Comparison of Frequency of Referral to Cardiothoracic Surgery for Aortic Valve Disease in Blacks, Hispanics, and Whites

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Racial differences in prevalence and in intervention rate of those with severe aortic stenosis have been reported. Our objective was to evaluate health disparities in referral to cardiothoracic surgery (CTS) for aortic stenosis in black and Hispanic compared with white patients before the transcatheter aortic valve replacement program was started in our community. Using a retrospective cohort design, we identified all patients >40 years, who had been captured with aortic valve disease from January 2011 to June 2016. Clinical and echocardiographic data were collected manually. Exposure was race/ethnicity; outcome was referral to CTS. Multivariable logistic regression analysis was conducted with variables that had significance of p <0.20 in univariate model. We included 952 patients in the final analysis (423 white, 376 black, and 153 Hispanic). Compared with whites, black subjects were significantly younger, had more advanced degrees of kidney disease, were more likely to have Medicaid as payer, and had more atherogenic co-morbidities. Black patients had significantly higher aortic valve area indexed for body surface area, more aortic regurgitation, lower peak velocities, lower transvalvular gradients, less calcified valves, and fewer patients in aortic stenosis stage D. The adjusted odds ratio for CTS referral was 0.48 for blacks (p <0.001) and 0.86 for Hispanics (p = 0.73) compared with whites. In conclusion, after adjusting for clinical and echocardiographic variables, black patients were less likely to be referred to CTS for treatment of aortic valve disease. We found no difference in the referral pattern of Hispanic compared with white patients. **(Am J Cardiol 2017;120:450−455)**

Studies from Europe[1] and more recently the United States[2] have suggested that a substantial burden of valvular disease exists in developed countries, likely related to increasing age and life expectancy of these populations, which leads to increased rates of degenerative valve disease. Previously reported studies of aortic valve morphology and disease included nonracially diverse populations consisting primarily of whites and to a much lesser extent blacks.[3] It has been suggested, however, that this underrepresentation might reflect racial differences in the prevalence of severe aortic valve stenosis by race or difference in intervention rate of those diagnosed with severe aortic valve stenosis.[4] Black patients underwent aortic valve replacement less frequently than whites and declined intervention more often (33% vs 20%, p = 0.04). When treated, both groups had similar 3-year survival.[5] Surgical replacement of the aortic valve was historically the only treatment proved to alter prognosis, but the recent introduction of transcatheter aortic valve replacement (TAVR) has offered an effective alternative for these patients.[6] Nonblacks were significantly more likely to receive TAVR than blacks.[7] Although black patients referred for TAVR shared similar risks and outcomes compared with whites, TAVR procedures in blacks were less frequently performed as part of a clinical trial (60.8 vs 76.8%; p = 0.014).[8] Our objective was to evaluate racial disparities in the referral to cardiothoracic surgery (CTS) for aortic valve disease, risk factors, and morphology of the aortic valve in blacks and Hispanics compared with whites before the TAVR program was started in our community.

Methods

Our study population included patients in Methodist Health System who had been diagnosed with aortic valve disease from January 2011 to June 2016. Methodist Health System comprised 4 community-based hospitals (including in Dallas 1 inner-city teaching hospital and referral center) in North Texas. Using a retrospective cohort design, we identified through the electronic medical record system all the patients with aortic valve disease. The search was performed using the *International Classification of Diseases, Ninth Revision* (*ICD 9*), codes: 424.1, 396.0, 396.1, 396.2, 396.3, 396.8, 396.9, 746.3, 746.4, 395.0, 395.2, 395.1, and 395.9; and *ICD 10* codes: I06.8, I06.9, I08.0, I08.2, I08.3, I35.0, I35.1, I35.2, I35.8, and I35.9.

Patients >40 years, of either gender, and of white, black, or Hispanic/Latino descent with aortic valve disease were captured from the inpatient electronic medical record from

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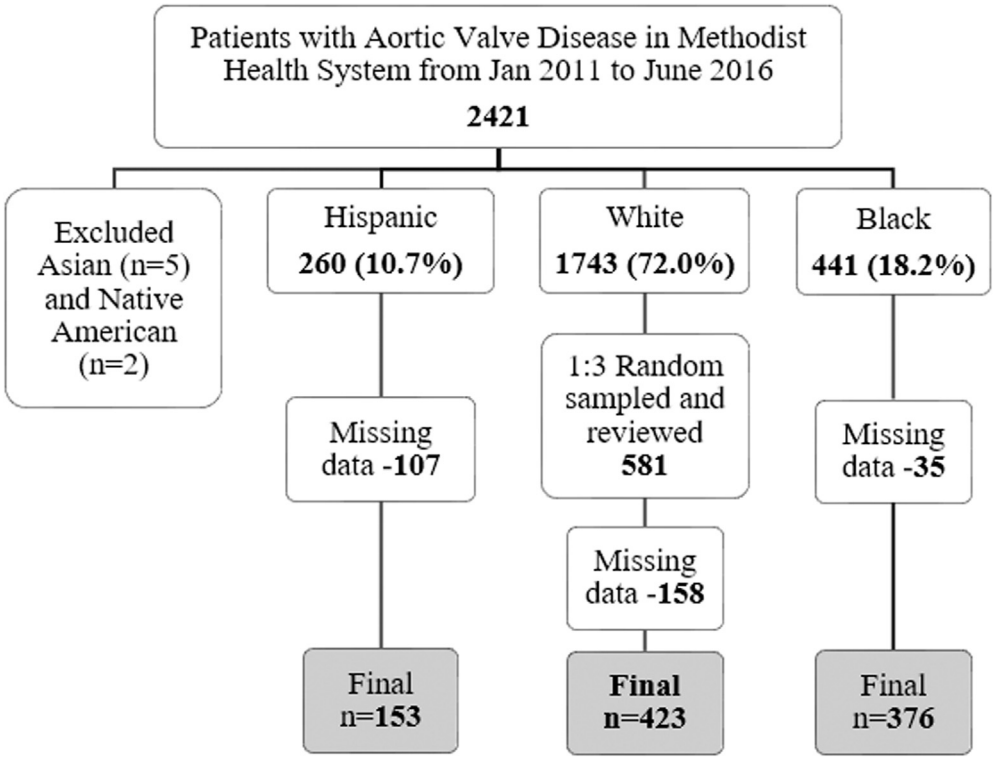

Figure 1. Study population. Sampling tree describing the patients in our study.

January 2011 to June 2016. Because they were so scarce, we excluded Asian (n = 5) and Native American patients (n = 2). We included only the most recent echocardiogram and visit for duplicated patients. Demographic, echocardiographic, and clinical data were gathered by manual review of charts. Echocardiographic data were obtained using the latest echocardiogram report for the index visit. The parameters used in the original echocardiogram report by a board-certified cardiologist were used in the database.

A power analysis using the G-power 3.1 computer program[9] indicated that a total sample of 969 people (323 in each of the 3 groups) would be needed to detect a small effect (Cohen's $F = 0.10$) with 80% power using F tests 1-way ANOVA with alpha at 0.05. We collected the data from 990 patients (330 in each of 3 groups). As we expected to have at least 70% white patients in our population, we decided to do 1:3 random sample of whites but take the totality of blacks and Hispanics.

Descriptive analyses were performed for all continuous variables. Means with SDs are presented for normally distributed variables and medians with interquartile ranges are presented for non-normal continuous variables. Count and proportions are presented for all categorical variables. Continuous outcomes for the 3 groups were analyzed with 1-way ANOVA test or the nonparametric Kruskal-Wallis test depending on if the data were normally distributed or not. Categorical outcomes were analyzed using chi-square test or Fisher's exact test for smaller samples. Missing clinical or echocardiographic data were handled with available case method.

Patient demographics, co-morbidities, medications, insurance status, and echocardiographic parameters were evaluated for inclusion in the regression model using univariate logistic regression. Except for age, left ventricle ejection fraction, aortic valve area (AVA), AVA indexed for body surface area, peak aortic velocity, and mean transvalvular gradient, all independent variables considered in the analysis were specified as categorical variables. Each level of a categorical variable was considered a unique risk factor. Candidate variables for the multivariable model were required to have clinical relevance and a p value <0.20 in the univariate analysis. Each selected variable was examined through the Wald's statistic to assess its contribution to the overall model. Variables with clinical relevance, a p value <0.10, were considered to be relevant to the final model.

First-order interaction terms were evaluated for the variables in final model. The methods by Lemeshow and Hosmer were used for assessing the model calibration.[10] The area under the receiver-operating characteristic (ROC) curve C-statistic (ROC area) was estimated to assess the discriminating ability of the final multivariate logistic regression model.[11] Analyses were performed using STATA, version 14.2 (StataCorp LP, College Station, Texas).

The study was approved by Aspire IRB and the Internal Medicine Department of Methodist Dallas Medical Center. Informed consent was waived because of the retrospective nature of the study.

Results

We identified a total of 2,421 patients (Figure 1). After the random sampling and exclusion criteria, our analytic sample was 423 white, 153 Hispanic, and 376 black

Table 1
Patient demographics and characteristics

Variable*	White n=423	Black n=376	Hispanic n=153	P-value
Age (years)	80 (70-87)	74 (63.5-82.5)	76 (69-85)	<0.001†
Men	192 (45.4%)	151 (40.2%)	66 (43.1%)	0.33‡
Insurance status				0.03‡
Private	28 (6.6%)	32 (8.5%)	8 (5.2%)	
Medicare	379 (89.6%)	314 (83.5%)	133 (86.9%)	
Medicaid	8 (1.9%)	17 (4.5%)	3 (2.0%)	
No insurance	8 (1.9%)	13 (3.5%)	9 (5.9%)	
Height (cm)	167.6 (157-175)	167.6 (162-175)	162.6(152-167)	<0.001‡
Weight (kg)	73.3 (60.1-87.5)	78.5 (63.5-95.3)	70.3 (59.8-86.2)	<0.001‡
BMI (kg/m^2)	25.8(22.2-30.4)	27.0 (22.8-32.8)	27.3 (23.0-32.3)	0.006‡
Groups BMI				
<18.5	29 (6.9%)	24 (6.4%)	8 (5.2%)	0.33‡
>=18.5 & <25	155 (36.6%)	114 (30.3%)	50 (32.7%)	
>=25 & <30	119 (28.1%)	99 (26.3%)	38 (24.8%)	
>=30& <40	96 (22.7%)	107 (28.5%)	45 (29.4%)	
>=40	24 (5.7%)	32 (8.5%)	12 (7.8%)	
BSA (m^2)	1.8 (1.6-2.0)	1.9 (1.7-2.1)	1.7 (1.6-2.0)	<0.001†
Comorbidities				
Diabetes Mellitus	144 (34.0%)	165 (43.9%)	79 (51.6%)	<0.001‡
Hypertension	374 (88.4%)	358 (95.2%)	140 (91.5%)	0.003‡
Hyperlipidemia	189 (44.7%)	179 (47.6%)	81 (52.9%)	0.21‡
End Stage Renal Disease	22 (5.2%)	52 (13.8%)	15 (9.8%)	<0.001‡
CKD 4 (GFR 15-30mL/min)	17 (4.0%)	51 (13.6%)	8 (5.2%)	
CKD 3b (GFR 31-45 mL/min)	18 (4.3%)	17 (4.5%)	8 (5.2%)	
CKD 3a (GFR 46-60 mL/min)	12 (2.8%)	13 (3.5%)	3 (2.0%)	
GFR >=60 mL/min	354 (83.7%)	243 (64.6%)	119 (77.8%)	
Chronic obstructive pulmonary disease	83 (19.6%)	50 (13.3%)	16 (10.5%)	0.008‡
Tobacco abuse	36 (8.5%)	70 (18.6%)	10 (6.5%)	<0.001‡
Medications				
Beta blocker	243 (57.4%)	222 (59.0%)	85 (55.6%)	0.75‡
Aspirin	183 (43.3%)	203 (54.0%)	79 (51.6%)	0.008‡
Second antiplatelet	127 (30.0%)	111 (29.5%)	34 (22.2%)	0.16‡
ACEI/ARB	170 (40.2%)	160 (42.6%)	71 (46.4%)	0.05‡
Statin	172 (40.7%)	195 (51.9%)	72 (47.1%)	0.006‡
LVEF (%)	55 (40-60)	55 (40-60)	55 (42-60)	0.54†
Groups CHF				<0.001‡
No CHF	225 (53.2%)	129 (34.3%)	76 (49.7%)	
Diastolic CHF (LVEF >=50%)	55 (13.0%)	107 (28.5%)	26 (17.0%)	
Borderline diastolic CHF (LVEF 41-49)	49 (11.6%)	47 (12.5%)	21 (13.7%)	
Systolic CHF (LVEF <40%)	94 (22.2%)	93 (24.7%)	30 (19.6%)	
Aortic valve area	1.5 (1.0-2.1)	1.8 (1.2-2.5)	0.8 (1.0-2.1)	<0.001†
Aortic valve area indexed for BSA	0.8 (0.6-1.2)	1.0 (0.6-1.3)	0.9 (0.5-1.2)	0.011†
Peak aortic valve velocity	2.3 (1.6-3.3)	2.4 (1.6-2.9)	2.6 (1.8-3.3)	0.021†
Mean transvalvular gradient	12 (5.2-25)	10 (5-20)	12.6 (6.8-25.2)	0.012†
Bicuspid aortic valve	10 (2.4%)	6 (1.6%)	4 (2.6%)	0.68‡
Aortic calcium				0.005‡
None	134 (31.7%)	154 (41.2%)	41 (26.8%)	
Mild	87 (20.6%)	84 (22.5%)	36 (23.5%)	
Moderate	129 (30.5%)	87 (23.3%)	55 (35.9%)	
Severe	73 (17.3%)	49 (13.1%)	21 (13.7%)	
Aortic regurgitation				0.091‡
None	149 (35.2%)	122 (32.6%)	55 (35.9%)	
Mild	185 (43.7%)	164 (43.9%)	77 (50.3%)	
Moderate	85 (20.1%)	77 (20.6%)	18 (11.8%)	
Severe	4 (0.9%)	11 (2.9%)	3 (2.0%)	
Aortic stenosis stage				0.008‡
B	281 (66.4%)	291 (77.4%)	101 (66.0%)	
C	84 (19.9%)	51 (13.6%)	33 (21.6%)	
D	58 (13.7%)	34 (9.0%)	19 (12.4%)	

(*continued*)

Table 1
(*continued*)

Variable*	White n=423	Black n=376	Hispanic n=153	P-value
Mitral calcium				0.1‡
None	238 (56.3%)	229 (61.2%)	90 (58.8%)	
Mild	156 (36.9%)	115 (30.7%)	49 (32.0%)	
Moderate	27 (6.4%)	23 (6.1%)	14 (9.2%)	
Severe	2 (0.5%)	7 (1.9%)	0 (0.0%)	
Mitral stenosis				0.38‡
None	405 (95.7%)	352 (94.1%)	145 (94.8%)	
Mild	13 (3.1%)	13 (3.5%)	2 (1.3%)	
Moderate	3 (0.7%)	5 (1.3%)	4 (2.6%)	
Severe	2 (0.5%)	4 (1.1%)	2 (1.3%)	
Mitral regurgitation				0.12‡
None	101 (23.9%)	99 (26.4%)	38 (24.8%)	
Mild	220 (52.0%)	210 (56.0%)	91 (59.5%)	
Moderate	73 (17.3%)	48 (12.8%)	21 (13.7%)	
Severe	29 (6.9%)	18 (4.8%)	3 (2.0%)	
Referral to cardiothoracic surgery	132 (31.2%)	79 (21.0%)	47 (30.7%)	0.003‡

ACEI = angiotensin converting enzyme inhibitors; ARB = angiotensin II receptor blocker; BMI = body mass index; BSA = body surface area; CHF = congestive heart failure; CKD = chronic kidney disease; GFR = glomerular filtration rate; LVEF = left ventricle ejection fraction.

* Continuous variables presented as median (25th − 75th percentile) unless otherwise specified.

† Kruskal Wallis test.

‡ ANOVA.

subjects. Table 1 describes the patient demographics, comorbidities, medications, and echocardiographic parameters. Compared with whites, black and Hispanic subjects were significantly younger. A higher proportion of white patients had Medicare insurance, Hispanic patients were more likely to be uninsured and black more likely to have Medicaid and private insurances. Blacks were significantly more likely to have advanced degrees of kidney disease and had higher proportions of diabetes mellitus, hypertension, active smoking, higher BMI, and systolic and diastolic heart failure.

Compared with whites, blacks had significantly higher AVA (both crude and indexed for body surface area), more severe aortic regurgitation (AR), lower peak velocities, lower transvalvular gradients, less calcified aortic valve, and lower proportion of aortic stenosis (AS) stage D by echocardiographic parameters. There was no statistical difference by race in left ventricle ejection fraction, proportion of bicuspid aortic valves, mild AR, or mitral valve pathology (calcification, stenosis, or insufficiency).

The estimates of the crude logistic regression with referral to CTS as the outcome are presented in Table 2. On univariate analysis, black patients were 61% less likely (unadjusted odds ratio [OR] 0.59 95% confidence interval [CI] 0.42 to 0.81) to be referred compared with whites. There was no significant difference between Hispanic and whites.

The final multivariate logistic regression for referral to CTS is displayed in Table 3. The odds of being referred to CTS were 54% lower (adjusted OR 0.46, 95% CI 0.31 to 0.67) in blacks compared with whites after adjusting for age, gender, aortic calcification, mitral regurgitation (MR), AS stage, AVA, mean transvalvular gradient, and use of antiplatelet agents, ACE/ARB, or statins. Compared with whites, Hispanics had a trend for being 10% less likely to be referred (adjusted OR 0.90, 95% CI 0.57 to 1.41), although this was not statistically significant. The adjusted odds of being referred were 89% lower in men compared with women (p value 0.031).

We found evidence of interaction between age and gender (p value = 0.004) and between severe MR and AS. Thus, as age increases, the difference in the referral patterns of men and women decreases. Likewise, patients are more likely to be referred if there is a combination of severe (p value = 0.004) or moderate (p value = 0.046) MR and AS.

The final multivariate model discriminated well with an ROC of 0.7619. The Hosmer-Lemeshow goodness-of-fit statistic (calibration) was 6.24 with a p value of 0.6205 (>0.05), indicating a significant goodness of fit.[10]

Discussion

Consistent with previous studies,[4,5,12] our results show that despite being in a high-volume tertiary care center serving a large black population in North Texas (33% of our patients), only 18% of the patients diagnosed with aortic valve disease were black. Although we did not aim to determine the prevalence of aortic valve disease in the overall population, there was an overwhelming majority of white patients with valve disease, even after adjusting for demographic and other echocardiographic variables.

The disparity in the referral pattern that we observed in black patients even after holding constant all the clinical and echocardiographic parameters may be explained by socioeconomic and cultural factors that need to be studied in the future. Previous studies have shown that compared with white patients, blacks declined aortic valve replacement more often.[5] Comparable with earlier stages in percutaneous coronary intervention and coronary artery bypass surgery, cultural preferences regarding major cardiac surgery may

Table 2
Univariate logistic regression model for referral to cardiothoracic surgery

Variable	Odds ratio (95%CI)	P-value
Race (reference: White)		
Black	0.59 (0.42-0.81)	0.001
Hispanic	0.98 (0.65-1.46)	0.911
Age	0.98 (0.97-0.99)	0.001
Male sex	1.72 (1.29-2.29)	0.002
Insurance status (reference: no insurance)		
Private	1.57 (0.59-4.22)	0.369
Medicare	1.21 (0.51-2.85)	0.667
Medicaid	1.10(0.33-3.65)	0.882
Groups BMI (reference: normal)		
<18.5	1.24 (0.67-2.29)	0.501
>=25 & <30	1.18 (0.81-1.72)	0.391
>=30& <40	1.61 (1.11-2.33)	0.012
>=40	0.76 (0.39-1.46)	0.403
BSA	1.58 (0.95-2.62)	0.079
Comorbidities		
Diabetes Mellitus	1.61(0.87-1.55)	0.310
Hypertension	1.54(0.87-2.71)	0.124
Hyperlipidemia	1.41 (1.06-1.88)	0.017
CKD groups (reference: GFR >=60)		
CKD 3a (GFR 46-60)	1.59 (0.72-3.52)	0.248
CKD 3b (GFR 31-45)	1.54 (0.80-2.94)	0.194
CKD 4 (GFR 15-30)	0.96 (0.55-1.65)	0.874
End Stage Renal Disease	1.39 (0.86-2.23)	0.176
Medications		
Beta blocker	1.27 (0.95-1.70)	0.106
Aspirin	1.35 (1.01-1.79)	0.042
Second antiplatelet	1.74 (1.29-2.37)	<0.001
ACEI/ARB	1.49 (1.11-1.98)	0.007
Statin	1.75 (1.31-2.33)	<0.001
LVEF	0.99 (0.98-0.998)	0.012
Groups of CHF (reference: no CHF)		
Diastolic CHF (LVEF >=50%)	0.73 (0.49-1.11)	0.142
Borderline diastolic CHF (LVEF 41-49%)	1.63 (1.06-2.51)	0.027
Systolic CHF (LVEF <40%)	1.15 (0.80-1.65)	0.490
Aortic valve area	0.64 (0.53-0.77)	<0.001
Aortic valve area indexed for BSA	0.40 (0.28-0.58)	<0.001
Peak aortic valve velocity	1.37 (1.21-1.56)	<0.001
Mean transvalvular gradient	1.02 (1.01-1.03)	<0.001
Bicuspid aortic valve	1.46 (0.57-3.69)	0.428
Aortic calcium (reference: none)		
Mild	0.75 (0.50-1.15)	0.189
Moderate	1.22 (0.85-1.75)	0.282
Severe	1.80 (1.18-2.74)	0.006
Aortic regurgitation (reference: none)		
Mild	0.94 (0.68-1.29)	0.687
Moderate	1.07 (0.71-1.59)	0.759
Severe	0.74 (0.24-2.34)	0.619
Aortic stenosis stage (reference: B)		
Stage C	2.13 (1.48-3.06)	<0.001
Stage D	2.61 (1.71-3.96)	<0.001
Mitral calcium (reference: none)		
Mild	1.09 (0.80-1.48)	0.595
Moderate	1.72 (1.00-2.95)	0.049
Severe	0.82 (0.17-3.99)	0.805
Mitral stenosis (reference: none)		
Mild	0.45 (0.15-1.30)	0.140
Moderate	2.68 (0.86-8.39)	0.090
Severe	1.61 (0.38-6.78)	0.517
Mitral regurgitation (reference: none)		
Mild	1.58 (1.10-2.27)	0.014
Moderate	1.47 (0.91-2.38)	0.113
Severe	1.46 (0.73-2.92)	0.282

ACEI = angiotensin converting enzyme inhibitors; ARB = angiotensin II receptor blocker; BMI = body mass index; BSA = body surface area; CHF = congestive Heart Failure; CKD = chronic kidney disease; GFR = glomerular filtration rate; LVEF = left ventricle ejection fraction.

Table 3
Multivariable logistic regression model for referral to cardiothoracic surgery

Variable	Odds Ratio (95%CI)	P-value
Race (reference: White)		
Black	0.46 (0.31-0.67)	<0.001
Hispanic	0.90 (0.57-1.41)	0.656
Age	0.98 (0.92-0.97)	<0.001
Male Sex	0.11 (0.01-0.82)	0.031
Second antiplatelet	1.85 (1.31-2.62)	<0.001
ACEI/ARB	1.66 (1.19-2.32)	0.003
Statin	1.64 (1.17-2.28)	0.004
Calcification Aortic (reference: none)		
Mild	0.66 (0.40-1.05)	0.080
Moderate	0.63 (0.39-1.02)	0.061
Severe	0.81 (0.43-1.52)	0.512
Mitral regurgitation (reference: none)		
Mild	2.07 (1.25-3.43)	0.005
Moderate	1.57 (0.79-3.10)	0.197
Severe	0.80 (0.25-2.59)	0.712
Mitral stenosis (reference: none)		
Mild	0.45 (0.14-1.39)	0.165
Moderate	3.23 (0.82-12.64)	0.093
Severe	1.19 (0.23-6.28)	0.836
Aortic valve area	0.67 (0.50-0.90)	0.008
Aortic stenosis stage (reference: B)		
Stage C	0.68 (0.22-2.05)	0.491
Stage D	3.63 (1.15-11.44)	0.028
Mean transvalvular gradient	1.01 (0.99-1.02)	0.287
Interaction terms*		
Male sex * age	1.04 (1.01-1.07)	0.004
Moderate MR * AS stage C	4.20 (1.02-17.23)	0.046
Severe MR * AS stage C	50.07 (3.56-703.4)	0.004

ACEI = angiotensin converting enzyme inhibitors; ARB = angiotensin II receptor blocker; AS = aortic stenosis; AVA = aortic valve area; MR = mitral regurgitation.

* Other stages of AS and MR were not statistically significant.

explain differences in the decision-making process between the groups.[13] This phenomenon has also been reported in the setting of esophageal, lung, and colorectal surgery.[13–15]

Another explanation for our findings may include poor culturally appropriate communication by practitioners[5] resulting in misunderstanding of the disease process by the patient. With the evolution of new technologies like TAVR,[6] awareness and a better understanding of the decision-making process through education and individual

counseling are especially important to reach health equity in treatment across minorities.

The racial and ethnic disparities in Hispanic patients with aortic valve disease reflect a gap in the literature. Although we found no difference in the referral pattern for Hispanic patients, further verification of the current results is needed.

Although there were differences in the proportion of insurances by racial group, we did not find any association between insurance status and referral to CTS. The insurance category might be a proxy of socioeconomic status that plays a role in the decision-making process of offering and accepting the referral to CTS because of the cost of the procedure and post-discharge care. Nonetheless, this effect could have been attenuated by selection bias.

The higher point prevalence of cardiovascular risk factors could explain the higher use of aspirin, statins, ACEI, and β blockers in the black subjects of our population. However, we did not collect any assessment of coronary artery disease.

This study is not free of limitations. First, patient selection through *ICD* codes from an administrative database could lead to diagnosis misclassification and might be biased toward patients with more severe disease. Second, we did not include mortality data as we did not have the capacity to follow patients outside our system. Third, because of the nature of the study, we did not had access to all the variables needed to assess operative risk through validated scores as STS or Euroscore. Fourth, as we collected data from hospital records, there is a chance of selection bias. Handling of missing data with available case methods could also lead to some selection bias if the missing pattern was not completely at random. Despite robust multivariable adjustment, unmeasured confounding likely exists. Socioeconomic status is difficult to assess from our clinical records. Risk factors were collected through chart review and might be subject to provider-to-provider variations in documentation although there is no reason to believe one race would have less documentation than another.[4] Finally, we only assessed the referral to CTS, not the valve replacement surgery itself, as we had no means of knowing if patients underwent surgery outside our system.

Our model fits reasonably well with calibration and discrimination statistics comparable with reported medical literature.[10] Nonetheless, because of the selection algorithm used, the performance of the regression model could be optimistic and further studies need to evaluate the model in different patient populations. To develop strategies to reach health equity across minorities, the reasons of this racial disparity need to be identified.

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Disclosures

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