Socioeconomic disparities in procedural choice and outcomes after aortic valve replacement

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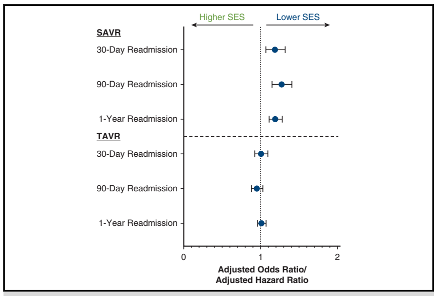
ABSTRACT

Objective: To identify potential socioeconomic disparities in the procedural choice of patients undergoing surgical aortic valve replacement (SAVR) versus transcatheter aortic valve replacement (TAVR) and in readmission outcomes after SAVR or TAVR.

Methods: The Nationwide Readmissions Database was queried to identify a total of 243,691 patients who underwent isolated SAVR and TAVR between January 2016 and December 2018. Patients were stratified according to a tiered socioeconomic status (SES) metric comprising patient factors including education, literacy, housing, employment, insurance status, and neighborhood median income. Multivariable analyses were used to assess the effect of SES on procedural choice and risk-adjusted readmission outcomes.

Results: SAVR (41.4%; 100,833 of 243,619) was performed less frequently than TAVR (58.6%; 142,786 of 243,619). Lower SES was more frequent among patients undergoing SAVR (20.2% [20,379 of 100,833] vs 19.4% [27,791 of 142,786]; *P* < .001). Along with such variables as small hospital size, drug abuse, arrhythmia, and obesity, lower SES was independently associated with SAVR relative to TAVR (adjusted odds ratio [aOR], 1.17; 95% confidence interval [CI], 1.11 to 1.24). After SAVR, but not after TAVR, lower SES was independently associated with increased readmission at 30 days (aOR, 1.19; 95% CI, 1.07-1.32), 90 days (aOR, 1.27; 95% CI, 1.15-1.41), and 1 year (adjusted hazard ratio, 1.19; 95% CI, 1.11 to 1.28; *P* < .05 for all).

Conclusions: Our study findings indicate that socioeconomic disparities exist in the procedural choice for patients undergoing AVR. Patients with lower SES had increased odds of undergoing SAVR, as well as increased odds of readmission after SAVR, but not after TAVR, supporting that health inequities exist in the surgical care of socioeconomically disadvantaged patients. (JTCVS Open 2023;16:139-57)



Risk-adjusted readmission outcomes after SAVR or TAVR according to socioeconomic status.

CENTRAL MESSAGE

Socioeconomic disparities exist in procedural choice and outcomes after surgical or transcatheter aortic valve replacement.

PERSPECTIVE

Available reports have indicated discrepancies in transcatheter aortic valve replacement (AVR) use in patients of lower socioeconomic status (SES). We identify and discuss the association between SES and the procedural choice of patients undergoing AVR. Additionally, although SES has been recognized as a risk factor for mortality after surgical AVR, its association with readmission remains underreported, and we explored it in this study.

Socioeconomic status (SES) is being increasingly recognized as a risk factor for adverse outcomes after cardiac surgery.[1-5] Previous studies of single variable surrogates or geographic measures for SES have shown an inverse association between SES and mortality after surgical aortic valve replacement (SAVR)[1,3,6]; however, this association has not been observed after transcatheter aortic valve replacement (TAVR).[1,7] Additionally, available reports have indicated discrepancies in TAVR use in patients with lower SES.[8-10] However, the association between SES and

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Abbreviations and Acronyms

aHR = adjusted hazard ratio
aOR = adjusted odds ratio
AVR = aortic valve replacement
ICD-10-CM = International Classification of Diseases, Tenth Revision, Clinical Modification
LOS = length of stay
NRD = Nationwide Readmissions Database
SAVR = surgical aortic valve replacement
SES = socioeconomic status
TAVR = transcatheter aortic valve replacement

the choice of procedure in patients undergoing aortic valve replacement (AVR) is unknown. Additionally, although mortality outcomes have been reported, the association between SES and readmission after SAVR and TAVR remains underexplored. Our metric builds on previously reported single variable definitions for SES, specifically admission payor and neighborhood income quartile. The use of SES-related International Classification of Diseases, Tenth Revision, Clinical Modification codes (problems related to education/literacy, employment/unemployment, occupational risk factors, physical environment, and housing/economic circumstances) is a novel aspect of our methodology. The Centers for Disease Control and Prevention has recognized the valuable contribution that these additional ICD-10-CM codes can provide to enhance our understanding of social determinants of health. These codes go beyond a simple identification of low-income patients; rather, they identify patients who experience barriers to healthcare. Our metric yields results that support differences in clinical outcomes for low SES patients, which is consistent with other models.

The primary goal of this study was to identify potential socioeconomic disparities in the procedural choice of patients undergoing AVR. We hypothesized that lower SES may be associated with undergoing SAVR instead of TAVR. As a secondary goal, we sought to examine the association between SES and readmission after SAVR or TAVR in a nationally representative cohort.

METHODS

Data Collection

In this study, we used data from the Nationwide Readmissions Database (NRD). Annually, approximately 35 million discharges are weighted using a clustered, poststratified design that allows for national estimates of outcomes. As the largest all-payor readmissions database, the NRD links patient index admission and readmissions within a calendar year.[11] This study was deemed exempt by the Baylor College of Medicine Institutional Review Board because the data were aggregated and deidentified, as recommended by the Health Insurance Portability and Accountability Act.

Patient Cohort

The NRD was queried to identify and stratify adult patients undergoing isolated SAVR or TAVR between January 1, 2016, and December 31, 2018, using the ICD-10-CM Procedure Coding System (PCS) (Table E1, Figure 1). Patients who underwent concomitant cardiac procedures and those with endocarditis were excluded (Table E1, Figure 1).

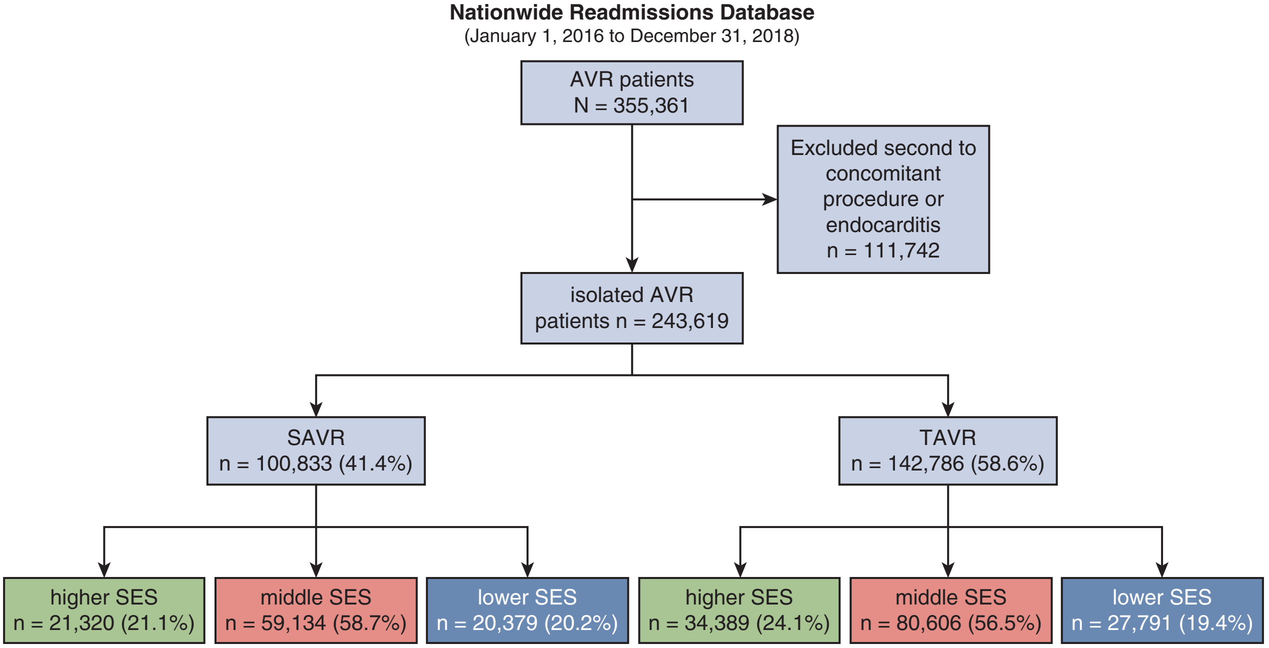

FIGURE 1. Flowchart diagram showing patient identification, exclusion, and stratification. *AVR*, Aortic valve replacement; *SAVR*, surgical aortic valve replacement; *TAVR*, transcatheter aortic valve replacement; *SES*, socioeconomic status.

TABLE 1. Patient and hospital characteristics according to aortic valve replacement procedure type

Variable	Overall (N = 243,619)	SAVR (N = 100,833; 41.4%)	TAVR (N = 142,786; 58.6%)	*P* value*
Age, y, median (IQR)	76 (67-83)	68 (60-74)	81 (75-86)	<.001
Age group, n (%)				<.001
<65 y	46,223 (18.9)	39,025 (38.7)	7198 (5.0)	
65-79 y	103,930 (42.7)	52,458 (52.0)	51,472 (36.0)	
≥80 y	93,466 (38.4)	9350 (9.3)	84,116 (58.9)	
Female sex, n (%)	103,893 (42.6)	38,973 (38.7)	64,920 (45.5)	<.001
Urgent intervention, n (%)	44,704 (18.3)	17,585 (17.4)	27,119 (19.0)	.02
SES, n (%)				<.001
Lower SES	48,170 (19.8)	20,379 (20.2)	27,791 (19.4)	
Middle SES	139,740 (57.3)	59,134 (58.7)	80,606 (56.5)	
Higher SES	55,709 (22.9)	21,320 (21.1)	34,389 (24.1)	
Income quartile, n (%)†				<.001
1	50,753 (20.8)	22,249 (22.1)	28,504 (20.0)	
2	69,877 (28.7)	29,319 (29.1)	40,558 (28.4)	
3	66,264 (27.2)	27,218 (27.0)	39,046 (27.3)	
4	56,725 (23.3)	22,047 (21.9)	34,678 (24.3)	
Primary payor, n (%)				<.001
Medicaid	7190 (3.0)	5704 (5.7)	1486 (1.0)	
Medicare	190,311 (78.2)	60,244 (59.8)	130,066 (91.2)	
Other	4609 (1.9)	2137 (2.1)	2472 (1.7)	
Private insurance	39,500 (16.2)	31,394 (31.2)	8106 (5.7)	
Self-pay	1741 (0.7)	1260 (1.3)	481 (0.3)	
Hospital bed size, n (%)				<.001
Large	177,003 (72.7)	70,050 (69.5)	106,954 (74.9)	
Medium	52,073 (21.4)	22,381 (22.2)	29,692 (20.8)	
Small	14,543 (6.0)	8402 (8.3)	6140 (4.3)	
Teaching hospital, n (%)	210,193 (86.3)	84,472 (83.8)	125,722 (88.0)	<.001
Rural patient, n (%)	20,220 (8.3)	8830 (8.8)	11,390 (8.0)	.03
Elixhauser score, median (IQR)	11 (5-19)	10 (2-20)	11 (6-19)	<.001
Congestive heart failure, n (%)	147,420 (60.5)	39,910 (39.6)	107,511 (75.3)	<.001
Arrhythmia, n (%)	140,140 (57.5)	58,839 (58.4)	81,301 (56.9)	<.001
Peripheral vascular disease, n (%)	51,283 (21.1)	18,183 (18.0)	33,100 (23.2)	<.001
Hypertension, n (%)	207,282 (85.1)	79,407 (78.8)	127,874 (89.6)	<.001
Chronic obstructive pulmonary disease, n (%)	62,023 (25.5)	21,081 (20.9)	40,942 (28.7)	<.001
Diabetes mellitus, n (%)	82,472 (33.9)	28,347 (28.1)	54,126 (37.9)	<.001
Renal failure, n (%)	67,728 (27.8)	16,086 (16.0)	51,642 (36.2)	<.001
Obesity, n (%)	55,177 (22.6)	27,350 (27.1)	27,827 (19.5)	<.001
Pulmonary circulation disorder, n (%)	40,928 (16.8)	13,726 (13.6)	27,201 (19.1)	<.001
Hyperlipidemia, n (%)	165,227 (67.8)	62,325 (61.8)	102,902 (72.1)	<.001
Drug abuse, n (%)	2482 (1.0)	1856 (1.8)	626 (0.4)	<.001
Smoking, n (%)	97,973 (40.2)	41,724 (41.4)	56,249 (39.4)	<.001

SAVR, Surgical aortic valve replacement; *TAVR*, transcatheter aortic valve replacement; *IQR*, interquartile range; *SES*, socioeconomic status. *Comparison between SES level determined using the Kruskal-Wallis rank-sum test for complex survey samples or the chi-square test with Rao and Scott second-order correction. †Based on patient ZIP code. Values are presented as median (interquartile range) for continuous variables or as number (percentage) for categorical variables. The denominator is indicated at the top of each column unless noted otherwise.

SES

Patients were further stratified according to SES by using a composite, tiered metric composed of individual- and neighborhood-level factors. Individual-level factors included admission payor, as well as education, literacy, housing, employment status, physical environment, and economic circumstances, which were identified using SES-related ICD-10-CM codes (Table E1). The neighborhood-level median household income factor is reported as quartiles by the NRD and is established using the median income of a ZIP code for a calendar year. Median income was used in lieu of mean income to better represent the overall income within the ZIP code. Lower SES was defined as one of the following: (1) having Medicaid or self-pay as the primary payor while being in the lowest- and middle-income neighborhood income quartiles; (2) being a Medicare beneficiary in the lowest neighborhood income quartile; or (3) having an SES-related ICD-10-CM code. Higher SES was defined as living in the highest neighborhood income quartile and having private insurance, self-pay, or Medicare as the primary payor. Patients who did not qualify as lower or higher SES were classified as middle SES.

Patient and Hospital Characteristics

Hospital characteristics examined included teaching status and hospital bed size as defined by the NRD.[11] Patient characteristics and comorbidities included age, sex, patient rural/urban classification, urgency of intervention, Elixhauser comorbidity index components, and additional cardiovascular risk factors, such as smoking and hyperlipidemia. The Elixhauser comorbidity index is a weighted composite score that categorizes patient comorbidities on the basis of ICD-10-CM diagnosis codes.[12]

Outcomes

The primary outcome of this study was procedural choice (SAVR or TAVR). Secondary outcomes included in-hospital mortality, index hospitalization length of stay (LOS), discharge disposition, and readmission at 30 days, 90 days, and at 1 year. Readmissions within a calendar year were determined using Kaplan-Meier analysis as described previously.[12]

Statistical Analysis

Statistical calculations were performed using R version 4.1.1.[13] We adjusted for the complex survey design of the NRD in all statistical calculations using the R package survey.[14] Less than 1% of data were missing from any category. Missing data were replaced with the median or mode of the overall cohort for continuous and categorical values, respectively. Continuous data were analyzed using a complex survey-adjusted Kruskal-Wallis rank-sum test and are represented as median (interquartile range). Categorical data were analyzed using a chi-square test with Rao and Scott adjustment and are represented as number (percentage). A survey-adjusted log-rank test was used to determine differences in the rate of readmission between groups within a calendar year. A P value $<.05$ was considered significant. The independent association of lower SES with 30- or 90-day readmission was assessed with multivariable logistic regression analyses. Independent variables included patient and hospital characteristics that differed significantly among groups on univariate analysis and/or with >5% prevalence, including age, sex, urgent intervention, comorbidities, rural versus urban living, teaching status, and hospital bed size. In all logistic regression models for both TAVR and SAVR, age was included as a covariate with 3 cohorts (age <65 years, 65-79 years, and >80 years). Area under the curve values were used to guide the selection of clinically relevant variables.[14] The variable inflation factor was used to assess and remove colinear variables. Schoenfeld residuals were used to assess covariates in the Cox proportional hazard model. Regression results are represented as an adjusted odds ratio (aOR) or an adjusted hazard ratio (aHR) with 95% confidence intervals (CIs) for logistic or Cox proportional hazards, respectively. P values were derived from a survey-adjusted Wald test. Figures were created using Prism 9.5.1 (GraphPad Software) or R version 4.1.1 (R Foundation for Statistical Computing).

RESULTS

Patient Characteristics According to Procedure Type

Over the 3-year study period, a total of 243,619 patients underwent isolated AVR, including 100,833 (41.4%) with SAVR and 142,786 (58.6%) with TAVR (Figure 1). Lower SES was more frequent in patients undergoing SAVR than in patients undergoing TAVR (20.2% vs 19.4%; $P < .001$) (Table 1). Compared with patients undergoing TAVR, patients undergoing SAVR were younger, less likely to be female and to be treated at large or teaching hospitals, and more likely to reside in rural areas than ($P < .05$ for all) (Table 1). The comorbidity burden was lower in the patients undergoing SAVR (Elixhauser score $P < .001$) (Table 1). Although the rates of congestive heart failure, peripheral vascular disease, hypertension, diabetes, chronic obstructive pulmonary disease, renal failure, hyperlipidemia, and pulmonary circulation disorders were higher among the TAVR group, the SAVR group was more likely to have arrhythmias, obesity, illicit drug use, and a history of smoking ($P < .001$ for all) (Table 1).

Multivariable Model of Procedural Choice

Based on the result of univariate analysis shown in Table 1, we created a multivariable model with procedural choice as an outcome (TAVR vs SAVR) (Figure 2). The full model is provided in Table E2. Patients with lower SES had a 17% higher risk-adjusted odds of undergoing SAVR relative to TAVR (aOR, 1.17; 95% CI, 1.11-1.24) (Figure 2). Patients age ≥80 years had the greatest odds of receiving TAVR (aOR, 0.03; 95% CI, 0.03-0.04). Additionally, females had risk-adjusted odds in favor of receiving TAVR (aOR, 0.83; 95% CI, 0.8-0.86). Patients requiring urgent

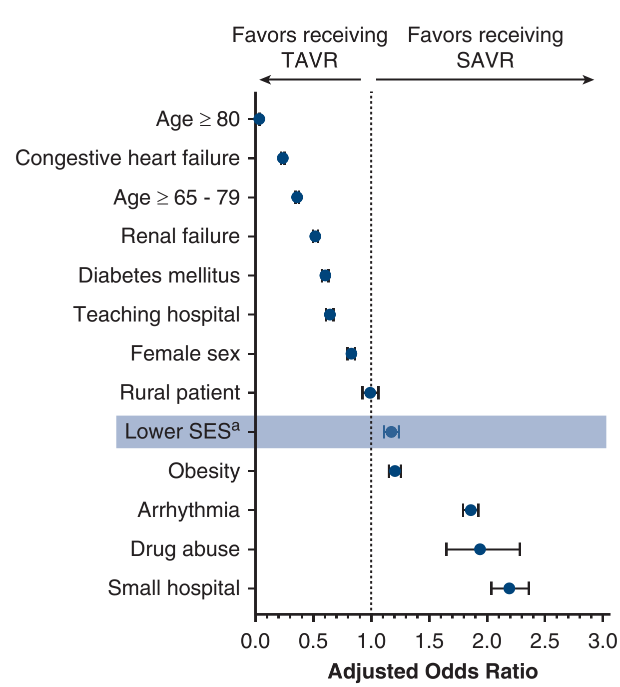

FIGURE 2. Multivariable model of procedural choice (SAVR vs TAVR). Procedural choice as a binary outcome, with TAVR = 0 and SAVR = 1. [a]Indexed to a higher SES. *TAVR*, Transcatheter aortic valve replacement; *SAVR*, surgical aortic valve replacement; *SES*, socioeconomic status.

TABLE 2. Patient and hospital characteristics according to SES

	SAVR (N = 100,833)				TAVR (N = 142,786)			
Variable	Higher SES (N = 21,320; 21.1%)	Middle SES (N = 59,134; 58.7%)	Lower SES (N = 20,379; 20.2%)	*P* value*	Higher SES (N = 34,389; 24.1%)	Middle SES (N = 80,606; 56.5%)	Lower SES (N = 27,791; 19.4%)	*P* value*
Age, y, median (IQR)	69 (61-75)	67 (60-74)	68 (58-74)	<.001	82 (76-87)	81 (75-86)	80 (74-86)	<.001
Age group, n (%)				<.001				<.001
<65 y	7311 (34.3)	23,591 (39.9)	8124 (39.9)		1174 (3.4)	4041 (5.0)	1982 (7.1)	
65-79 y	11,783 (55.3)	30,167 (51.0)	10,508 (51.6)		11,201 (32.6)	29,492 (36.6)	10,779 (38.8)	
≥80 y	2227 (10.4)	5376 (9.1)	1748 (8.6)		22,014 (64.0)	47,073 (58.4)	15,029 (54.1)	
Female sex, n (%)	7707 (36.2)	22,517 (38.1)	8749 (42.9)	<.001	15,161 (44.1)	36,289 (45.0)	13,470 (48.5)	<.001
Urgent intervention, n (%)	3315 (15.6)	9287 (15.7)	4982 (24.4)	<.001	6557 (19.1)	15,016 (18.6)	5546 (20.0)	.26
Income quartile, n (%)†				<.001				<.001
1	<11 (<1.1)‡	6452 (10.9)	15,796 (77.5)		<11 (<1.1)‡	2155 (2.7)	26,349 (94.8)	
2	<11 (<1.1)‡	27,033 (45.7)	2286 (11.2)		<11 (<1.1)‡	39,983 (49.6)	576 (2.1)	
3	<11 (<1.1)‡	25,648 (43.4)	1570 (7.7)		<11 (<1.1)‡	38,469 (47.7)	577 (2.1)	
4	21,320 (100.0)	<11 (<1.1)‡	727 (3.6)		34,389 (100.0)	<11 (<1.1)‡	288 (1.0)	
Primary payor, n (%)				<.001				<.001
Medicaid	<11 (<1.1)‡	<11 (<1.1)‡	5704 (28.0)		<11 (<1.1)‡	<11 (<1.1)‡	1486 (5.3)	
Medicare	12,940 (60.7)	33,820 (57.3)	13,485 (66.2)		31,749 (92.4)	72,384 (90.0)	25,933 (93.3)	
Other	330 (1.5)	21 (0.1)	1786 (3.1)		324 (0.9)	2144 (2.6)	<11 (<1.1)‡	
Private insurance	7889 (37.0)	23,443 (39.7)	61 (0.3)		2174 (6.3)	5922 (7.4)	<11 (<1.1)‡	
Self-pay	152 (0.7)	<11 (<1.1)‡	1108 (5.4)		125 (0.4)	<11 (<1.1)‡	356 (1.3)	
Hospital bed size, n (%)				.002				.02
Large	14,639 (68.7)	14,541 (71.4)	40,869 (69.1)		24,967 (72.6)	60,703 (75.3)	21,283 (76.6)	
Medium	5337 (25.0)	4310 (21.2)	12,733 (21.5)		8394 (24.4)	15,960 (19.8)	5338 (19.2)	
Small	1344 (6.3)	1528 (7.5)	5531 (9.4)		1028 (3.0)	3943 (4.9)	1169 (4.2)	
Teaching hospital, n (%)	19,142 (89.8)	48,740 (82.4)	16,590 (81.4)	<.001	31,535 (91.7)	70,242 (87.1)	23,945 (86.2)	<.001
Rural patient, n (%)	95 (0.5)	5523 (9.3)	3211 (15.8)	<.001	117 (0.3)	6372 (7.9)	4901 (17.6)	<.001
Elixhauser score, median (IQR)	11 (2-20)	10 (2-19)	11 (3-21)	<.001	11 (6-19)	11 (6-19)	11 (7-19)	.007
CHF, n (%)	7622 (35.7)	22,724 (38.4)	9564 (46.9)	<.001	24,768 (72.0)	61,020 (75.7)	21,723 (78.2)	<.001
Arrhythmia, n (%)	12,899 (60.5)	34,178 (57.8)	11,762 (57.7)	<.001	20,246 (58.9)	45,782 (56.8)	15,274 (55.0)	<.001
PVD, n (%)	4102 (19.2)	10,409 (17.6)	3672 (18.0)	<.001	7724 (22.5)	18,741 (23.2)	6635 (23.9)	.18
Hypertension, n (%)	16,431 (77.1)	46,585 (78.8)	16,391 (80.4)	<.001	30,739 (89.4)	72,172 (89.5)	24,963 (89.8)	.65
COPD, n (%)	3686 (17.3)	12,034 (20.4)	5360 (26.3)	<.001	8867 (25.8)	23,118 (28.7)	8957 (32.2)	<.001
Diabetes mellitus, n (%)	5225 (24.5)	16,844 (28.5)	6278 (30.8)	<.001	11,649 (33.9)	30,999 (38.5)	11,478 (41.3)	<.001
Renal failure, n (%)	3159 (14.8)	9076 (15.3)	3851 (18.9)	<.001	11,653 (33.9)	29,537 (36.6)	10,452 (37.6)	<.001
Obesity, n (%)	5044 (23.7)	16,786 (28.4)	5520 (27.1)	<.001	5452 (15.9)	16,401 (20.3)	5975 (21.5)	<.001
Pulmonary circulation disorder, n (%)	2587 (12.1)	7766 (13.1)	3373 (16.6)	<.001	6342 (18.4)	15,290 (19.0)	5569 (20.0)	<.04
Hyperlipidemia, n (%)	11,758 (55.2)	36,797 (62.2)	13,859 (68)	<.001	25,424 (73.9)	57,893 (71.8)	19,585 (70.5)	<.001
Drug abuse, n (%)	213 (1.0)	820 (1.4)	824 (4.0)	<.001	123 (0.4)	325 (0.4)	178 (0.6)	<.001
Smoking, n (%)	8159 (38.3)	24,289 (41.1)	9276 (45.5)	<.001	13,588 (39.52)	31,612 (39.2)	11,049 (39.8)	.69
Mechanical valve, n (%)	2770 (13)	10,408 (17.6)	3843 (18.9)	<.001	NA	NA	NA	NA

SAVR, Surgical aortic valve replacement; *TAVR*, transcatheter aortic valve replacement; *SES*, socioeconomic status; *IQR*, interquartile range; *CHF*, congestive heart failure; *PVD*, peripheral vascular disease; *COPD*, chronic obstructive pulmonary disease; *NA*, not applicable. *Comparison between SES level determined using the Kruskal-Wallis rank-sum test for complex survey samples or the χ^2 test with Rao and Scott second-order correction. †Based on patient ZIP code. ‡Observations with cell count <11 reported as <11, according to Healthcare Cost and Utilization Project regulations. Values are presented as median (IQR) for continuous variables or as number (percentage) for categorical variables. The denominator is at the top of the column unless noted otherwise.

intervention (aOR, 1.15; 95% CI, 1.1-1.2), patients with arrhythmia (aOR, 1.86; 95% CI, 1.79-1.93) or obesity (aOR, 1.2; 95% CI, 1.15-1.26), patients with a history of illicit drug use (aOR, 1.94; 95% CI, 1.65-2.28), and patients treated at small hospitals (aOR, 2.19; 95% CI, 2.04-2.36) had odds in favor of receiving SAVR relative to TAVR. Patient rurality (aOR, 0.99; 95% CI, 0.93-1.07) and smoking (aOR, 0.99; 95% CI, 0.95-1.02) were not associated with significant odds of receiving SAVR or TAVR (Table E2).

Patient Characteristics According to SES in SAVR and TAVR Groups

Patients were further stratified according to SES (Figure 1), and their characteristics were analyzed in the SAVR and TAVR groups. Patients with lower SES undergoing SAVR or TAVR were younger, more likely to be female and to reside in rural areas, and had a higher comorbidity burden compared with patients with a higher SES ($P < .001$ for all) (Table 2). Patients with lower SES undergoing SAVR or TAVR also were less likely to be treated at a teaching hospital ($P < .001$) (Table 2). Unique to the SAVR group, patients with lower SES were more likely to require urgent intervention, to have a history of smoking, and to use illicit drugs ($P < .001$ for all) (Table 2).

Observed Outcomes According to SES After SAVR or TAVR

After SAVR, patients with lower SES had higher rates of in-hospital mortality and longer index hospitalization stays and were less likely to be discharged with home health care compared to patients with higher SES ($P < .001$ for all) (Table 3). In addition, patients in the SAVR group with lower SES had the highest readmission rates at 30 days and 90 days among all SES levels (Figure 3, Table 3); this persisted at 1 year. Although higher risk-adjusted readmission was observed at 30 days (aOR, 1.19; 95% CI, 1.07-1.32), 90 days (aOR, 1.27; 95% CI, 1.15-1.41), and 1 year (aHR, 1.19; 95% CI, 1.11-1.28) in the SAVR group, the risk of readmission was not independently associated with SES in the TAVR group at 30 days (aOR, 1.01; 95% CI, 0.92-1.09), 90 days (aOR, 0.95; 95% CI, 0.88-1.03), or 1 year (aHR, 1.01; 95% CI, 0.96-1.07) (Figure 4). Full regression models for 30-day, 90-day, and 1-year readmission after SAVR and TAVR are shown in Tables E3-E8.

DISCUSSION

Both neighborhood- and individual-level factors have been shown to contribute to existent socioeconomic disparities in cardiovascular outcomes.[15] Although single-variable surrogates are often reported, they do not capture the multiplexity of a patient's SES.[15] In this study, we used a composite tiered SES metric composed of individual- and neighborhood-level factors to reflect a patient's SES level. We showed in a national cohort of patients that lower SES was independently associated with receiving SAVR relative to TAVR. In addition, our data support that lower SES was associated with an increased risk-adjusted odds of readmission after SAVR but not after TAVR (Figure 5). To our knowledge, this study is the first to assess the interaction between SES and procedural choice for patients undergoing AVR. Furthermore, it is the largest,

TABLE 3. Observed patient outcomes according to SES

	SAVR (N = 100,833)				TAVR (N = 142,786)			
Outcome	Higher SES (N = 19,347)	Middle SES (N = 53,107)	Lower SES (N = 18,263)	P value*	Higher SES (N = 30,905)	Middle SES (N = 72,354)	Lower SES (N = 24,960)	P value*
In-hospital mortality, n/N (%)	359/21,320 (1.7)	1316/59,134 (2.2)	609/20,379 (3.0)	<.001	437/34,389 (1.3)	1102/80,606 (1.4)	410/27,791 (1.5)	.32
Index hospitalization LOS, d, median (IQR); mean ± SD	6 (5-8); 7.9 ± 6.9	6 (5-9); 8.1 ± 7.0	7 (5-11); 9.8 ± 9.2	<.001	2 (2-5); 4.4 ± 6.0	2 (2-4); 4.3 ± 5.7	2 (2-5); 4.7 ± 6.4	.005
Disposition, n (%)				<.001				.003
Home-health care	9748 (50.4)	23,426 (44.1)	7709 (42.2)		8607 (27.9)	15,807 (21.8)	5418 (21.7)	
Routine	6788 (35.1)	21,339 (40.2)	6938 (38.0)		18,616 (60.2)	47,452 (65.6)	16,365 (65.6)	
SNF or ICF	2739 (14.2)	8126 (15.3)	3496 (19.1)		3567 (11.5)	8855 (12.2)	3096 (12.4)	
Other	73 (0.3)	120 (0.6)	215 (0.4)		115 (0.4)	241 (0.3)	81 (0.4)	<.001
30-d readmission, n (%)	2161 (11.2)	5970 (11.2)	2570 (14.1)	<.001	3895 (12.6)	8939 (12.4)	3268 (13.1)	.14
90-d readmission, n/N (%)	2430/15,931 (15.3)	7174/43,849 (16.4)	3045/15,030 (20.3)	<.001	5364/24,764 (21.7)	12,622/57,916 (21.8)	4446/20,067 (22.2)	.73

SAVR, Surgical aortic valve replacement; *TAVR*, transcatheter aortic valve replacement; *SES*, socioeconomic status; *LOS*, length of stay; *IQR*, interquartile range; *SD*, standard deviation; *SNF*, skilled nursing facility; *ICF*, intermediate care facilities. *Comparison between SES level determined using the Kruskal-Wallis rank-sum test for complex survey samples or the χ^2 test with Rao and Scott second-order correction. Values are presented as median (IQR) for continuous variables or as number (percentage) for categorical variables. The denominator is listed at the top of the column unless noted otherwise.

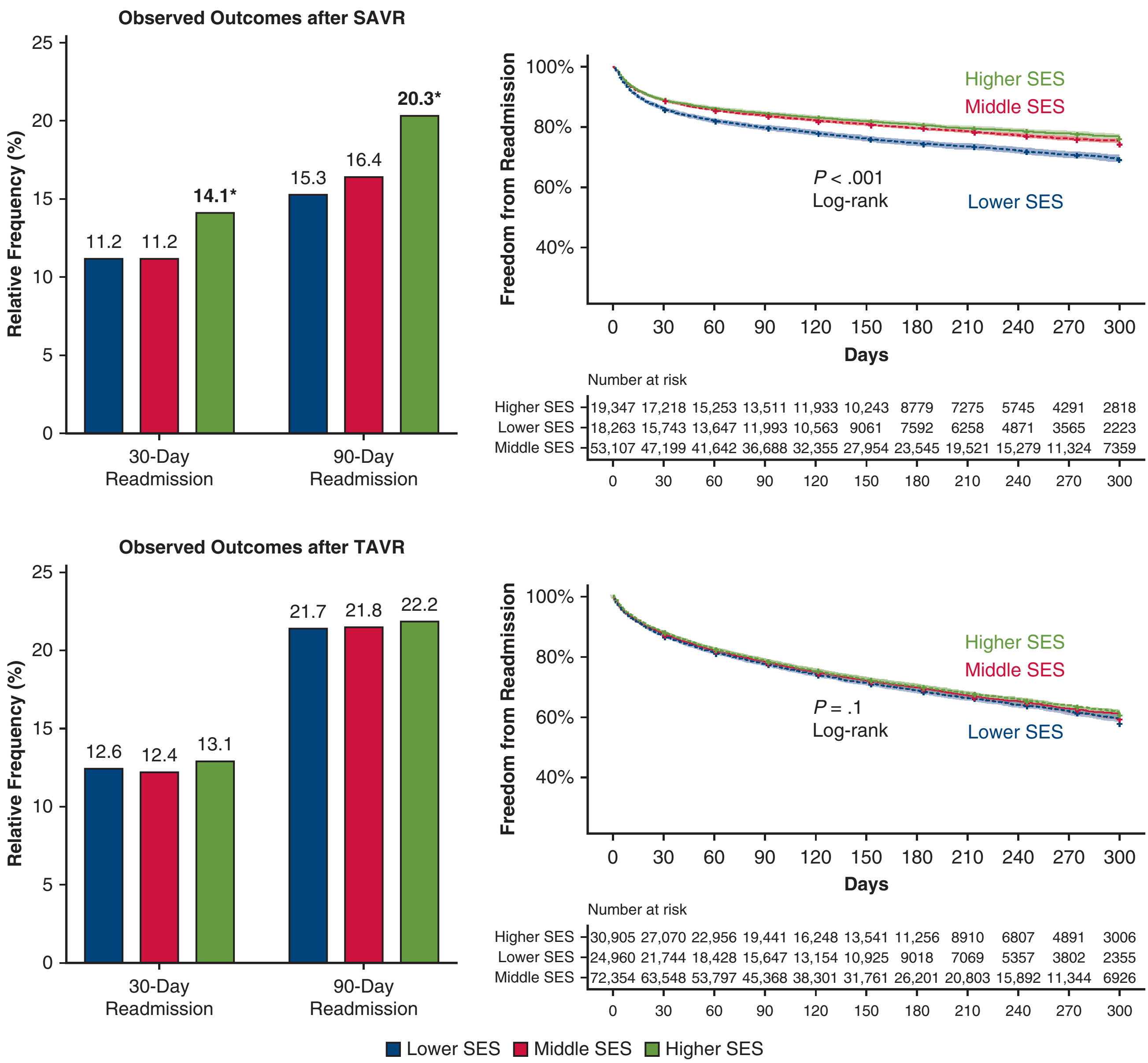

FIGURE 3. Observed readmission outcomes after SAVR (*left*) and TAVR (*right*) according to SES. *SES*, Socioeconomic status; *SAVR*, surgical aortic valve replacement; *TAVR*, transcatheter aortic valve replacement. *$P < .05$.

most comprehensive investigation of readmission outcomes after SAVR and TAVR according to patient SES reported to date.

Socioeconomic Disparities in Procedural Choice of Patients Undergoing AVR

We found that patients with lower SES have a 17% increased risk-adjusted odds of undergoing SAVR relative to TAVR compared to patients with higher SES. The adjustment accounted for patient demographic factors, such as age, sex, comorbidities, and rurality, and hospital factors, including teaching status and bed size. One potential explanation for the choice of SAVR over TAVR is that patients with lower SES may present to hospitals without TAVR capabilities. Furthermore, disparities may exist in the TAVR referral process for patients with lower SES. A wide spectrum of social determinants of health may prevent patients who could benefit from TAVR from ultimately undergoing the procedure. These may include inadequate social support and health literacy, inability to afford care, and inability or willingness to utilize public transportation.[15] With this in mind, we found that patient rurality was not associated with an increased odds of undergoing SAVR relative to TAVR. This suggests that socioeconomic

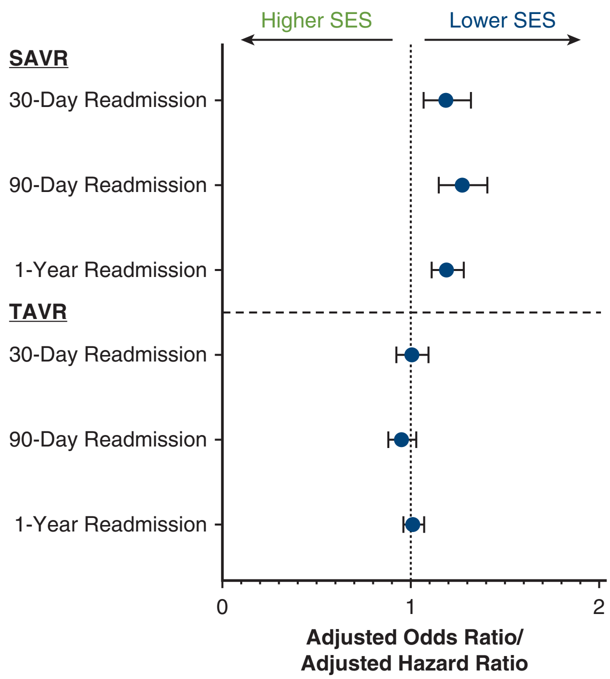

FIGURE 4. Risk-adjusted readmission outcomes after SAVR and TAVR according to SES. Readmission as a binary outcome with readmitted = 1 and not readmitted = 0. Adjusted odds ratio listed for 30-day readmission and 90-day readmission. The adjusted hazard ratio is listed for 1-year readmission. *SES*, Socioeconomic status; *SAVR*, surgical aortic valve replacement; *TAVR*, transcatheter aortic valve replacement.

barriers, but not patient geographical location, contribute to disparities in access to TAVR. In support of this, Nathan and colleagues[8] reported that socioeconomic disparities in the use of TAVR persisted despite geographic proximity to a hospital with a TAVR program. Contradictory to this, a report from Damluji and colleagues[16] demonstrated a rural-urban divide in the rates of TAVR use; however, these results were not adjusted for SES. Given that our study shows that patients with lower SES are much more likely to reside in rural locations, those latter results may be confounded by the association between lower SES and patient rurality.

Additionally, despite the increasing volume of TAVR procedures and the growing number of sites with TAVR capabilities, we showed that patients treated at smaller hospitals had the highest adjusted odds of undergoing SAVR, and patients treated at teaching hospitals had higher adjusted odds of undergoing TAVR. This is supported by a recent report indicating that new TAVR programs are more likely to be developed at hospitals with a large bed size (aOR, 2.73; 95% CI, 1.53-4.89) and teaching hospitals (aOR, 2.47; 95% CI, 1.93-3.15).[9] We also made the universal observation that regardless of AVR type, patients with lower SES were more likely than patients with higher SES to be treated at hospitals of smaller bed size.

Finally, another potential explanation for procedural choice favoring SAVR over TAVR in patients with lower SES is that different SES levels may coincide with different disease pathologies or severities. This is supported by differing patient baseline characteristics among the SES tiers. SAVR may be more appropriate than TAVR for patients with lower SES.

Socioeconomic Disparities in Outcomes After AVR

Concordant with prior reports, we show an inverse relationship between SES and in-hospital mortality after SAVR.[1,3,6] Likewise, in agreement with previous studies, no SES-based disparities in mortality were identified among patients undergoing TAVR.[1,7] We also found an association between lower SES and longer hospital LOS after SAVR and TAVR, which is supported by previous studies.[1,7]

In the present study, patients with lower SES were found to have higher rates of readmission after SAVR but not after TAVR at all examined time points. After adjusting for patient demographics, such as age, sex, comorbidities, rurality, valve type (for SAVR), and hospital factors, including teaching status and bed size, this trend was confirmed with greater odds of readmission for patients with lower SES after SAVR but not after TAVR at 30 days, 90 days, and 1 year. These data are strongly suggestive of SAVR-specific socioeconomic disparities. Given the more complex postoperative recovery and follow-up for patients who undergo SAVR versus TAVR, intuitively these disparities are more significant after SAVR. Previous studies have identified lower SES as a strong determinant of poor health literacy.[17,18] In turn, reduced health literacy has been associated with reduced medical compliance.[17,19] This may partially explain the greater odds of readmission in patients of lower SES after SAVR. Further investment in SES-tailored patient education after SAVR may be warranted to reduce readmissions in this population.[20,21] We can only speculate whether TAVR providers identify patients with lower SES through effective social screening and implement more appropriate SES-tailored care plans to prevent readmission. This warrants further analysis to understand the root cause of these differences.

Although we adjusted for valve type in our multivariate logistic regression analysis, the increased use of mechanical valves in patients with lower SES in the SAVR group may contribute to the increased readmission rates in these patients. The greater use of mechanical valves in patients with lower SES in the SAVR group is likely explained by their younger age. However, Dalén and colleagues[22] reported that patients with lower SES were more likely to experience bleeding complications after mechanical valve implantation.

Proposed solutions to ameliorate socioeconomic disparities in cardiac surgery outcomes have included the implementation of universal health coverage, although this is

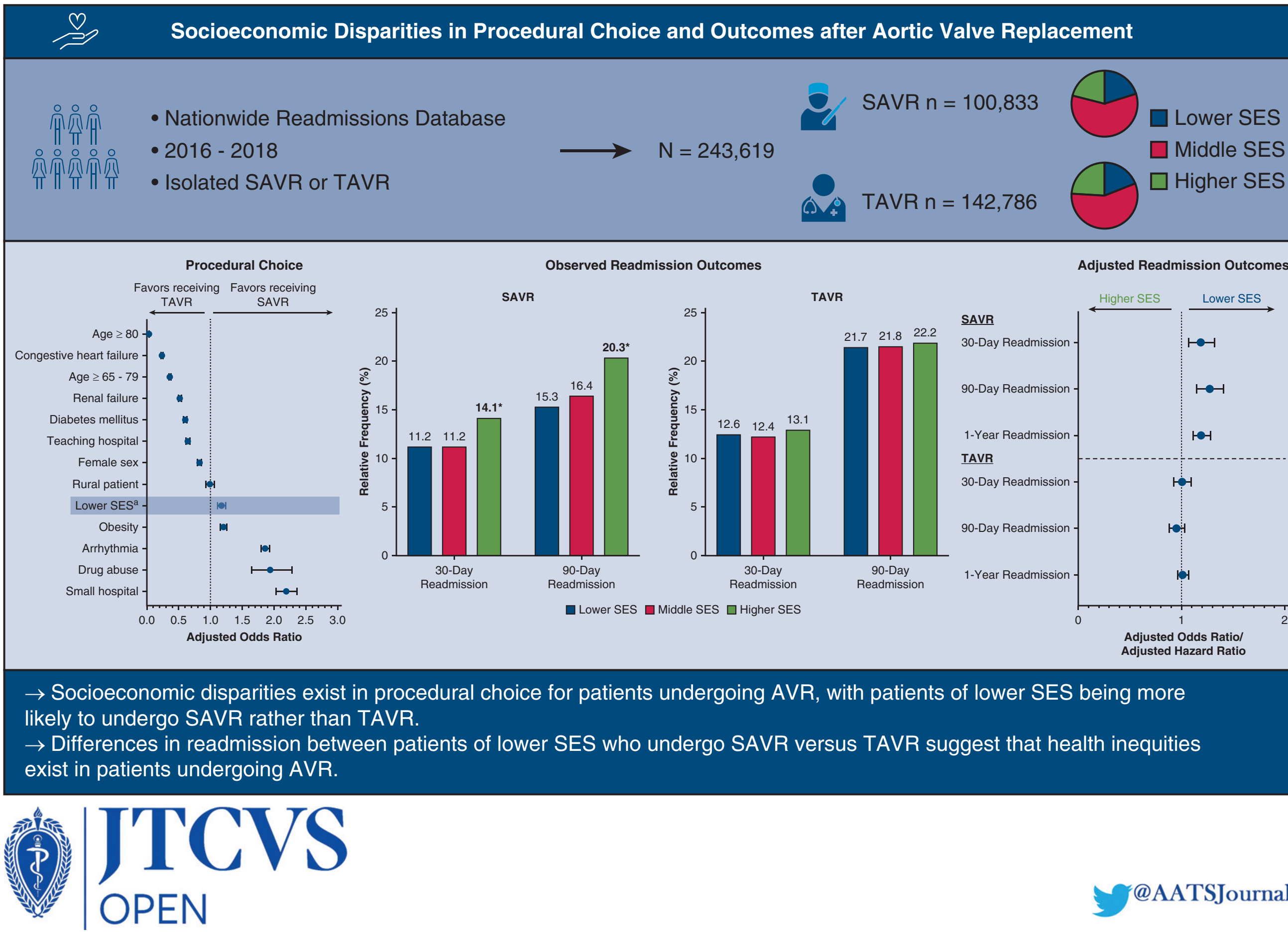

FIGURE 5. Socioeconomic disparities in procedural choice and outcomes after aortic valve replacement. Data from the Nationwide Readmissions Database were collected and analyzed for patients who underwent isolated aortic valve replacement during a 3-year study period. Lower SES was independently associated with undergoing SAVR relative to TAVR. Additionally, lower SES was associated with increased risk-adjusted odds of readmission after SAVR, but not after TAVR. *SAVR*, Surgical aortic valve replacement; *SES*, socioeconomic status; *TAVR*, transcatheter aortic valve replacement; *AVR*, aortic valve replacement. *$P < .05$.

not supported by studies performed in Europe.[23] We showed that home health care is more likely to be necessary for patients who undergo SAVR compared with patients who undergo TAVR. Furthermore, we observed fewer discharges with home health care in patients with lower SES compared to those with higher SES after SAVR. Home health care has been associated with a reduced readmission rate after cardiac surgery.[24] As a result, patients with lower SES might not receive the benefits from discharge with home health after SAVR.

Implementing universal health coverage in turn could increase the rate of discharge with home health care in patients with lower SES, theoretically resulting in decreased readmissions. However, studies from Europe have shown that socioeconomic disparities persist despite study populations that benefit from universal health coverage.[22,25] This supports the concept that socioeconomic disparities in outcomes after cardiac surgery are more complex than socioeconomic barriers in health care access. Therefore, it is important that we continue to identify socioeconomic disparities and their causes in cardiac surgery outcomes so that we may develop, disseminate, and implement SES-tailored strategies to close the socioeconomic gap. Minimal progress has been made on addressing these disparities. A variety of interventions are likely necessary to reduce inequities in care. In addition to raising awareness through further study, using a SES metric such as the one proposed in this study may help identify patients of lower SES, allowing for resource allocation and SES-tailored postdischarge support, such as home-health care, cardiac rehab, and SES-tailored discharge protocols. In this context, although patient-level interventions and care customizations may help increase equity in the care of SAVR patients, the multiplexity of cardiovascular health disparities reaches a macro level. Neighborhood socioeconomic characteristics have been associated with an increased risk of cardiovascular disease after adjusting for individual SES characteristics. Outside the scope of this analysis, primary, secondary, and tertiary preventive measures need to be taken at a community level to manage cardiovascular risk factors, and social determinants of health need to be improved within disparate communities.

The results of this study must be interpreted in light of several limitations, including those inherent to a retrospective analysis of a large administrative database. Limitations of using the NRD include dependence on the ICD-10-CM–based derivations of comorbidities. The inclusion of ICD codes in the SES metric and their potential underutilization introduces the possibility of a misclassification error for SES. There is no perfect model for capturing the complexity of SES; ideally, SES would be measured as a continuous variable. However, we believe that the tiered SES metric used in this study, which is a composite of numerous variables, provides a robust method of reporting SES. Another limitation of the NRD is that it lacks granular admission data, such as ejection fraction, disease etiology, cardiac anatomy, lab values, medications, intraoperative details, race/ethnicity, and hospital TAVR/SAVR availability, reducing the ability to capture key clinical and demographic intersectionality data elements. Therefore, as is common with large database studies, we were unable to account for individual hospital practices. Because the NRD does not track patients across calendar years, index admissions in December were excluded from the 30-day readmission analysis, and index admissions from October to December were excluded from the 90-day readmission analysis.[12,26] Overall, the NRD generates standardized, robust calculations reflecting national-level in-hospital outcomes and readmissions.

CONCLUSIONS

Our study findings suggest that socioeconomic disparities exist in the procedural choice for patients undergoing AVR, with patients of lower SES having increased odds of undergoing SAVR over TAVR. Furthermore, the increased odds of readmission after SAVR, but not after TAVR, in patients with lower SES support the concept that health inequities exist in the surgical care of socioeconomically disadvantaged patients undergoing AVR. Therefore, it is important to investigate the causality of these disparities in future studies to enable the development, dissemination, and implementation of SES-tailored strategies to close the socioeconomic gap in cardiac surgery.

Conflict of Interest Statement

J.S.C. reports participation in clinical studies with and/or consulting for Terumo Aortic, Medtronic, W. L. Gore & Associates, CytoSorbents, Edwards Lifesciences, and Abbott Laboratories and royalties and grant support from Terumo Aortic. M.R.M. serves on an advisory board for Medtronic. S.C. has served on advisory boards for Edwards Lifesciences, La Jolla Pharmaceutical, Eagle Pharmaceuticals, and Baxter Pharmaceuticals. All other authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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Key Words: aortic valve replacement, socioeconomic status, socioeconomic determinants, surgical aortic valve replacement, transcatheter aortic replacement

TABLE E1. ICD-10-CM/PCS

ICD-10-CM/PCS codes	Associated procedure/Diagnosis
Inclusion codes	
ICD-10-PCS 02RF0	Replacement, aortic valve, open approach
ICD-10-PCS 02RF3	Replacement, aortic valve, percutaneous approach
Exclusion codes	
ICD-10-CM I20	Angina pectoris
ICD-10-CM I21	Acute myocardial infarction
ICD-10-CM I38	Endocarditis, valve unspecified
ICD-10-CM I33.0	Acute and subacute infective endocarditis
ICD-10-CM I33.9	Acute and subacute endocarditis, unspecified
ICD-10-CM B37.6	Candidal endocarditis
ICD-10-PCS 02QF	Repair, aortic valve
ICD-10-PCS 02QG	Repair, mitral valve
ICD-10-PCS 02QH	Repair, pulmonary valve
ICD-10-PCS 02QJ	Repair, tricuspid valve
ICD-10-PCS 02RG	Replacement, mitral valve
ICD-10-PCS 02RH	Replacement, pulmonary valve
ICD-10-PCS 02RJ	Replacement, tricuspid valve
ICD-10-CM I25.4	Coronary artery aneurysm and dissection
ICD-10-PCS 0210	Bypass, coronary artery, one artery
ICD-10-PCS 0211	Bypass, coronary artery, two arteries
ICD-10-PCS 0212	Bypass, coronary artery, three arteries
ICD-10-PCS 0213	Bypass, coronary artery, four or more arteries
ICD-10-PCS 02RX	Replacement of thoracic aorta, ascending/arch
ICD-10-PCS 02RW	Replacement of thoracic aorta, descending
ICD-10-PCS 02QX	Repair of thoracic aorta, ascending/arch
ICD-10-PCS 02QW	Repair of thoracic aorta, descending
ICD-10-PCS 04R0	Replacement of abdominal aorta
ICD-10-PCS 04Q0	Repair of abdominal aorta
SES-related codes	
ICD-10-CM Z55	Problems related to education and literacy
ICD-10-CM Z56	Problems related to employment and unemployment
ICD-10-CM Z57	Occupational exposure to risk factors
ICD-10-CM Z58	Problems related to physical environment
ICD-10-CM Z59	Problems related to housing and economic circumstances

ICD-10-CM/PCS, International Classification of Diseases, Tenth Revision, Clinical Modification/Procedure Coding System; *SES*, socioeconomic status.

TABLE E2. Full regression model for procedure choice

Risk factor	aOR	95% CI	*P* value*
Age 65-79 y†	0.360	0.345-0.376	<.001
Age >80 y†	0.034	0.032-0.036	<.001
Female sex	0.829	0.800-0.860	<.001
Urgent intervention	1.147	1.095-1.201	<.001
Lower SES‡	1.174	1.112-1.239	<.001
Middle SES‡	1.123	1.076-1.172	<.001
Congestive heart failure	0.237	0.228-0.246	<.001
Arrhythmia	1.859	1.793-1.927	<.001
Pulmonary circulation disorder	0.980	0.931-1.026	.36
Peripheral vascular disease	0.810	0.776-0.846	<.001
Hypertension	0.786	0.748-0.827	<.001
Chronic obstructive pulmonary disease	0.616	0.590-0.642	<.001
Diabetes mellitus	0.604	0.581-0.628	<.001
Renal failure	0.517	0.495-0.540	<.001
Obesity	1.204	1.154-1.255	<.001
Drug abuse	1.938	1.648-2.279	<.001
Smoking	0.990	0.950-1.023	.46
Hyperlipidemia	0.835	0.803-0.868	<.001
Rural patient	0.990	0.927-1.066	.87
Teaching hospital	0.641	0.611-0.672	<.001
Hospital bed size			
Medium§	1.227	1.177-1.279	<.001
Small§	2.190	2.035-2.358	<.001

aOR, Adjusted odds ratio; *CI*, confidence interval; *SES*, socioeconomic status. *Wald test. †Indexed to <65 years. ‡Indexed to higher SES. §Indexed to larger bed size. Procedural choice as binary outcome with transthoracic surgical aortic valve replacement (TAVR) = 0 and surgical aortic valve replacement (SAVR) = 1.

TABLE E3. Full regression model for 30-day readmission after SAVR

Risk factor	aOR	95% CI	*P* value*
Age 65-79 y†	1.083	0.999-1.173	.052
Age > 80 y†	1.502	1.332-1.694	<.001
Female sex	1.120	1.043-1.203	.002
Urgent intervention	1.063	0.970-1.169	.20
Lower SES‡	1.186	1.068-1.317	.001
Middle SES‡	0.980	0.900-1.070	.66
Congestive heart failure	1.191	1.106-1.283	<.001
Arrhythmia	1.340	1.243-1.445	<.001
Pulmonary circulation disorder	1.212	1.103-1.332	<.001
Peripheral vascular disease	1.076	0.990-1.174	.10
Hypertension	1.120	1.021-1.228	.02
Chronic obstructive pulmonary disease	1.233	1.136-1.339	<.001
Diabetes mellitus	1.192	1.102-1.288	<.001
Renal failure	1.354	1.239-1.480	<.001
Obesity	1.028	0.949-1.114	.50
Drug abuse	0.980	0.771-1.241	.86
Smoking	0.913	0.849-0.980	.01
Hyperlipidemia	0.901	0.835-0.970	.007
Index hospitalization LOS	1.022	1.016-1.027	<.001
Rural patient	0.885	0.769-1.019	.09
Teaching hospital	0.933	0.854-1.020	.13
Hospital bed size			
Medium§	1.012	0.932-1.100	.77
Small§	0.921	0.802-1.056	.24
Mechanical valve‖	1.226	1.119-1.344	<.001

aOR, Adjusted odds ratio; *CI*, confidence interval; *SES*, socioeconomic status; *LOS*, length of stay. *Wald test. †Indexed to <65 years. ‡Indexed to higher SES. §Indexed to larger bed size. ‖Indexed to bioprosthetic valve. Readmission as binary outcome with no readmission = 0 and readmission = 1.

TABLE E4. Full regression model for 90-day readmission after SAVR

Risk factor	aOR	95% CI	*P* value*
Age 65-79y†	1.116	1.034-1.204	.005
Age> 80y†	1.561	1.390-1.752	<.001
Female sex	1.103	1.031-1.181	.005
Urgent intervention	1.064	0.970-1.167	.18
Lower SES‡	1.271	1.149-1.406	<.001
Middle SES‡	1.073	0.990-1.166	.10
Congestive heart failure	1.245	1.160-1.336	<.001
Arrhythmia	1.275	1.187-1.369	<.001
Pulmonary circulation disorder	1.279	1.169-1.400	<.001
Peripheral vascular disease	1.096	1.009-1.191	.03
Hypertension	1.130	1.035-1.235	.007
Chronic obstructive pulmonary disease	1.237	1.144-1.338	<.001
Diabetes mellitus	1.239	1.151-1.334	<.001
Renal failure	1.317	1.209-1.434	<.001
Obesity	1.043	0.970-1.125	.28
Drug abuse	1.077	0.859-1.350	.52
Smoking	0.960	0.899-1.030	.27
Hyperlipidemia	0.928	0.863-0.997	.041
Index hospitalization LOS	1.029	1.023-1.035	<.001
Rural patient	0.861	0.753-0.990	.03
Teaching hospital	0.990	0.906-1.076	.77
Hospital bed size			
Medium§	1.043	0.960-1.128	.29
Small§	0.950	0.838-1.082	.45
Mechanical valve‖	1.198	1.097-1.307	<.001

aOR, Adjusted odds ratio; *CI*, confidence interval; *SES*, socioeconomic status; *LOS*, length of stay. *Wald test. †Indexed to <65 years. ‡Indexed to higher SES. §Indexed to larger bed size. ‖Indexed to bioprosthetic valve. Readmission as binary outcome with no readmission = 0 and readmission = 1.

TABLE E5. Full regression model for 1-year readmission after SAVR

Risk factor	aHR	95% CI	*P* value*
Age 65-79y†	1.07	1.02-1.12	.007
Age >80y†	1.36	1.26-1.47	<.001
Female sex	1.12	1.07-1.16	<.001
Urgent intervention	1.13	1.06-1.20	<.001
Lower SES‡	1.19	1.11-1.28	<.001
Middle SES‡	1.05	0.99-1.11	.13
Congestive heart failure	1.21	1.15-1.27	<.001
Arrhythmia	1.25	1.19-1.31	<.001
Pulmonary circulation disorder	1.19	1.12-1.27	<.001
Peripheral vascular disease	1.11	1.06-1.18	<.001
Hypertension	1.11	1.04-1.17	.001
Chronic obstructive pulmonary disease	1.23	1.17-1.30	<.001
Diabetes mellitus	1.22	1.16-1.29	<.001
Renal failure	1.28	1.21-1.36	<.001
Obesity	1.04	0.99-1.09	.17
Drug abuse	1.13	0.98-1.30	.10
Smoking	0.97	0.92-1.02	.18
Hyperlipidemia	0.93	0.88-0.97	.003
Index hospitalization LOS	1.02	1.01-1.02	<.001
Rural patient	0.92	0.85-0.99	.03
Teaching hospital	0.97	0.91-1.04	.39
Hospital bed size			
Medium§	1.03	0.97-1.10	.30
Small§	0.98	0.89-1.08	.69
Mechanical valve‖	1.11	1.04-1.18	.001

aHR, Adjusted hazard ratio; *CI*, confidence interval; *SES*, socioeconomic status; *LOS*, length of stay. *Wald test. †Indexed to <65 years. ‡Indexed to higher SES. §Indexed to larger bed size. ‖Indexed to bioprosthetic valve. Readmission as binary outcome with no readmission = 0 and readmission = 1.

TABLE E6. Full regression model for 30-day readmission after TAVR

Risk factor	aOR	95% CI	*P* value*
Age 65-79 y†	0.990	0.865-1.123	.83
Age >80 y†	1.113	0.980-1.266	.10
Female sex	1.058	0.998-1.120	.06
Urgent intervention	1.179	1.093-1.270	<.001
Lower SES‡	1.005	0.923-1.094	.91
Middle SES‡	0.980	0.914-1.042	.46
Congestive heart failure	1.228	1.143-1.320	<.001
Arrhythmia	1.278	1.205-1.355	<.001
Pulmonary circulation disorder	1.055	0.990-1.129	.13
Peripheral vascular disease	1.098	1.030-1.171	.004
Hypertension	1.007	0.916-1.107	.88
Chronic obstructive pulmonary disease	1.164	1.094-1.237	<.001
Diabetes mellitus	1.164	1.098-1.234	<.001
Renal failure	1.417	1.336-1.502	<.001
Obesity	0.980	0.909-1.055	.58
Drug abuse	1.095	0.739-1.622	.65
Smoking	0.980	0.921-1.037	.44
Hyperlipidemia	0.874	0.822-0.930	<.001
Index hospitalization LOS	1.032	1.027-1.037	<.001
Rural patient	0.906	0.804-1.021	.11
Teaching hospital	0.980	0.904-1.069	.69
Hospital bed size			
Medium§	0.980	0.919-1.056	.67
Small§	1.038	0.899-1.199	.61

aOR, Adjusted odds ratio; *CI*, confidence interval; *SES*, socioeconomic status; *LOS*, length of stay. *Wald test. †Indexed to <65 years. ‡Indexed to higher SES. §Indexed to larger bed size. Readmission as binary outcome with no readmission = 0 and readmission = 1.

TABLE E7. Full regression model for 90-day readmission after TAVR

Risk factor	aOR	95% CI	*P* value*
Age 65-79 y†	0.950	0.847-1.075	.44
Age > 80 y†	1.048	0.931-1.179	.44
Female sex	1.078	1.024-1.135	.004
Urgent intervention	1.116	1.040-1.198	.002
Lower SES‡	0.950	0.881-1.028	.21
Middle SES‡	0.990	0.928-1.045	.62
Congestive heart failure	1.247	1.170-1.328	<.001
Arrhythmia	1.272	1.207-1.340	<.001
Pulmonary circulation disorder	1.090	1.024-1.160	.007
Peripheral vascular disease	1.126	1.062-1.194	<.001
Hypertension	1.022	0.938-1.113	.62
Chronic obstructive pulmonary disease	1.181	1.118-1.249	<.001
Diabetes mellitus	1.197	1.135-1.263	<.001
Renal failure	1.399	1.327-1.475	<.001
Obesity	0.960	0.895-1.022	.19
Drug abuse	1.430	1.031-1.985	.03
Smoking	0.980	0.931-1.035	.50
Hyperlipidemia	0.864	0.817-0.914	<.001
Index hospitalization LOS	1.034	1.028-1.039	<.001
Rural patient	0.894	0.802-0.997	.043
Teaching hospital	0.946	0.878-1.019	.15
Hospital bed size			
Medium§	0.997	0.936-1.061	.92
Small§	1.029	0.907-1.166	.66

aOR, Adjusted odds ratio; *CI*, confidence interval; *SES*, socioeconomic status; *LOS*, length of stay. *Wald test. †Indexed to <65 years. ‡Indexed to higher SES. §Indexed to larger bed size. Readmission as binary outcome with no readmission = 0 and readmission = 1.

TABLE E8. Full regression model for 1-year readmission after TAVR

Risk factor	aHR	95% CI	*P* value*
Age 65-79 y†	0.97	0.92-1.03	.31
Age > 80 y†	1.03	0.97-1.08	.37
Female sex	1.06	1.02-1.09	.002
Urgent intervention	1.15	1.09-1.20	<.001
Lower SES‡	1.01	0.96-1.07	.60
Middle SES‡	0.98	0.94-1.02	.41
Congestive heart failure	1.15	1.11-1.20	<.001
Arrhythmia	1.29	1.26-1.33	<.001
Pulmonary circulation disorder	1.09	1.04-1.14	<.001
Peripheral vascular disease	1.11	1.07-1.15	<.001
Hypertension	1.01	0.96-1.07	.66
Chronic obstructive pulmonary disease	1.19	1.15-1.23	<.001
Diabetes mellitus	1.17	1.13-1.20	<.001
Renal failure	1.32	1.27-1.36	<.001
Obesity	0.93	0.89-0.97	<.001
Drug abuse	1.31	1.09-1.59	.005
Smoking	0.98	0.94-1.01	.19
Hyperlipidemia	0.90	0.87-0.93	<.001
Index hospitalization LOS	1.02	1.01-1.02	<.001
Rural patient	0.90	0.84-0.95	<.001
Teaching hospital	0.98	0.92-1.04	.52
Hospital bed size			
Medium§	1.00	0.95-1.06	.89
Small§	1.08	0.99-1.19	.08

aHR, Adjusted hazard ratio; *CI*, confidence interval; *SES*, socioeconomic status; *LOS*, length of stay. *Wald test. †Indexed to <65 years. ‡Indexed to higher SES. §Indexed to larger bed size. Readmission as binary outcome with no readmission = 0 and readmission = 1.