (0.1)	118 (0.2)	6 (0.4)	111 (0.2)	
PVD					0.001
Yes	124,511 (14.1)	14,060 (17.6)	247 (14.2)	7,955 (10.4)	
No	756,858 (85.6)	65,510 (82.0)	1,479 (85.2)	68,067 (89.2)	
Unknown/missing	3,237 (0.4)	301 (0.4)	10 (0.6)	271 (0.4)	
History of stroke					0.003
Yes	61,568 (7.0)	9,355 (11.7)	170 (9.8)	5,861 (7.7)	
No	818,236 (92.5)	70,050 (87.7)	1,548 (89.2)	70,099 (91.9)	
Unknown/missing	4,802 (0.5)	466 (0.6)	18 (1.0)	333 (0.4)	
Chronic lung disease					<0.001
Yes	221,093 (25.0)	20,775 (26.0)	319 (18.4)	13,996 (18.4)	
No	647,862 (73.2)	57,466 (72.0)	1,373 (79.1)	61,073 (80.1)	
Unknown/missing	15,651 (1.8)	1,630 (2.0)	44 (2.5)	1,224 (1.6)	

	White	Black	Black+	Other	P *
End-stage renal disease					<0.001
Yes	19,102 (2.2)	6,861 (8.6)	109 (6.3)	4,699 (6.2)	
No	864,020 (97.7)	72,880 (91.3)	1,620 (93.3)	71,448 (93.7)	
Unknown/missing	1,484 (0.2)	130 (0.2)	7 (0.4)	146 (0.2)	
Chronic heart failure					0.001
Yes	163,451 (18.5)	19,964 (25.0)	373 (21.5)	17,127 (22.5)	
No	716,840 (81.0)	59,481 (74.5)	1,348 (77.7)	58,822 (77.1)	
Unknown/missing	4,315 (0.5)	426 (0.5)	15 (0.9)	344 (0.5)	
Insurance					<0.001
Medicare	247,544 (28.0)	21,500 (26.9)	483 (27.8)	17,809 (23.3)	
Medicaid	37,279 (4.2)	7,370 (9.2)	262 (15.1)	8,171 (10.7)	
Government	23,649 (2.7)	3,393 (4.3)	32 (1.8)	2,826 (3.7)	
Commercial	248,230 (28.1)	18,890 (23.7)	397 (22.9)	20,635 (27.1)	
Other	87,785 (9.9)	10,811 (13.5)	226 (13.0)	12,956 (17.0)	
Multiple	240,119 (27.1)	17,907 (22.4)	336 (19.4)	13,896 (18.2)	
Preoperative laboratories					0.739
Hemoglobin A1c (%) (SE)	6.6 (0.002)	7.1 (0.008)	7.1 (0.050)	7.1 (0.007)	
Hematocrit (%), (SE)	39.4 (0.006)	36.8 (0.02)	38.1 (0.1)	38.5 (0.02)	<0.001
Platelet count (*1000 cells/ μ L), (SE)	214.6 (71.7)	226.6 (260.4)	221.5 (1773.5)	219.0 (248.7)	0.012
INR, (SE)	1.06 (0.0003)	1.06 (0.001)	1.06 (0.01)	1.05 (0.001)	0.782
Operative factors					
OR duration, min, (SE)	309.5 (0.09)	321.6 (0.3)	350.4 (2.3)	321.6 (0.3)	1.000 [†]
Internal mammary used	840,397 (95.0)	75,187 (94.1)	1,670 (96.2)	73,004 (95.7)	0.001
Radial artery used	42,755 (4.8)	2,754 (3.5)	92 (5.3)	4,142 (5.4)	<0.001
Previous cardiac intervention	297,010 (33.6)	26,587 (33.3)	534 (30.8)	20,941 (27.5)	0.008
Prior CAB	21,778 (2.5)	1,576 (2.0)	40 (2.3)	1,155 (1.5)	<0.001
Status/indication					<0.001
Elective	337,537 (38.2)	26,722 (33.5)	717 (41.3)	26,762 (35.1)	
Urgent	504,829 (57.1)	49,940 (62.5)	936 (53.9)	46,180 (60.5)	
Emergent	40,320 (4.6)	3,004 (3.8)	80 (4.6)	3,188 (4.2)	
Salvage	1,693 (0.2)	156 (0.2)	3 (0.2)	137 (0.2)	

	White	Black	Black+	Other	<i>P</i> *
Unknown/missing	227 (0.03)	49 (0.1)	0 (0.0)	26 (0.03)	
Bypass time, min (SE)	94.3 (0.04)	93.1 (0.1)	98.6 (0.9)	97.0 (0.1)	<0.001
Cross-clamp time, min (SE)	68.2 (0.03)	66.5 (0.1)	74.5 (0.8)	70.9 (0.1)	<0.001
STS-predicted mortality (%), (SE)	2.03 (0.004)	2.42 (0.01)	2.24 (0.1)	2.18 (.01)	0.177
STS-predicted morbidity (%), (SE)	14.2 (0.01)	19.7 (0.05)	17.9 (0.3)	16.0 (.05)	<0.001

* Percentages and *P* values reported for categorical variables. Given focus on race, the *P* values reported are the most conservative (largest) among all pair-wise comparisons of Black race versus other race groups. Note: 95% CIs reported in parenthesis unless otherwise stated. Continuous variables presented as mean values with standard error (SE).

[†] For OR duration, *P* value of 1.000 represents pair-wise comparison of Black to Other patients. Other pair-wise comparisons (ie, Black vs White and Black vs Black+) had a *P* value <0.001.

INR indicates international normalized ratio; OR, operating room; CAB, coronary artery bypass.

TABLE 2.

Unadjusted Postoperative Outcomes, Stratified by Race

	White	Black	Black+	Other	P
Death, n (%)	18,040 (2.19)	2,065 (2.76)	39 (2.33)	1,638 (2.33)	<.001
O/E ratio *	1.06 (1.05–1.08)	1.12 (1.07–1.17)	0.98 (0.69–1.35)	1.05 (1.00–1.11)	
Readmitted, n (%) [†]	83,534 (9.92)	9,607 (12.77)	194 (11.72)	7,281 (10.07)	<.001
Postoperative LOS, mean days *	6.73 (6.72–6.74)	7.79 (7.75–7.84)	7.60 (7.27–7.94)	7.10 (7.05–7.14)	
Surgical Site Infection, n (%)	11,548 (1.31)	1,332 (1.67)	37 (2.15)	977 (1.28)	<.001
Sepsis, n (%)	7,004 (0.79)	1,006 (1.26)	14 (0.81)	853 (1.12)	<.001
Pneumonia, n (%)	22,424 (2.54)	2,571 (3.23)	50 (2.89)	2,091 (2.75)	<.001
Stroke, n (%)	10,764 (1.22)	1,599 (2.01)	33 (1.91)	1,162 (1.53)	<.001
Reoperation, bleeding, n (%)	15,167 (1.72)	1,474 (1.85)	28 (1.62)	1,628 (2.14)	<.001
Reintervention, MI, n (%) [‡]	684 (0.40)	95 (0.60)	3 (0.85)	67 (0.40)	0.001
Early extubation, n (%)	320,775 (59.9)	23,406 (47.9)	551 (53.6)	25,920 (53.5)	<.001
Ventilation > 24 h, n (%)	70,578 (7.99)	9,129 (11.46)	160 (9.23)	7,209 (9.48)	<.001
Total hours ventilated * [‡]	16.26 (16.10–16.42)	22.20 (21.51–22.90)	18.80 (13.42–24.18)	18.13 (17.55–18.71)	

* Ninety-five percent (95%) confidence intervals presented in place of *P* values.

[‡]Change in STS definitions: in earlier versions of STS database, the readmitted within 30 days variable was from time of operation; in later versions, it was calculated from time of discharge. Reduced sample size for reintervention, MI (n = 204,322) and total hours ventilated (n = 623,402).

LOS indicates length of stay; MI, myocardial infarction.

TABLE 3.
Univariable and Multivariable Analysis of Factors Associated With 30-Day Mortality*

Covariates	Multivariable Model			
	Odds Ratio	95% CI	Odds Ratio	95% CI
Year of surgery				
2011	1.00 (ref)	—	1.00 (ref)	—
2012	1.01	0.95–1.08	1.01	0.94–1.09
2013	0.98	0.91–1.04	0.98	0.91–1.05
2014	0.97	0.90–1.04	0.97	0.89–1.04
2015	0.95	0.89–1.02	0.92	0.85–0.99
2016	0.91	0.84–0.98	0.90	0.83–0.97
2017	0.98	0.91–1.06	0.98	0.91–1.07
2018	0.95	0.88–1.02	0.96	0.88–1.04
Race				
White	1.00 (Ref)	—	1.00 (Ref)	—
Black	1.27	1.20–1.34	1.11	1.05–1.18
Black+	1.06	0.77–1.47	1.01	0.74–1.40
Other	1.07	0.98–1.16	1.09	1.00–1.18
Sex				
Male	1.00 (Ref)	—	1.00 (Ref)	—
Female	1.68	1.63–1.73	1.26	1.21–1.30
Age category, y				
<50	1.00 (Ref)	—	1.00 (Ref)	—
50–59	1.11	1.03–1.19	1.12	1.03–1.21
60–69	1.49	1.39–1.59	1.31	1.22–1.42
70–79	2.40	2.24–2.57	1.79	1.65–1.94
80	4.44	4.12–4.77	2.79	2.55–3.05
Insurance				
Medicare	1.00 (Ref)	—	1.00 (Ref)	—
Medicaid	0.62	0.57–0.67	0.94	0.86–1.03
Government	0.66	0.60–0.72	0.96	0.88–1.06

Univariable Model		Multivariable Model		
Covariates		Odds Ratio	95% CI	95% CI
Commercial		0.43	0.41–0.45	0.80
Other		0.63	0.59–0.67	0.95
Multiple		0.93	0.89–0.97	0.95
Hypertension		1.23	1.17–1.29	0.96
Diabetes		1.21	1.17–1.25	1.00
PVD		2.15	2.08–2.22	1.36
History of stroke		1.81	1.73–1.88	1.14
CVD		1.72	1.66–1.77	1.10
CHF		2.80	2.69–2.91	1.63
Chronic lung disease	None	1.00 (Ref)	—	1.00 (Ref)
Mild		1.24	1.18–1.30	1.13
Moderate		1.85	1.74–1.96	1.43
Severe		3.03	2.88–3.19	1.73
Documented, Severity Unknown		2.03	1.91–2.16	1.48
ESRD		3.34	3.18–3.51	1.65
No. of diseased vessels	3	1.00 (Ref)	—	1.00 (ref)
2		0.78	0.75–0.81	0.83
1		0.66	0.60–0.71	0.71
Previous coronary intervention		1.35	1.32–1.39	1.13
Previous CAB		2.61	2.45–2.78	2.01
Status Elective		1.00 (Ref)	—	1.00 (Ref)
Urgent		1.78	1.71–1.86	1.40
Emergent		6.72	6.37–7.09	3.76
Salvage		66.23	59.29–73.98	15.72
Body mass index		0.99	0.99–0.99	1.01
Hematocrit		0.93	0.93–0.93	0.98
Platelets		1.00	1.00–1.00	1.00
STS-predicted mortality		1.12	1.12–1.13	1.05

* Multivariable analysis includes 943,694 observations with standard error adjusted for 1,175 clusters.

CVD indicates cerebral vascular disease; CAB, coronary artery bypass.