

Temporal trends in transcatheter aortic valve replacement use and outcomes by race, ethnicity, and sex

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Abstract

Objectives: To identify trends in transcatheter aortic valve replacement (TAVR) use and outcomes by race (non-Hispanic White, Black), ethnicity (Hispanic), and sex over time.

Background: Despite rapid growth in TAVR use over time, our understanding of its use and outcomes among males and females of underrepresented racial/ethnic groups remains limited.

Methods: A retrospective analysis of hospitalizations from 2013 to 2017 from the Healthcare Cost and Utilization Project database was performed.

Results: White patients comprised 65% ($n = 2.16 \times 10^7$) of all hospitalizations, yet they comprised 83% ($n = 176,887$) of the admissions for aortic stenosis ($p < 0.0001$). Among 91,693 hospitalizations for aortic valve replacement, 64,069 were surgical (34.0% female, 7.0% Hispanic, and 5.9% Black) and 27,624 were transcatheter (46.6% female, 4.5% Hispanic, and 4.4% Black). Growth in TAVR volumes was the slowest among minorities and females. Hispanic males, Hispanic females, and White females had the highest in-hospital mortality (2.7%–3.3%; compared to White males, adjusted odds ratio: Hispanic males 1.9 [1.2–3.0], Hispanic females 1.9 [1.2–3.1], and White females 1.4 [1.2–1.7]). Despite less baseline vascular disease, females of all races/ethnicities had more vascular complications than men (female 5% vs. male 3.5%, $p \leq 0.001$). Further adjustment for vascular complications only partially attenuated mortality differences. Black and Hispanic patients had a longer mean length of hospital stay than White patients, which was most pronounced among females. Pacemaker requirements were consistently low among all groups.

Conclusion: Differences in TAVR growth and outcomes by race, ethnicity, and sex over time highlight areas for focused efforts to close gaps in minimally invasive structural heart disease care.

KEYWORDS

aortic stenosis, disparities, gender, outcomes

Abbreviations: AVR, aortic valve replacement; CABG, coronary artery bypass grafting; HCUP, Healthcare Cost and Utilization Project; ICD-9 and ICD-10, International Classification of Diseases, Ninth and Tenth Revision; SAVR, surgical aortic valve replacement; TAVR, transcatheter aortic valve replacement.

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1 | INTRODUCTION

Over the last decade, transcatheter aortic valve replacement (TAVR) has transformed life-saving treatment options for patients with aortic stenosis.¹ However, our understanding of how TAVR use and outcomes by race, ethnicity, and sex have responded to recent increases in accessibility is limited, with a paucity of data reflecting the modern structural heart era.² Most prior studies of race, ethnicity, or sex predate landmark TAVR trials, as well as national regulatory approvals, updated guidelines, and modern-day practices.^{3–7} Importantly, they largely examine race/ethnicity alone, or sex alone, but do not focus on the important interaction between sex and race/ethnicity. The aim of this study is to understand potential differences in TAVR use and outcomes by race, ethnicity, and sex over time, which will be essential to guide programs as we rapidly scale across the spectrum of novel minimally invasive cardiac procedures.

2 | METHODS

2.1 | Data source

We used the Nationwide Inpatient Sample from the Agency for Healthcare Research and Quality, Healthcare Cost and Utilization Project (HCUP),⁸ which is the largest, most comprehensive source of longitudinal hospital data in the United States. It includes all-payer, encounter-level information without selection bias, and has been widely used.⁹ We identified all patients in whom race (White or Black), ethnicity (Hispanic or non-Hispanic), and sex (male or female) were known. Few were excluded due to low representation (Asian 0.4%, Native American 0.1%, and other 0.8%) or missing race (1.8%). If the source supplied race and ethnicity in separate data elements, ethnicity took precedence over race. We used the International Classification of Diseases, Ninth (ICD-9) and Tenth Revision (ICD-10) codes to identify all admissions for any form of aortic valve replacement (AVR) from January 2013 to December 2017 (Table S1).

2.2 | Health outcomes

We identified health outcomes measures of in-hospital mortality and length of stay, as well as postprocedural in-hospital complications, specifically permanent pacemaker implantation and vascular complications (intraoperative or postprocedural hemorrhage, hematoma, or arterial/venous complication). We also identified all patients hospitalized with a diagnosis of aortic stenosis to approximate the burden of severe disease by race/ethnicity during 2015–2017 (during which the transition to ICD-10 coding allowed aortic stenosis to be distinguished from aortic regurgitation, Table S1).

2.3 | Analytic methods

We evaluated differences in patient characteristics by race, ethnicity, and sex using χ^2 tests for categorical variables and analysis of variance for continuous variables. Socioeconomic status was determined using HCUP income data that stratifies patients into four quartiles based on median household state-specific and year-specific income by patient ZIP code (range \$0–\$74,000+). We used the Mantel–Haenszel test for trends to evaluate outcomes over time among race/ethnicity/sex subgroups. We used multivariate logistic regression to adjust for all baseline differences in Table 1, as well as procedure year. We additionally adjusted for postprocedural vascular complications to determine the degree to which this impacted mortality. To handle missing data, we imputed the mean for continuous variables and created a missing category for categorical data to not lose categorical data. A $p < 0.05$ was considered statistically significant. The statistical program SAS 8.2 was used for all analyses. The data that support the findings of this study are available from the corresponding author upon reasonable request. This study was approved by the Stanford Institutional Review Board.

3 | RESULTS

White patients were significantly more likely to have a diagnosis of aortic stenosis as their indication for hospitalization compared to other races/ethnicities; White patients comprised 65% ($n = 2.2 \times 10^7$) of all admissions, yet comprised 83% ($n = 176,887$) of the admissions for aortic stenosis ($p < 0.0001$). The breakdown of admissions for aortic stenosis by race/ethnicity/sex were 93,149 (44.8%) White males, 88,152 (42.4%) White females, 5761 (2.8%) Black males, 8405 (4.0%) Black females, 6252 (3.0%) Hispanic males, and 6415 (3.1%) Hispanic females. The proportion of patients receiving TAVR from among those hospitalized with any diagnosis of aortic stenosis was 8.6% of White males, 7.4% of White females, 5.2% of Black males, 4.4% of Black females, 5.6% of Hispanic males, and 5.8% of Hispanic females. When limiting hospitalizations to only those with a principal diagnosis of aortic stenosis (which would more specifically approximate those with severe aortic stenosis), the proportion receiving TAVR was 40.1% White males, 46.2% White females, 35.0% Black males, 39.7% Black females, 27.4% Hispanic males, and 39.7% Hispanic females. Similar proportions were found for aortic stenosis as a secondary diagnosis. Of note, 28% ($n = 6284$) of TAVRs were performed in patients without a diagnosis of aortic stenosis, with a higher proportion among Black females (31.3%) and Hispanic females (32.2%) compared to other groups (27.2%–29.0%).

For our primary analysis of procedural treatments for AS, we included 91,693 hospitalizations for AVR, representing 458,465 total U.S. hospitalizations for AVR from 2013 to 2017. Of those studied, 64,069 were for surgical aortic valve replacement (SAVR) (34.0% female, 7.0% Hispanic, and 5.9% Black) and 27,624 were for TAVR (46.6% female, 4.5% Hispanic, and 4.4% Black). The total number of AVRs grew over time, with a cumulative annual increase of 6%–9%. For all patients

TABLE 1 Baseline characteristics

	Female				Male				p
	All n = 27624	White n = 11539	Black n = 692	Hispanic n = 641	White n = 13630	Black n = 513	Hispanic n = 609		
Age (SD)	80.3 (8.5)	81.2 (8.0)	78.0 (10.0)	79.3 (9.1)	80.1 (8.5)	75.2 (11.0)	78.2 (10.7)	<0.0001	
Medical Comorbidity									
HTN	24022 (87%)	10013 (86.8%)	640 (92.5%)	574 (89.6%)	11792 (86.5%)	469 (91.4%)	534 (87.7%)	<0.0001	
DM	10074 (36.5%)	3788 (32.8%)	332 (48.0%)	291 (45.4%)	5132 (37.7%)	229 (44.6%)	302 (49.6%)	<0.0001	
IHD	1262 (4.6%)	563 (4.9%)	28 (4.1%)	17 (1.4%)	603 (4.4%)	29 (5.7%)	22 (3.6%)	<0.05	
AF/A flutter	11727 (42.5%)	4859 (42.1%)	185 (26.7%)	186 (29.0%)	6117 (44.9%)	162 (31.6%)	218 (35.8%)	<0.0001	
Chronic renal disease	10100 (36.6%)	3509 (30.4%)	306 (44.2%)	229 (35.7%)	5479 (40.2%)	316 (61.6%)	261 (42.9%)	<0.0001	
CHF	20639 (74.7%)	8576 (74.3%)	532 (76.9%)	470 (73.3%)	10207 (74.9%)	410 (79.9%)	444 (72.9%)	<0.04	
PAD	7690 (27.8%)	2689 (23.3%)	169 (24.4%)	150 (23.4%)	3933 (29.3%)	140 (27.3%)	176 (28.9%)	<0.0001	
Chronic pulmonary disease	9869 (35.7%)	4195 (36.4%)	265 (38.3%)	215 (33.5%)	4827 (35.4%)	183 (35.7%)	184 (30.2%)	0.02	
Malignancy	953 (3.4%)	298 (2.6%)	15 (2.2%)	19 (3.0%)	567 (4.2%)	27 (5.3%)	27 (4.4%)	<0.0001	
Charlson comorbidity index								<0.0001	
0-2	12437 (45%)	5845 (51%)	253 (36%)	277 (43.2%)	5694 (42%)	133 (26%)	235 (38.6%)		
3-4	8950 (32.4%)	3500 (30%)	236 (34%)	213 (33.2%)	4599 (34%)	202 (39%)	200 (32.8%)		
5+	6237 (22.6%)	2194 (19%)	203 (29%)	151 (23.6%)	3337 (25%)	178 (35%)	174 (28.6%)		
Primary payer								<0.0001	
Medicare	24924 (90.4%)	10706 (92.9%)	614 (88.9%)	542 (84.6%)	12121 (89.1%)	428 (83.9%)	513 (84.4%)		
Other	357 (1.3%)	53 (0.5%)	2 (0.3%)	7 (1.1%)	271 (2.0%)	13 (2.6%)	11 (1.8%)		
Medicaid	304 (1.1%)	90 (0.8%)	19 (2.8%)	36 (5.6%)	123 (0.9%)	13 (2.6%)	23 (3.8%)		
Private	1866 (6.8%)	638 (5.5%)	53 (7.7%)	52 (8.1%)	1021 (7.5%)	51 (10.0%)	51 (8.4%)		
Self-pay	126 (0.5%)	41 (0.4%)	2 (0.3%)	4 (0.6%)	64 (0.5%)	5 (1.0%)	10 (1.6%)		
No charge	5 (0%)	1 (0.01%)	1 (0.1%)	0	3 (0.02%)	0	0		
Income quartile								<0.0001	
1	5951 (21.9%)	2346 (20.6%)	358 (52.5%)	201 (32.3%)	2604 (19.4%)	250 (49.2%)	192 (32.7%)		
2	6958 (25.6%)	2937 (25.8%)	121 (17.7%)	151 (24.2%)	3507 (26.2%)	100 (19.7%)	142 (24.2%)		
3	7097 (26.1%)	2965 (26.0%)	113 (16.6%)	140 (22.5%)	3635 (27.1%)	90 (17.2%)	154 (26.2%)		
4	7185 (26.4%)	3147 (27.6%)	90 (13.2%)	131 (21.0%)	3650 (27.3%)	68 (13.4%)	99 (16.9%)		

Note: Income Quartile 4 is highest.

Abbreviations: AF/A flutter, atrial fibrillation/atrial flutter; CHF, congestive heart failure; DM, diabetes; HTN, hypertension; IHD, ischemic heart disease; PAD, peripheral arterial disease.

combined, TAVR volumes increased 30%–49% per year, while SAVR volumes decreased minimally over time (Figure 1A). Relative to the year-specific population of each race/ethnicity/sex subgroup per the U.S. Census, the rate of uptake in TAVR use over time among White males exceeded all other groups, with Hispanics and Blacks experiencing the slowest growth (Figure 1B). The pattern of increasing TAVRs with concomitant decreasing SAVRs over time was mirrored in each race/ethnicity and sex subgroup, with the exception of Black and Hispanic males, who had a slight rise in SAVRs over time (Figure 1B, Table 2).

White patients ($p < 0.0001$). Black patients were younger and had more comorbidities than White patients. Men of all races/ethnicities had more baseline vascular disease than women (28.5% men vs. 23.7% women, $p < 0.0001$). Over time, TAVR procedures were performed in younger patients (81.2 ± 8.7 in 2013 to 79.6 ± 8.5 in 2017) with lower Charlson comorbidity indices (3.2 ± 1.9 in 2013 to 3.0 ± 2.2 in 2017).

3.1 | Baseline characteristics

Among TAVR patients (Table 1), Black and Hispanic patients had more Medicaid insurance ($p < 0.0001$) and lower income compared to

3.2 | Clinical outcomes

Hispanic males and females, followed by White females, had the highest in-hospital TAVR mortality of all groups (3.3% Hispanic males, 3.0% Hispanic females, 2.7% of White females vs. 1.6%–1.9% for all other groups, $p = 0.0002$, Figure 2), which remained significant after

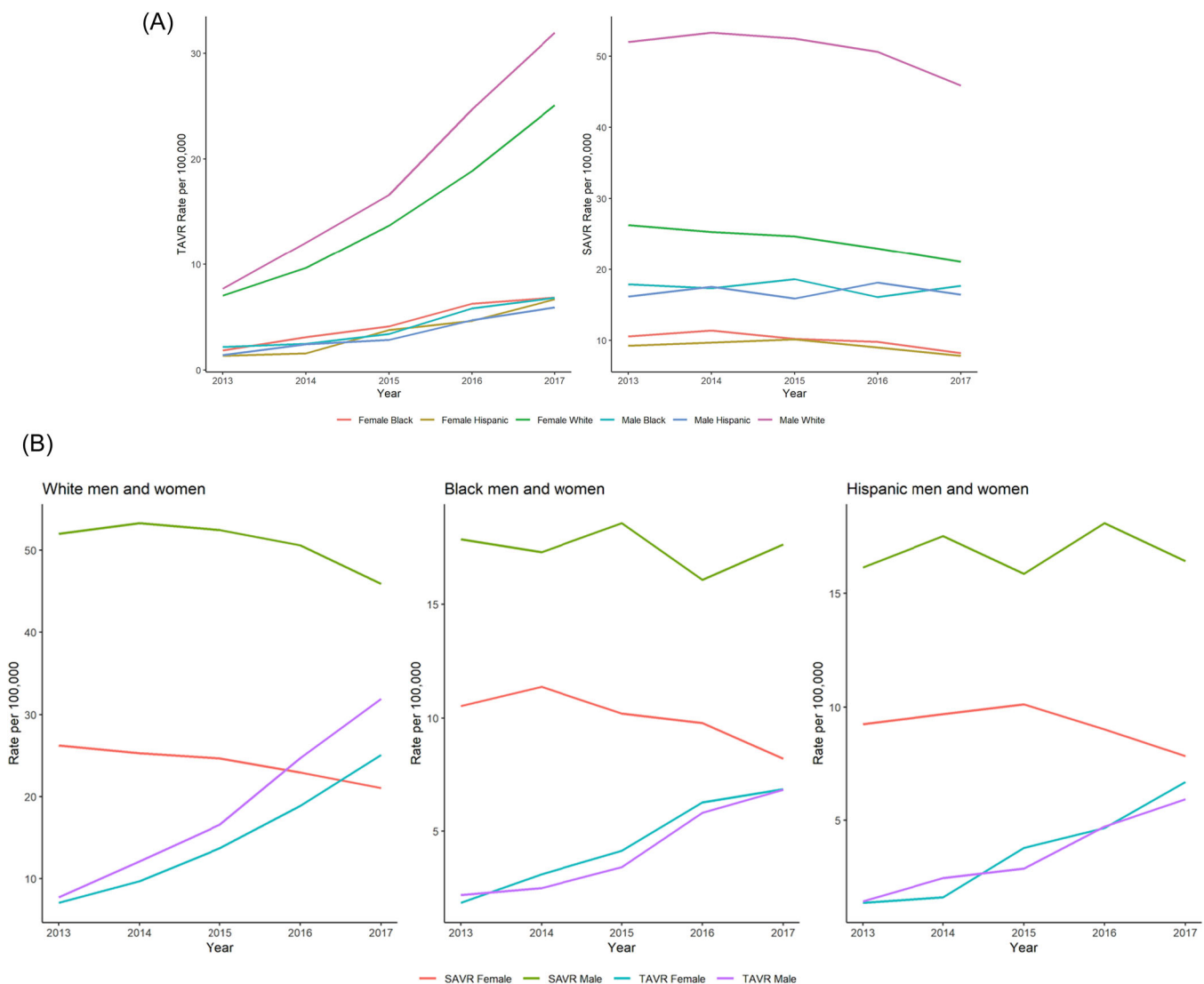


FIGURE 1 Temporal trends in TAVR and SAVR volumes by race/ethnicity and sex. Rates of weighted procedural volumes reported per 100,000 population by respective race/ethnicity/sex and year according to U.S. Census data. (A) TAVR and SAVR rates for all races/ethnicities and sexes combined. (B) TAVR and SAVR rates by race/ethnicity and sex. SAVR, surgical aortic valve replacement; TAVR, transcatheter aortic valve replacement

TABLE 2 SAVR and TAVR procedure volumes by race, ethnicity, and sex over time

Year	Female						Male					
	White		Black		Hispanic		White		Black		Hispanic	
	SAVR	TAVR	SAVR	TAVR	SAVR	TAVR	SAVR	TAVR	SAVR	TAVR	SAVR	TAVR
2013	4048	1085	315	55	303	44	7558	1118	434	33	528	46
2014	3912	1493	345	94	325	53	7784	1765	431	62	590	82
2015	3830	2127	316	128	354	132	7664	2425	474	87	550	99
2016	3563	2929	307	197	324	167	7419	3622	417	151	646	168
2017	3274	3905	261	218	287	245	6751	4700	465	180	594	214

Abbreviations: SAVR, surgical aortic valve replacement; TAVR, transcatheter aortic valve replacement.

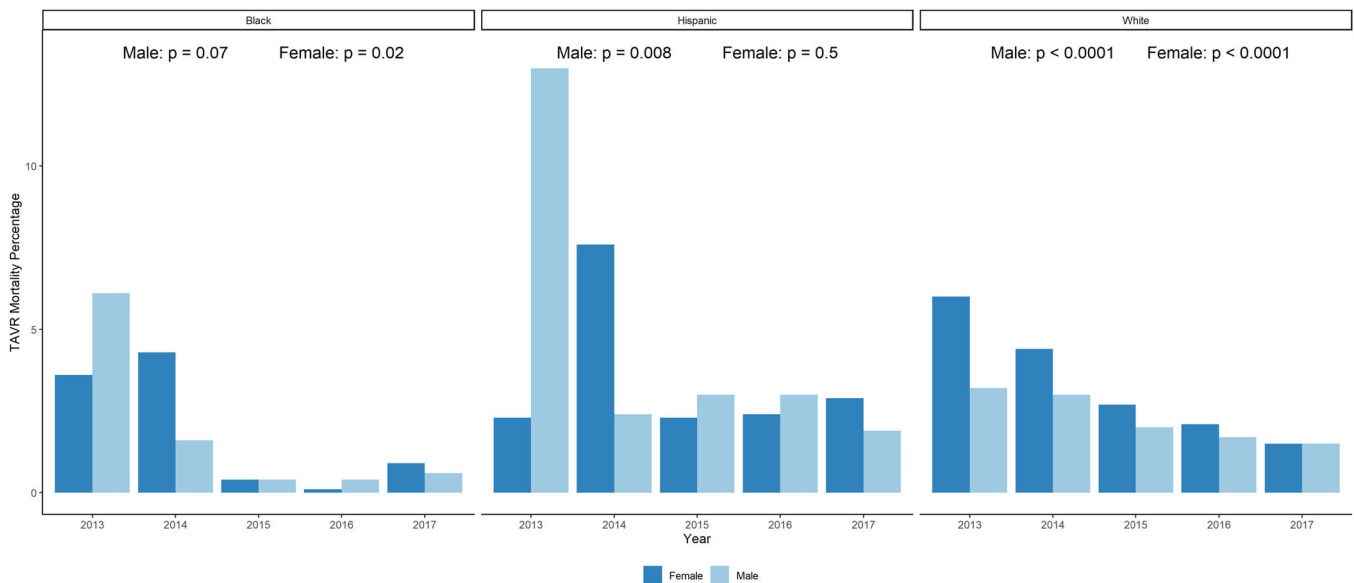


FIGURE 2 Temporal trends in mortality after TAVR by race, ethnicity, and sex. Mortality declined over time among all White patients, Hispanic males, and Black females. *p*-values denote the *p* trend. TAVR, transcatheter aortic valve replacement [Color figure can be viewed at wileyonlinelibrary.com]

adjustment for baseline characteristics and year (compared to White males, White females: odds ratio [OR]: 1.42, 95% confidence interval [CI]: 1.22–1.71, Hispanic females: OR: 1.89, 95% CI: 1.17–3.05, Hispanic males: OR: 1.91, 95% CI: 1.19–3.04, Figure 3). After further adjustment for vascular complications, the odds of mortality among Hispanic males, Hispanic females, and White females decreased, but remained significantly worse compared to White males (Hispanic men: OR: 1.89 [95% CI: 1.18–3.02], Hispanic females: OR: 1.75 [95% CI: 1.08–2.83], White females: OR: 1.39 [95% CI: 1.17–1.65], Figure 3). Black males and females had the lowest mortality rates, which were comparable to White males after adjustment for comorbidities and vascular complications (compared to White males with 1.9% mortality rate, Black males: 1.8%, OR: 0.93 [0.47–1.8], Black females: 1.6%, OR: 0.91 [0.49–1.7]). While all subgroups had reductions in mortality over time, Hispanic females had an initial bump in mortality from 2.3% in 2013 to 7.6% in 2014 before reaching a steady lower rate over time. Hispanic males had the

highest initial mortality rate (13.0% in 2013) which dropped significantly by the next year (2.4% in 2014).

When race and sex were included as separate variables in the model, females had an OR of 1.39 (95% CI: 1.19–1.64), Black patients had an OR of 0.74 (95% CI: 0.47–1.17), and Hispanic patients had an OR of 1.57 (95% CI: 1.12–2.19) for mortality. An interaction term (race × sex) was not significant ($p = 0.24$).

Baseline comorbidities that predicted higher odds of mortality included atrial fibrillation (OR: 1.25 [1.06–1.47]), heart failure (OR: 1.32 [1.08–1.62]), renal failure (OR: 1.64 [1.39–1.94]), and peripheral arterial disease (1.22 [1.03–1.45]). Compared to 2017, receipt of a procedure in earlier years also predicted higher risk of in-hospital mortality (2013: OR: 3.07 [95% CI: 2.38–3.97], 2014: OR: 2.35 [95% CI: 1.84–3.01], 2015: OR: 1.52 [95% CI: 1.19–1.96], 2016: OR: 1.27 [95% CI: 1.00–1.61]).

Black and Hispanic patients had a longer mean length of stay than White patients, which was particularly pronounced among

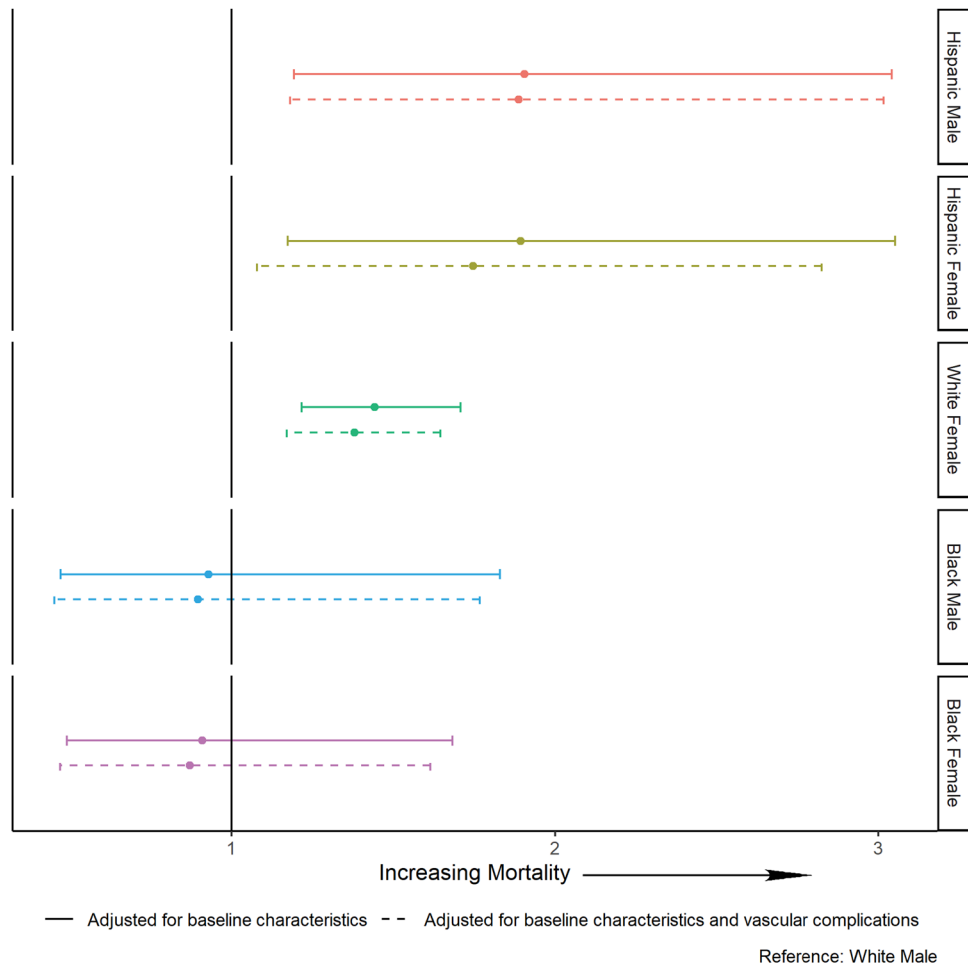


FIGURE 3 Adjusted mortality after TAVR by race/ethnicity and sex. Hispanic males and females, followed by White females, had higher adjusted mortality after TAVR compared to White males. Additional adjustment for procedural vascular complications only partially attenuated these differences. TAVR, transcatheter aortic valve replacement [Color figure can be viewed at wileyonlinelibrary.com]

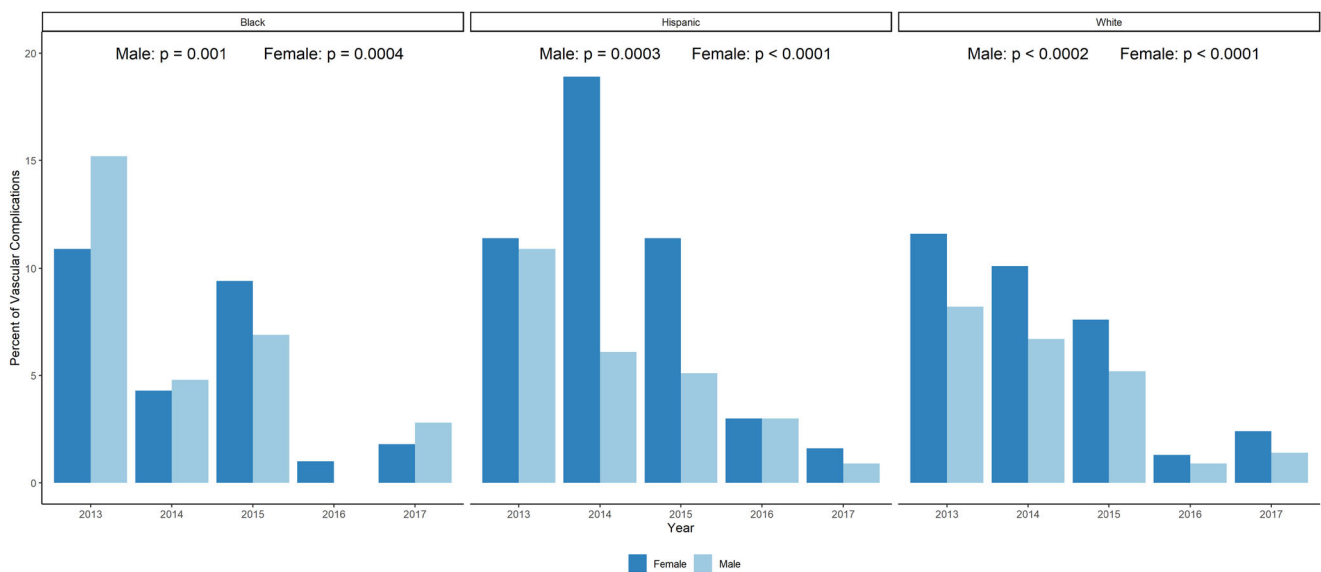


FIGURE 4 Temporal trends in vascular complications after TAVR by race, ethnicity, and sex. Major vascular complications decreased for all patients over time, with higher complications among women across all race/ethnic groups. *p*-values denote the *p* trend. TAVR, transcatheter aortic valve replacement [Color figure can be viewed at wileyonlinelibrary.com]

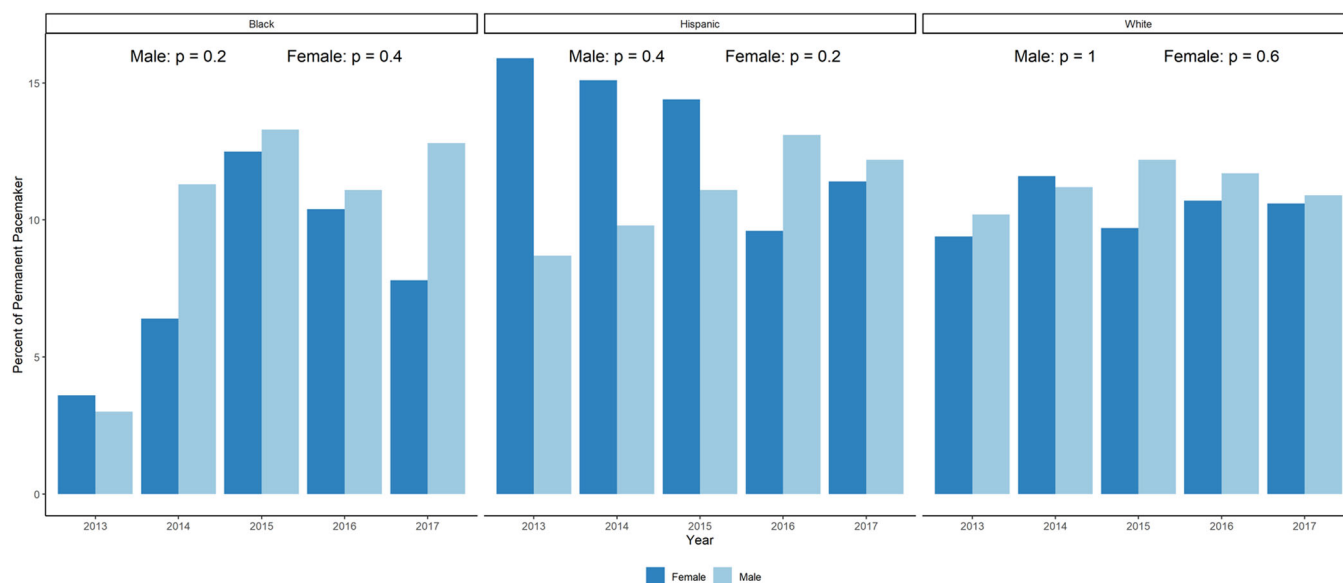


FIGURE 5 Temporal trends in pacemaker implantation after TAVR by race, ethnicity, and sex. All groups experienced similar low post-TAVR permanent pacemaker implantation requirements. *p*-values denote the *p* trend. TAVR, transcatheter aortic valve replacement [Color figure can be viewed at wileyonlinelibrary.com]

females (Black males: 6.7 ± 7.6 days, Black females: 7.1 ± 7.4 , Hispanic males: 6.5 ± 8.1 , Hispanic females: 7.0 ± 7.4 , White males: 5.3 ± 6.2 , and White females: 5.7 ± 6.1 , $p < 0.0001$).

3.3 | Procedural complications

Females had more vascular complications after TAVR than males (female 5% vs. male 3.5%, Figure 4). Vascular complications consistently declined over time for each race and sex combination, with the exception of an increase among Hispanic females from 2013 to 2014 (11.4%–18.9%). Overall, permanent pacemaker rates were low among all groups (female 10.5%, male 11.1%, Figure 5).

4 | DISCUSSION

In a large national study of aortic stenosis treatment and outcomes by race, ethnicity, and sex,¹⁰ we found a steep rise in the use of TAVR among White males over time, with slower growth among all other subgroups. Hispanic males and females suffer the highest TAVR mortality of all subgroups, followed by White females, even after adjusting for baseline demographics, comorbidities, and procedure year. Poorer outcomes among these subgroups are only partially mediated by their higher vascular complication rates. Despite a higher burden of comorbidities and lower socioeconomic status, Black males and females experience similar low mortality to White males.

Our data on changes in AVR volumes over time suggest that TAVRs have not simply replaced SAVR volume, but rather allowed more patients to receive valve replacement who might not otherwise receive treatment. The fact that SAVR volumes remained stable while

TAVR volumes grew over time, particularly among Hispanic and Black males, suggests undertreatment of aortic stenosis in these groups during the pre-TAVR era. However, relative to current proportions of underrepresented groups in the U.S. (14% Black, 20% Hispanic per U.S. Census, with year-specific subgroup populations used as a reference in Figure 1A),¹¹ the uptake of TAVR among Black and Hispanic populations continues to lag behind White patients. The uneven growth in TAVR volumes over time represents a missed opportunity to close gaps in equitable access to this life-saving procedure to date, and at the same time, identify targets for future efforts.

We uncover persistent inequities in mortality by ethnicity and sex—though not in the same patterns reported in other procedural and surgical literature.¹² This suggests that our existing approaches to addressing disparities may not apply to this novel paradigm of care. When comparing TAVR mortality between sexes, we found that females suffered higher in-hospital mortality than males, which persisted after adjustment for baseline characteristics. Older registry data showed higher procedural complications among females with lower long-term mortality compared to males,⁴ likely related to vascular complications in the setting of smaller vessel sizes.¹³ While vascular complications have long been cited to explain sex differences in outcomes, the higher in-hospital mortality risk among females in our study was only minimally reduced after adjustment for those differences. These findings give us pause to consider whether there may be unexamined critical factors influencing the observed sex differences.

Hispanic males and females had higher mortality compared to White males, despite fewer comorbidities and higher socioeconomic levels than Black males and females. This counters what has been described as the “Hispanic paradox,” in which Hispanics are less likely

to die from the cardiovascular disease despite higher risk profiles than non-Hispanic White patients.¹⁴ The impact of acculturation on treatment refusal and the applicability of the “healthy migrant effect” as described in the cardiovascular literature warrant further investigation about their potential application to the TAVR space.^{15,16} Note that the higher mortality of 13% among Hispanic males in 2013 represents very small numbers (only 46 TAVRs were performed in Hispanic males in 2013) and should be interpreted with uncertainty. If true, it may reflect a lag in adoption among either Hispanic male patients or their providers during this early period, which seemed to improve in subsequent years to more closely match non-Hispanic groups. Slower early adoption among Hispanics who were healthy enough to be offered traditional surgical alternatives may have left only high-risk Hispanic patients to undergo TAVR in the earliest time period, translating into higher mortality rates. Surgical literature also suggests that Hispanics undergoing coronary artery bypass grafting (CABG) are half as likely as White patients to receive treatment from high-quality surgeons.¹⁷ Among TAVR operators, less experience may be linked to a lag in early adoption of improved techniques (e.g., transfemoral in favor of transapical access), which could also contribute to high mortality rates among Hispanic patients in the earlier years.¹⁸

Black patients had lower income with more Medicaid insurance, and a higher Charlson comorbidity index despite younger age. Collectively these factors likely contributed to the higher absolute mortality in Black men, but after adjustment for baseline characteristics, the Black race was no longer a significant predictor of mortality, consistent with other studies.^{19–22} Since we know that the benefit of higher-volume hospital treatment is stronger for Black patients undergoing CABG than White patients,²³ it is possible that disparities in TAVR outcomes among Black patients have diminished as a direct impact of the sheer increase in TAVR volumes. At the least, this, in combination with our findings, provides hope that TAVR may be narrowing racial differences in health outcomes in ways that other procedural treatments have not.²⁴ We speculate that the Affordable Care Act Medicaid and Marketplace coverage expansions in 2014 that increased insurance coverage for lower income Black patients could have also contributed to the notable drop in mortality among Black men that year, even though it did not impact overall TAVR uptake.²⁵

Despite these promising results, we must be wary of interpreting the low mortality rates among Black patients as a definite accomplishment, as they may in fact be masking gaps in care. Our findings that demonstrate a higher proportion of White patients hospitalized with a diagnosis of aortic stenosis (AS) and higher receipt of TAVR from among those hospitalized suggest at least three alternative possible explanations for the low mortality among Black patients: (1) we may not be fully capturing overall poor outcomes among the sickest Black patients if they remain underdiagnosed (skewing prevalence estimates), (2) extremely late presentation could result in undertreatment due to poor procedural candidacy, and (3) treatment bias may exclude the highest risk Black patients from receiving novel procedural treatments.

Our findings that a higher proportion of Black and Hispanic females had a TAVR without a diagnosis of aortic stenosis suggest either variable diagnostic coding accuracy or atypical or inappropriate use of TAVRs in these groups. These findings also question the validity of prior AS prevalence estimates that rely on equivalent coding accuracy across race/ethnic groups, which warrants further study.²⁶ Further studies of patient preferences are also needed to provide context for our mortality findings.

Our findings on longer lengths of stay among Black and Hispanic patients likely reflect time spent managing their higher burden of comorbidities, and particularly among females, their vascular complications. However, given the older age of females receiving TAVR, it is also possible that the proportion of females with a living spouse/partner is lower than among males, potentially decreasing their social network to support recovery and consequently, increasing their length of stay.

There are limitations to this study. While our dataset provides the advantage of capturing in-hospital procedures without bias from voluntary reporting, it lacks the granularity to assess detailed information about anatomy, operator experience, the severity of comorbidities, contraindications, procedural access, patient preferences, and nuanced social determinants of health. Indications for SAVR and TAVR may include conditions other than aortic stenosis, but these should not meaningfully impact utilization trends over time. We recognize that the absolute numbers of Black and Hispanic patients were low despite sampling the entire country over multiple years. For this reason, we excluded racial minorities with even lower representation (less than 1%) and did not examine heterogeneity within each race/ethnicity or mixed race. This dataset also did not allow us to assess longer-term outcomes. We do not capture the population of patients who may never receive a procedure due to preprocedural barriers to care. While we adjusted extensively for patient characteristics, unadjusted covariates may persist.

5 | CONCLUSION

Amidst the recent rapid growth of novel minimally invasive therapies for cardiovascular disease, this study reveals slower TAVR uptake among underrepresented minorities over time and disparate outcomes among certain ethnic/sex subgroups. As we struggle as a nation to narrow health disparities, the promising findings of low procedural mortality among Black patients offer hope that novel treatments need not widen them. However, the disproportionate diagnosis of aortic stenosis by race among those hospitalized and the variable diagnostic coding of aortic stenosis among patients treated with TAVR, particularly among Black and Hispanic women, suggest additional complexities that warrant further study.

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CONFLICTS OF INTEREST

Wayne Batchelor reports consulting for Abbott, Medtronic, and Boston Scientific. Celina M. Yong, Karolina Jaluba, Santosh Gummipundi, Steven M. Asch, and Paul Heidenreich report no relevant conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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