

STATE-OF-THE-ART REVIEW

Racial and Ethnic Differences in Treatment and Outcomes of Severe Aortic Stenosis



A Review

Jimica B. Wilson, BS,^a Larry R. Jackson II, MD,^b Francis E. Ugowe, MD,^c Terrell Jones, BS,^d George S.A. Yankey, Jr, MD,^c Colin Marts, BA,^d Kevin L. Thomas, MD^b

ABSTRACT

Aortic stenosis (AS) is among the most common valvular heart diseases encountered in the United States. In this review the authors examine differences between racial and ethnic groups in the epidemiology and management of severe AS, explore potential explanations for these findings, and discuss the implications for improving the delivery of care to racially and ethnically diverse populations. Underrepresented racial and ethnic groups experience a paradoxically lower prevalence or incidence of AS relative to white subjects, despite having a higher prevalence of traditional risk factors. Historically, UREGs with severe AS have had lower rates of both surgical and transcatheter aortic valve replacement and experienced more post-surgical complications, including, bleeding, worsening heart failure, and rehospitalization. Last, UREGs with severe AS have an increased risk for morbidity and mortality relative to white patients. To date much of the research on AS has examined black-white differences, so there is a need to understand how other racial and ethnic groups with severe AS are diagnosed and treated, with examination of their resulting outcomes. Overall, racial and ethnic disparities in health care access and care delivery are a public health concern given the changing demographics of the U.S. population. These differences in AS management and outcomes highlight the need for additional research into contributing factors and appropriate interventions to address the lower rates of aortic valve replacement and higher morbidity and mortality among UREGs. (J Am Coll Cardiol Intv 2020;13:149-56) © 2020 by the American College of Cardiology Foundation.

Aortic stenosis (AS) is the most common valvular heart disease globally and the third most common cardiovascular disease after hypertension and coronary artery disease (1,2). Risk factors associated with AS include hypertension, tobacco use, hyperlipidemia, renal insufficiency, diabetes mellitus, atherosclerosis, congenital bicuspid aortic valve (AV), congestive heart failure, and advanced age (3-7). The prevalence of AS is 12.4% in persons ≥ 75 years of age and affects approximately

2.7 million and 4.9 million people in North America and Europe, respectively (8).

AS is a progressive disease with high mortality and an average life expectancy of 1 year after the onset of symptoms such as angina, dyspnea, and heart failure or syncope (9,10). Severe AS affects 3.4% of the elderly population, with approximately 75.6% of these patients experiencing symptoms (8). In North America alone, it is estimated that there will be 0.8 million and 1.4 million patients with symptomatic

From the ^aAlbany State University, Albany, Georgia; ^bDuke Clinical Research Institute, Durham, North Carolina; ^cDuke University Medical Center, Durham, North Carolina; and the ^dDuke University Medical School, Durham, North Carolina. This research was not supported by agencies in the public, commercial, or not-for-profit sectors. The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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**ABBREVIATIONS
AND ACRONYMS**

- aOR** = adjusted odds ratio
- AS** = aortic stenosis
- AV** = aortic valve
- AVR** = aortic valve replacement
- CI** = confidence interval
- HR** = hazard ratio
- SAVR** = surgical aortic valve replacement
- TAVR** = transcatheter aortic valve replacement
- UREG** = underrepresented racial and ethnic group

severe AS in 2025 and 2050 respectively (8). An analysis of Medicare data from 2003 estimated that the total annual cost of medically managed severe, symptomatic AS is between \$600 million and \$1.3 billion per year, representing a substantial financial burden to the health care system (11). Management of symptomatic AS has evolved over time from medical therapy and balloon angioplasty to surgical AV replacement (SAVR). More recently, transcatheter AV replacement (TAVR) has been successful in reducing morbidity and mortality in the highest risk patients (5,12,13), and eligibility is expanding to moderate and low surgical risk patients.

To date, few studies have examined differences in the prevalence, management, and outcomes of severe AS in racially and ethnically diverse populations. Moreover, most studies of severe AS have focused largely on data from black and white

HIGHLIGHTS

- Data on the management and outcomes of diverse populations with severe AS are lacking.
- Underrepresented racial/ethnic groups have lower rates of AVR and worse outcomes.
- Studies assessing reasons for lower AVR and strategies/interventions are needed.

racial groups; thus, data from Asian and Hispanic populations with severe AS are limited. Given the changing demographics of the U.S. population, understanding the public health impact of AS across racial and ethnic groups is necessary. In this review, our objectives were to examine the prevalence and incidence of severe AS among racially/ethnically diverse populations, analyze the management of

TABLE 1 Cited Studies on the Prevalence, Management, or Outcomes of Severe Aortic Stenosis in Underrepresented Racial and Ethnic Groups

First Author, Year (Ref. #)	Title	Study Design	Major Findings
Alkhouli et al., 2019 (27)	Racial Disparities in the Utilization and Outcomes of TAVR: TVT Registry Report	RCS, from ACC/STS TVT Registry using CMS data in a subset of patients for outcomes	TAVR rates were lower among nonwhites relative to whites, but no differences in adjusted 30-day or 1-yr mortality.
Alqahtani et al., 2018 (24)	Effect of Race on the Incidence of Aortic Stenosis and Outcomes of Aortic Valve Replacement in the United States	Retrospective propensity-matched cohort study of patients ≥60 yrs of age with diagnoses of AS who underwent AVR	Blacks undergo AVR less than whites. After AVR, in-hospital mortality is similar, but blacks have higher costs and longer hospitalizations than whites.
Aronow et al., 2001 (14)	Comparison of Echocardiographic Abnormalities in African-American, Hispanic, and White Men and Women Aged >60 Years	Prospective cohort study analyzing the prevalence of echocardiographic findings in black, Hispanic, and white men and women age ≥60 yrs in long-term health care facilities	The overall prevalence of AS was higher in white men and women relative to blacks and Hispanics.
Brennan et al., 2019 (23)	Race and Sex-Based Disparities Persist in the Treatment of Patients With Severe, Symptomatic Aortic Valve Stenosis	Retrospective claims linked database study using hierarchical logistic regression models to determine the propensity of AVR and TAVR among women and racial and ethnic minorities	Blacks were less likely to undergo AVR relative to whites but underwent TAVR at a similar rate.
Beydoun et al., 2016 (1)	Sex, Race, and Socioeconomic Disparities in Patients With Aortic Stenosis (From a Nationwide Inpatient Sample)	Cross-sectional study of the Healthcare Cost and Utilization Project Nationwide Inpatient Sample to examine sex, racial, and socioeconomic disparities in AS-related health in patients age ≥50 yrs	AS prevalence was ~2% and was higher among men, whites, and higher income groups; length of stay for AS hospitalization varied by sex, race, and income.
Chandra et al., 2012 (7)	Bicuspid Aortic Valve: Inter-Racial Difference in Frequency and Aortic Dimensions	RCS of 229 patients from echocardiography database with BAV (65% black, 31% white) to assess patient characteristics and risk factors and AV morphology and function	Smaller aortic dimensions were observed in blacks despite more risk factors, suggesting race as a potential disease modifier in the development of BAV.
Cruz Rodriguez et al., 2017 (18)	Comparison of Frequency of Referral to Cardiothoracic Surgery for Aortic Valve Disease in Blacks, Hispanics, and Whites	RCS of clinical and echocardiographic data of 952 patients with AV disease (423 white, 376 black, and 153 Hispanic) to assess referral to CTS as function of race/ethnicity	Blacks were less likely to be referred to CTS for treatment of AS relative to whites; there was no difference in referral of Hispanics.
Minha et al., 2015 (13)	Outcome Comparison of African-American and Caucasian Patients with Severe Aortic Stenosis Subjected to Transcatheter Aortic Valve Replacement: A Single-Center Experience	Prospective cohort study of 469 consecutive patients with severe, symptomatic AS (10.8% black, 74.5% white) who underwent TAVR at a single center from 2007 to 2013	TAVR procedures in black patients were less frequently performed; black patients referred for TAVR shared similar risks and outcomes compared with whites.

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severe AS as a function of race/ethnicity, and compare morbidity and mortality among patients with severe AS according to race/ethnicity.

METHODS

STUDY SELECTION. In accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, a search of PubMed, Scopus, and Web of Science was performed using a mixture of the following terms as Medical Subject Headings or their equivalent: “aortic valve stenosis or aortic stenosis,” “minority,” “ethnic groups,” “African Americans,” “blacks,” “Hispanics,” “Latinos,” “Mexican American,” “Asian,” “Pacific Islander,” “Asian American,” “Native American,” “Indian,” “Caucasian,” “European American,” “disparity,” and “bias.” The search strategy focused on studies in English from January 2001 to December 2018. Our initial findings were supplemented with manual searches of the

bibliographies of relevant papers. Several independent reviewers (J.B.W., T.J., C.M., G.S.A.Y., K.L.T., F.E.U., L.R.J.) appraised a selection of both full publications and abstracts of randomized controlled trials, observational studies, and systematic reviews and meta-analyses. We identified 31 published papers and abstracts focused on diverse racial and ethnic populations with severe AS; 15 were ultimately included (Table 1). Our search strategy is outlined in the Consolidated Standards of Reporting Trials diagram in Figure 1.

RESULTS

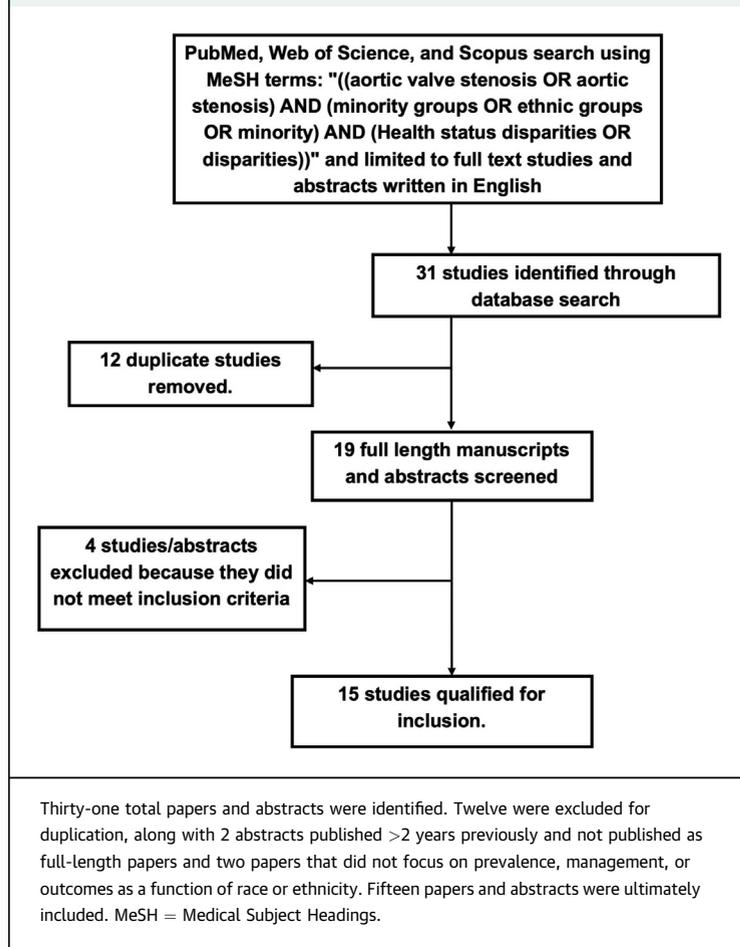
RACIAL AND ETHNIC DIFFERENCES IN PREVALENCE OF SEVERE AS. AS is a progressive, degenerative process that results in clinically significant narrowing of the valve and resultant outflow obstruction. The most common cause of AS in the United States is

TABLE 1 Continued

First Author, Year (Ref. #)	Title	Study Design	Major Findings
Patel et al., 2014 (5)	Racial differences in the Prevalence of Severe Aortic Stenosis	RCS of echocardiographic data from the Synthetic Derivative at Vanderbilt University Medical Center to assess the association of race with severe AS	Blacks patients have a significantly lower risk of developing severe AS compared with whites.
Sleder et al., 2017 (16)	Socioeconomic and Racial Disparities: A Case-Control Study of Patients Receiving Transcatheter Aortic Valve Replacement for Severe Aortic Stenosis	Retrospective case-control study of 67 patients with severe AS who underwent TAVR from 2013 to 2014	The odds of undergoing TAVR increased by 10% with every \$10,000 increase in income; nonblacks were significantly more likely to undergo TAVR than blacks, with no differences in comorbidities between groups.
Stamou et al., 2012 (29)	Effects of Gender and Ethnicity on Outcomes After Aortic Valve Replacement	RCS of Massachusetts Cardiac Surgery Database, which identified 6,809 adults ≥18 yrs of age who underwent isolated AVR or AVR with CABG	Ethnicity and sex were not associated with greater 30-day and 1-yr mortality after AVR or AVR with CABG; there were no differences in postoperative outcomes between ethnic groups.
Taylor et al., 2005 (12)	Relationship Between Race and Mortality and Morbidity After Valve Replacement Surgery	RCS of 3,137 black and 46,249 white patients who underwent MVR alone or AVR alone from 1999 through 2002 in the Society of Thoracic Surgeons National Cardiac Database	There was evidence of an association between race and certain complications, but overall race did not appear to be a significant predictor of operative mortality after isolated AVR or MVR.
Yankey et al., 2018 (22)	Aortic Valve Replacement and Outcomes in Patients with Severe Aortic Stenosis: Is It Black or White?	Abstract for RCS of patients from a single center between 1999 and 2013 who met criteria for AVR on the basis of echocardiographic indices plus EF <50%, evidence of heart failure, or need for CABG	There were no significant racial differences in all-cause mortality; black patients were less likely to receive AVR; risk was attenuated after adjustment for demographics and comorbidities.
Yeung et al., 2013 (17)	Racial Differences in Rates of Aortic Valve Replacement in Patients with Severe Aortic Stenosis	RCS of rates of AVR in 880 patients (10% AA, 90% EA) from a single center between 2004 and 2010	AA patients had a higher prevalence of comorbidities; AA patients underwent AVR less frequently than EA patients and refused treatment more often; among those who received intervention, AA and EA patients had similar 3-yr survival.
Yoon et al., 2016 (28)	Clinical Outcomes Following Transcatheter Aortic Valve Replacement in Asian Population	Prospective cohort study of a multicenter, international Asian TAVR registry examining patients with AS who underwent TAVR in Asian countries	TAVR clinical outcomes in observed Asian population were comparable with those previously published in trials and observational studies.

AA = African American; ACC = American College of Cardiology; AS = aortic stenosis; AV = aortic valve; AVR = aortic valve replacement; BAV = bicuspid aortic valve; CABG = coronary artery bypass grafting surgery; CMS = Centers for Medicare and Medicaid Services; EA = European American; EF = ejection fraction; MVR = mitral valve replacement; RCS = retrospective cohort study; STS = Society of Thoracic Surgeons; TAVR = transcatheter aortic valve replacement; TVT = Transcatheter Valve Therapy.

FIGURE 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses
Flowchart Documenting Search Strategy, Exclusions, and Final Numeric Selection of
Papers for the Review



calcific AV disease, which shares many risk factors with the development of atherosclerosis, including older age, male sex, hypertension, and tobacco use. AS can also be caused by congenital bicuspid valve and rheumatic heart disease, which are less common in developed countries. The overall prevalence of severe AS (AV area <1.0 cm² or AV index ≤0.60 cm²/m² or AV velocity ≥40 mm Hg) in the United States is approximately 2% to 7% of the general population (2,13). The overall estimated prevalence of AS in elderly patients is reported to range from 2.6% to 22.8%, with severe AS prevalent in 1.2% to 6.1% (8).

Several cohort studies have analyzed the epidemiology of AS in various racial and ethnic populations. An analysis of data from the Healthcare Cost and Utilization Project Nationwide Inpatient Sample found that relative to white patients, the diagnosis of AS was less prevalent in underrepresented racial and ethnic groups (UREGs) with adjusted odds ratios

(aORs) of 0.68 in black patients (95% confidence interval [CI]: 0.66 to 0.71), 0.79 in Hispanics (95% CI: 0.76 to 0.84), and 0.68 in Asians (95% CI: 0.64 to 0.74) (1). Data support the relative underdetection of AS among UREGs. Patel et al. (5) identified a cohort of 272,429 patients with echocardiographic data from the Synthetic Derivative at Vanderbilt University Medical and found that severe AS was observed in 0.29% of black and 0.91% of white patients; after multivariate adjustment, black patients remained significantly less likely to be diagnosed with severe AS relative to white patients (aOR: 0.41; 95% CI: 0.33 to 0.50).

Using a large echocardiography database of 40,878 patients, Chandra et al. (7) discovered, in their sample of 183 patients with bicuspid AV, that blacks had a lower prevalence relative to Caucasians (0.17% vs. 1.1%; $p = 0.001$) of this anomaly. Patel et al. (5), in an analysis of echocardiographic records in a large patient cohort, found that blacks were less likely to have severe AS secondary to calcific disease or congenital bicuspid disease, with aORs of 0.47 (95% CI: 0.36 to 0.61) and 0.13 (95% CI: 0.02 to 0.80), respectively. In a study analyzing the echocardiographic findings of 2,805 black, Hispanic, and white men and women living in a long-term care facility, there were no differences in echocardiographic AS indexes by race or ethnicity (14).

In an effort to examine the genetics underlying the development of phenotypically significant AS, Thanassoulis et al. (15) conducted a genomewide association study using patients from the CHARGE (Cohorts for Heart and Aging Research in Genomic Epidemiology) consortium (15). Researchers isolated a single-nucleotide polymorphism (rs10455872) in the lipoprotein(a) locus that reached significance for AV calcification (odds ratio: 2.05; $p = 9.0 \times 10^{-10}$). This finding was successfully replicated in cohorts of European white, black, and Hispanic patients ($p < 0.05$ for all comparisons). In prospective analyses, the lipoprotein(a) genotype was linked to incident AS (hazard ratio [HR]: 1.68; 95% CI: 1.32 to 2.15), as well as AV replacement (AVR) (HR: 1.54; 95% CI: 1.05 to 2.27). Further research in the field of AS genetics is important to potentially identify additional genetic loci associated with the phenotypic development of AS and severe AS physiology and the conceivable variable expression in different racial and ethnic groups.

It is known that UREGs relative to white patients possess higher rates of traditional AS risk factors, such as congestive heart failure, chronic kidney disease, smoking, hypertension, obesity, and diabetes mellitus (1,4,5,12,13,16-18). The paradox whereby

UREGs cluster more AS risk factors relative to whites but display a lower burden of disease has been observed in other cardiovascular diseases, most notably with atrial fibrillation (19,20). A lower incidence of bicuspid AV, lower likelihood of developing calcific AS, and potential racial and ancestry variations in AS genetic risk predilection may, in part, explain variances in AS prevalence. However, the mechanism behind this finding has yet to be completely elucidated (**Central Illustration**).

RACIAL DIFFERENCES IN MANAGEMENT OF SEVERE AS. SAVR. Approximately 67,500 SAVR procedures are performed annually in the United States (21). Few studies have examined racial/ethnic differences in SAVR procedures. However, those that have consistently demonstrate that UREGs are less likely to undergo SAVR compared with white patients (12,17,22,23). Yeung et al. (17) found that blacks underwent SAVR significantly less often than whites (39% vs. 53%; $p = 0.02$) (17). Similarly, Alqahtani et al. (24) analyzed data from 96,278 patients who underwent SAVR between 2003 and 2014 and found that among patients admitted for AS, black patients were less likely to undergo SAVR than white patients (6.7% vs. 11.3%; $p < 0.001$) (24).

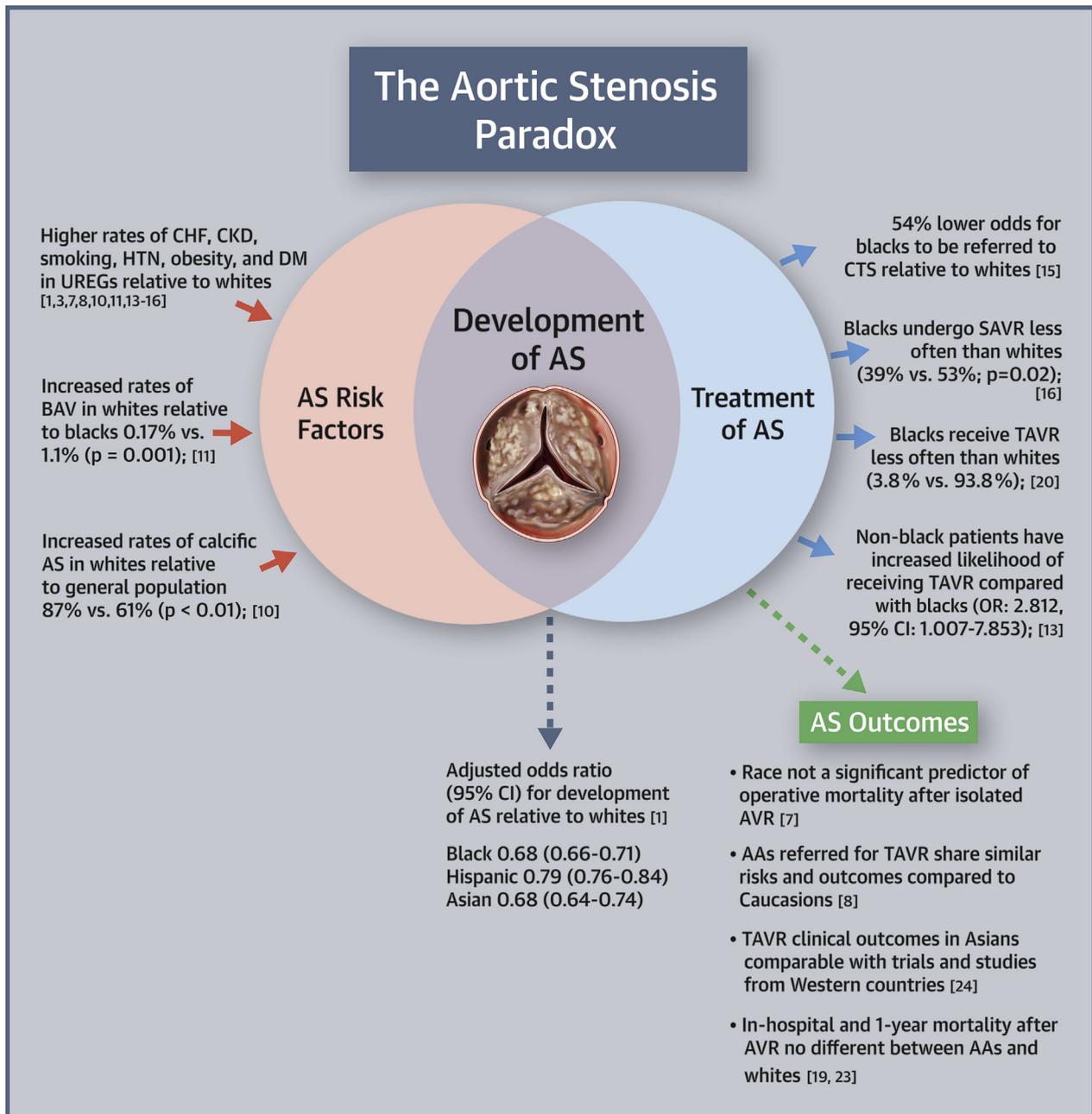
There is a paucity of research examining the reasons for racial and ethnic differences in AVR. Racial and ethnic differences in referral to specialists may in part explain differences in AVR rates. Cruz Rodriguez et al. (18), after adjusting for age, sex, aortic calcification, AV area, or stage of AS, found that black patients with AV disease had a 54% lower odds of being referred to cardiothoracic surgery (aOR: 0.46; 95% CI: 0.31 to 0.67) relative to white patients. Hispanics were 10% less likely to be referred for cardiothoracic surgical evaluation, but this value did not reach statistical significance. Additional hypotheses for differences in cardiothoracic surgery referral rates and SAVR procedures include dissimilarities in socioeconomic and cultural influences and black patients' more often declining intervention (17,18). Consistent with other invasive procedures, black patients may decline SAVR because of misconceptions about the surgical procedure or lack of insight regarding their disease prognosis (8,18,25). Consequently, shared decision making may represent an opportunity to address racial and ethnic disparities in SAVR.

Additionally, UREGs may be less likely to undergo SAVR because of an increased burden of comorbidities. This was observed by Yeung et al. (17) in blacks with AVA $< 1 \text{ cm}^2$, who were found to have higher rates of hypertension (82% vs. 67%; $p < 0.01$), diabetes mellitus (45% vs. 32%; $p = 0.02$), chronic kidney

disease (28% vs. 17%; $p = 0.01$), and end-stage renal disease (18% vs. 2%; $p < 0.001$) relative to whites. Yeung et al. (17) also found that noncardiac comorbidities were the most common reasons preventing patients from undergoing major cardiovascular surgery. Assessing surgical risk through tools validated in diverse populations may determine the cogency of this explanation.

TAVR. Over the past decade, TAVR has emerged as an effective and safe alternative for treatment of symptomatic severe AS in patients at high surgical risk (26). However, several studies have demonstrated that racial and ethnic disparities also exist in the use of TAVR. Data from the Society of Thoracic Surgeons/American College of Cardiology TVT (Transcatheter Valve Therapy) Registry revealed from 2012 to 2014, blacks underwent TAVR less often than whites (3.8% vs. 93.8%) (25). Similarly, in a retrospective case-control study, Sleder et al. (16) observed that nonblack patients had an increased likelihood of undergoing TAVR compared with black patients (odds ratio: 2.812; 95% CI: 1.007 to 7.853; $p = 0.048$). Moreover, the odds of undergoing TAVR increased by 10% for every \$10,000 increase in income ($p = 0.05$). Last, in a more recent analysis of the TVT Registry from 2011 to 2016 by Alkhouli et al. (27), relative to white patients, black, Hispanic, and other nonwhite groups remained underrepresented among patients undergoing TAVR in the United States. The reasons for this difference in TAVR receipt are likely multifactorial, with a complex interplay of socioeconomic, cultural, and patient- and provider-centric factors. Specifically, patients' mistrust of physicians and the health system, patients' denial or misunderstanding of the grave risks associated with untreated AS, and the lack of access to care and qualified services all likely play a role in differences in receipt of TAVR procedures (9). Brennan et al. (23), using records from the claims-linked Optum database (2014 to 2017), found that among 20,577 patients (3.3% black, 0.7% Asian, and 6.9% other) with severe symptomatic AS, blacks (odds ratio: 0.77; 95% CI: 0.63 to 0.95) but not Asians were less likely to undergo AVR relative to whites but had a similar propensity for TAVR. These findings suggest TAVR use among UREGs may be different among the broader community, and underuse may be diminishing over time.

OUTCOMES IN PATIENTS WITH SEVERE AS BY RACE AND ETHNICITY. Without AVR, patients with symptomatic, severe AS have a 50% mortality risk at 2 years (10) (**Figure 2**). Patients who undergo AVR have significantly better survival at 1 and 3 years (10,17). Alqahtani et al. (24) found in black relative to white

CENTRAL ILLUSTRATION The Aortic Stenosis Paradox

Wilson, J.B. et al. *J Am Coll Cardiol Interv.* 2020;13(2):149-56.

This diagram depicts the "aortic stenosis (AS) paradox," whereby underrepresented racial and ethnic groups (UREGs) cluster more AS risk factors relative to whites but display a lower burden of disease. Complicating this picture is the differential use of aortic valve replacement (AVR) by race and outcomes among those with severe AS. AA = African American; BAV = bicuspid aortic valve; CHF = congestive heart failure; CI = confidence interval; CKD = chronic kidney disease; CTS = cardiothoracic surgery; DM = diabetes mellitus; HTN = hypertension; OR = odds ratio; SAVR = surgical aortic valve replacement; TAVR = transcatheter aortic valve replacement.

patients, blacks had a higher crude mortality rate after AVR (6.4% vs. 4.7%; $p < 0.001$), longer hospitalizations (12 ± 12 days vs. 10 ± 9 days; $p < 0.001$), increased costs of hospitalization ($\$55,631 \pm \$37,773$ vs. $\$52,521 \pm \$38,040$; $p < 0.001$), and higher rates of discharge to skilled nursing facilities or nursing homes (32.1% vs. 27.2%; $p = 0.004$).

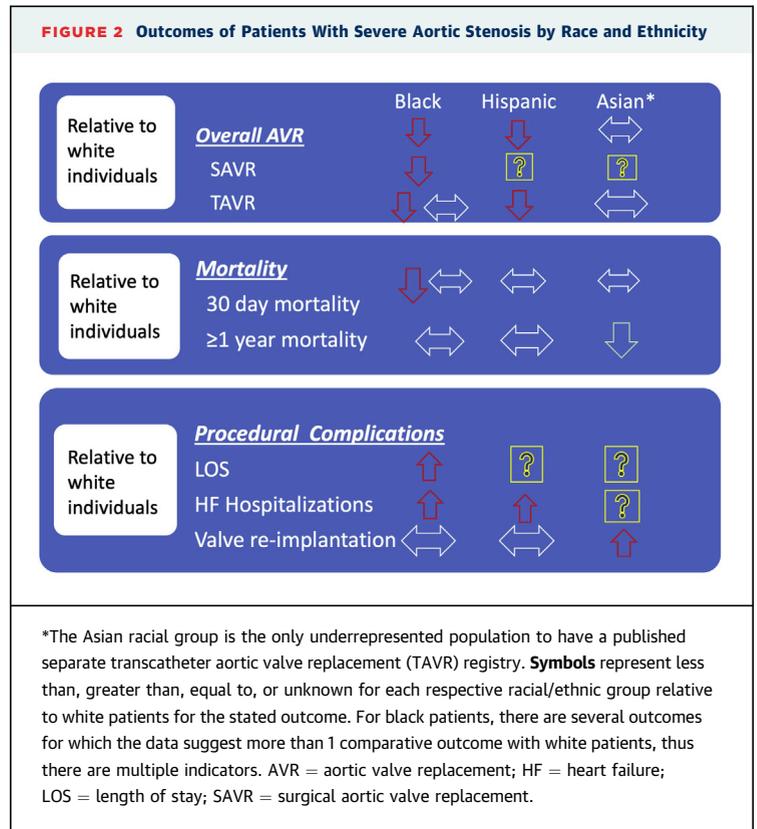
Yeung et al. (17) found that black and white patients had similar 3-year survival rates after AVR (49% [95% CI: 38% to 60%] vs. 50% [95% CI: 45% to 54%]; $p = 0.31$). Taylor et al. (12) found that after adjusting for risk factors that black race was not associated with increased operative mortality after SAVR but was linked to several complications including prolonged intubation and ventilation, longer post-operative stay, and higher reoperation rates for bleeding after SAVR compared with white patients. In a cohort of 469 patients undergoing TAVR, post-procedural mortality risk was not found to differ by race, although black relative to white patients had higher rates of hemodynamic instability and use of intra-aortic balloon pumps (13). In a contemporary subset of 29,351 patients from the TVT Registry with Centers for Medicare and Medicaid Services linkage, 1-year adjusted mortality rates were similar in blacks and Hispanics compared with whites but lower among patients of Asian, Native American, or Pacific Islander race. Black and Hispanic patients had more heart failure hospitalizations compared with whites (27).

In a recent study by Yankey et al. (22), among patients with severe AS, blacks had lower rates of AVR relative to white patients (26.6% vs. 40.3%; HR: 0.70; 95% CI: 0.50 to 0.98; $p = 0.036$) and comparable 1-year mortality rates (25.7% vs. 23.4%, respectively; HR: 1.01; 95% CI: 0.71 to 1.45) (22).

In Asians, Yoon et al. (28) showed in 848 patients who underwent TAVR that the procedural success rate was 97.5% and 30-day and 1-year mortality rates were 2.5% ($p = 0.12$) and 10.8% ($p = 0.40$), respectively, among the lowest reported rates among observational studies. They also observed that the rates of stroke, serious vascular complications, major bleeding, and acute kidney injury were in line with the clinical outcomes observed in other previously published trials.

FUTURE DIRECTIONS AND UNANSWERED QUESTIONS

Few studies have examined racial and ethnic patterns in the prevalence, management, and outcomes of patients with severe symptomatic AS. The majority of this research has focused on differences



between black and white patients, thus limited data exist in other nonwhite racial and ethnic groups. Given the changing demographics of the U.S. population, further investigation of treatment and management considerations for diverse populations is necessary to address the significant morbidity and mortality of AS for all. In an era of more personalized medicine, studies of genetics and epigenetics in the development of AS are needed. Additionally, an increased focus on inclusion of UREGs in registries and clinical trials is essential to better understand possible risks and benefits of treatment in at risk populations. Last, investigating the epidemiology and natural history of AS in diverse populations will lend insight into the development of screening programs, increased access to care, and appropriate referral and intervention to ameliorate differences in outcomes.

STUDY LIMITATIONS. The data presented were obtained from a collection of nonrandomized studies of various designs, each with separate techniques for data analysis, which because of their heterogeneity may reduce the generalizability of our findings. In addition, there is a paucity of data on severe AS in patients of Hispanic ethnicity and other nonwhite

racess, which limits our review findings. Finally, although we conducted a systematic search and review of the available published research, the omission of relevant data, including unpublished data, cannot be completely excluded.

CONCLUSIONS

Among the limited published data, black and other nonwhite racial and ethnic groups relative to white patients with severe symptomatic AS appear to have a lower incidence and prevalence, experience a lower

receipt of SAVR and TAVR, and have either similar or worse short- and long-term outcomes. Racial and ethnic disparities in AVR are likely multifactorial and may in part be explained by differences in subspecialty referral rates and uninformed patient refusal. Future research into these racial/ethnic disparities will help bridge the gap in equitable health care delivery.

ADDRESS FOR CORRESPONDENCE: Dr. Kevin L. Thomas, Duke Clinical Research Institute, 200 Morris Street, Durham, North Carolina 27705. E-mail: kevin.thomas@dm.duke.edu.

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