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Racial and Ethnic Inequities in In-Hospital Outcomes Following Transcatheter Pulmonary Valve Replacement: A Nationwide Analysis of the United States

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Research Article

Keywords: Transcatheter pulmonary valve replacement, TPVR, racial disparities, in-hospital mortality, clinical outcomes, RVOT, heart, cardiac, Whites, Blacks, Hispanics, mixed ethnicities

Posted Date: June 19th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9875415/v1

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Additional Declarations: No competing interests reported.

Abstract

Introduction

Transcatheter pulmonary valve replacement (TPVR) is a less invasive non-surgical approach for treating the right ventricular outflow tract obstruction and other cardiac morbidities, listed by AHA/ACA. This study aimed to compare in-hospital mortality and clinical outcomes in White, Black, Hispanic, and multiethnic patients after TPVR intervention.

Methods

Inpatient data, from 2015 to 2020, regarding TPVR outcomes was extracted from the NIS–2020 database. The ICD-10 codes (02RH3KZ, LA88.0, and I42.1) guided the inclusion of 2,045 TPVR-related hospitalizations for Whites, Blacks, Hispanics, and other (mixed) ethnicities. In-hospital mortality and respiratory failure (requiring mechanical ventilation) were the primary outcomes. The secondary outcomes included cardiac arrest, cardiogenic shock, stroke, major bleeding, renal failure, patient disposition (routine home discharge), hospital length of stay, and total hospitalization charges. The statistical analyses were undertaken by Fisher exact/Pearson X^2 and Chi-Square tests. The p-value (≤ 0.05) determined the statistical significance of outcomes.

Results

We investigated 2045 TPVR-related hospitalizations for White (n = 1390; median age: 34y), Black (n = 245; median age: 27y), Hispanic (n = 245; median age: 31y), and multiethnic (n = 165; median age: 33y) patients. A high in-hospital mortality rate was observed in multiethnic patients (6.0% vs. 0.4%), and a greater prevalence of cardiac arrest (6.0% vs. 4.0% vs 2.0% vs. 0%) and major bleeding (6.0% vs. 6.1% vs. 6.1% vs. 3.2%) in multiethnic, Black, and Hispanic patients, respectively, compared to Whites (all $p < 0.05$). The lowest routine home discharges were observed in Blacks (93.9%) and the highest in Whites (96.4%) ($p < 0.0001$). Multiethnic patients had a greater median hospital length of stay (2d; range: 1-4d) than Whites (1d; range: 1-2d), Blacks (1d; range: 1-2d), and Hispanics (1d; range: 1-2d) ($p < 0.0001$). Higher total hospitalization charges were reported for Blacks ($51,323), Hispanics ($58,931.15), and mixed ethnicities ($52,097) versus White patients ($48,951) ($p < 0.0001$).

Conclusion

This study reported a higher burden of in-hospital mortality and postprocedural complications in ethnic minorities who underwent TPVR for right ventricular outflow tract dysfunction. Racial disparities were observed in major bleeding, cardiac arrest, routine home discharges, median hospital stay duration, and

hospitalization charges. Future studies should re-evaluate these results, considering the comorbidity burden and demographic factors in each ethnic group.

Introduction

Transcatheter pulmonary valve replacement (TPVR) is a minimally invasive approach, which aims to treat and manage right ventricular outflow tract (RVOT) dysfunction [1]. TPVR is preferred over conventional operative interventions for patients with a history of RVOT dysfunction and congenital heart disease (CHD) [2]. Literature evidence indicates differences in outcomes among patients treated with routine surgical approaches for CHD management [3]. Research studies have reported racial disparities in treatment and clinical outcomes in patients with cardiac complications [4–8]. However, racial/ethnic disparities in TPVR use and outcomes are largely unknown [9]. Several potential factors, such as treatment/cardiovascular care biases, comorbid conditions, healthcare access, and socioeconomic status trigger ethnic/racial disparities among patients treated for cardiovascular complications [10–14]. Accordingly, it is important to investigate and determine the impact of these disparities to formulate healthcare processes for improving clinical outcomes, prognosis, and treatment results in TPVR-treated patients.

The study analyses the United States Nationwide Inpatient Sample (NIS) data to investigate in-hospital outcomes, observed among TPVR-treated patients between 2015 and 2020 [15]. The Agency for Healthcare Research and Quality (AHRQ) sponsors the publicly accessible NIS data, which includes treatment results, baseline characteristics, comorbidities, clinical complications, mortality/survival rates, healthcare access, hospital bed allocation, and treatment locations[16]. The authors of this study extracted NIS data to compare and analyze several inpatient outcomes, including respiratory failure, mortality, total hospitalization charges ($), hospital length of stay, patient disposition, renal failure, major bleeding, stroke, cardiogenic shock, and cardiac arrest among multiethnic TPVR-treated patients.

We aimed to segregate these in-hospital outcomes based on the ethnicity of TPVR-treated patients, to assess inconsistencies in healthcare quality and treatment patterns among Whites, Blacks, and Hispanics. The other objective of this study was to update the contemporary literature regarding the magnitude of TPVR-related racial disparities and their impact on treatment results. The study outcomes will inform future policies and healthcare practices, to effectively improve equity in healthcare processes, including TPVR access and outcomes in patients of all ethnicities.

Methods

Data source

We utilized the National/Nationwide Inpatient Sample (NIS)–2020 database to gather in-hospital data based on demographic attributes, mortality, and clinical outcomes in adult patients (age: ≥18 years) who underwent TPVR for right ventricular outflow tract dysfunction, from 2015 to 2020 in the United States

[16]. The Agency for Healthcare Research and Quality (AHRQ) sponsors the publicly assessable, single largest inpatient database (NIS), containing healthcare-related data of patients discharged from acute care settings and short-term, non-rehabilitation, and non-federal hospitals [15]. Of note, in the United States, nearly 20% of patient discharges and overall hospital admissions are covered by the NIS [17]. The inpatient data provided by the NIS include hospital-level attributes and national patient estimates, which are rationalized and weighted annually. The NIS-based patient information is publicly assessable and represents the nationwide healthcare/treatment outcomes in the United States. The deidentified NIS data do not require ethical approval for their statistical analysis.

Study population

We extracted entire TPVR procedures, performed from 2015 to 2020 in the United States. All data were gathered from the NIS database. The data search was guided by the International Classification of Disease-10-Procedure Coding System (ICD-10-PCS) code “02RH3KZ (Replacement of Pulmonary Valve with Non-autologous Tissue Substitute, Percutaneous Approach)” and ICD-10-Clinical Modification (CM) codes “LA88.0 (Congenital Right Ventricular Outflow Tract Obstruction) and I42.1 (Obstructive Hypertrophic Cardiomyopathy with Obstruction of the Ventricular Outflow Tract)” [18]. Discharge data from a total of 2,045 hospitalizations were extracted for Whites, Blacks, Hispanics, and other (mixed) ethnicities (i.e., multiracial/multiethnic patients). The demographic attributes included age, sex, comorbidities, elective treatment status, primary payer, bed size, and hospital region.

Primary and secondary outcomes

The primary outcomes were in-hospital mortality and respiratory failure (requiring mechanical ventilation). The secondary outcomes included cardiac arrest, cardiogenic shock, stroke, major bleeding, renal failure, patient disposition (i.e., routine home discharge), hospital length of stay, and total hospitalization charges ($).

Statistical analysis

The weighted data were utilized for statistical analysis. Fisher exact/Pearson X^2 test was used to compare categorical variables [19]. The means of the continuous variables were evaluated with their standard deviations. The in-hospital mortality and clinical outcomes were stratified by ethnicity/race. We assessed Cramer's V values, Contingency Coefficient, Phi Coefficient, Mantel-Haenszel Chi-Square values, and Likelihood Ratio Chi-Square values to compare the continuous/categorical variables [20]. The baseline characteristics were adjusted for procedural complications. The statistical significance of outcomes was determined by the two-tailed probability value reference (i.e., $p \leq 0.05$) [21]. The Bonferroni correction method was implemented to adjust the significance level of the results. The statistical analyses were undertaken by Statistical Analysis Software (SAS)–9.4 (2013; SAS Institute Inc., Cary, North Carolina, United States) [22].

Results

Baseline characteristics

A total of 2045 patients were hospitalized after TPVR. Of them, 1390 were Whites, 245 were Blacks, 245 were Hispanics, and 165 had mixed ethnicities. Black patients had the highest percentage of females (59.18%), compared to Hispanics (48.98%), Whites (45.32%), and other patients (48.48%) (**Table 1**). The median ages of Whites, Blacks, Hispanics, and other ethnicities were 34y (range: 25-48y), 27y (range: 25–41), 31y (range: 22-38y), and 33y (range: 25-52y), respectively.

The baseline prevalence of hypertension, obesity, and coagulopathy was significantly higher in Blacks, compared to Whites (all $p < 0.05$) (**Table 1a**). Alternatively, the prevalence of hyperlipidemia, coronary artery disease, atrial fibrillation, peripheral artery disease, and chronic kidney disease was significantly greater in Whites than Blacks (all $p \leq 0.05$) (**Table 1a**). The prevalence of obesity, coagulopathy, and peripheral artery disease was significantly high in Hispanics, in comparison to Whites and Blacks (all $p \leq 0.05$) (**Table 1a**). The prevalence of chronic kidney disease in Hispanics was equivalent to Whites but higher than Blacks ($p < 0.03$) (**Table 1a**). Of note, the prevalence of hypertension, coronary artery disease, and coagulopathy was highest in mixed ethnicities, compared to other patient groups (all $p < 0.05$) (**Table 1a**). No statistically significant differences were observed in chronic lung disease, diabetes mellitus, smoking status, prior conduction disorder, end-stage renal disease, and elective procedure status between the study groups (all $p > 0.05$) (**Table 1a**).

While most White patients received their healthcare coverage from private insurance, most Blacks and Hispanics had Medicaid to support their healthcare expenses (Fig. 1). Of note, most Medicaid coverage was availed by White patients, followed by Black and Hispanic patients, respectively (Fig. 1). Most patients from other (mixed) ethnicities had private healthcare insurance coverage, followed by federal Medicaid and Medicare health insurance (Fig. 1). Compared to Blacks and other ethnicities, Whites and Hispanics occupied large beds in the hospital setting (Fig. 2). The highest percentage of medium-size beds were occupied by Blacks, compared to Whites, Hispanics, and other patients (Fig. 2). A greater percentage of small-size beds were occupied by other ethnicities, compared to Blacks, Whites, and Hispanics (Fig. 2). While most Hispanic patients were treated with TPVR in West-based hospitals, most Black and White patients were hospitalized across the Southern locations (Fig. 3).

Primary outcomes

In-hospital mortality

A significantly high prevalence of in-hospital mortality was observed in multiethnic patients, compared to Whites ($p < 0.05$). Of note, no in-hospital mortality was observed in Black and Hispanic patients, respectively (**Supplementary Table 1**) (Table 2).

Respiratory failure requiring mechanical ventilation

No statistically significant differences in the respiratory failure (requiring mechanical ventilation) prevalence were observed between Whites, Blacks, Hispanics, and multiethnic patients (p = 0.13). (**Supplementary Table 2**) (Table 2).

Secondary outcomes

Cardiac arrest

The prevalence of cardiac arrest was higher in Blacks than Hispanics (p < 0.0001) (**Supplementary Table 3**) (Table 2). Of note, the highest occurrence of cardiac arrest was observed in multiethnic patients versus all other patient groups (p < 0.0001). However, no events of cardiac arrest were reported in White patients.

Cardiogenic shock

No statistically significant differences in cardiogenic shock were observed among Whites, Blacks, Hispanics, and those with mixed ethnicities (p = 0.10) (**Supplementary Table 4**) (Table 2).

No statistically significant differences in stroke events were observed among patients of White, Black, Hispanic, and mixed ethnicities (p = 3.0) (**Supplementary Table 5**) (Table 2).

Major bleeding

The major bleeding events (after TPVR) in Black, Hispanic, and multiethnic patients were significantly higher than in Whites (p = 0.02) (**Supplementary Table 6**) (Table 2).

Renal failure

The renal failure prevalence did not statistically differ among Whites, Blacks, Hispanics, and mixed ethnicities (**Supplementary Table 7**) (Table 2).

Patient disposition (routine home discharge)

Of all study groups, the routine home discharges were reportedly highest in Whites and lowest in Blacks (p < 0.0001) (**Supplementary Table 8**) (Table 2).

Hospital length of stay

The median hospital length of stay was significantly greater for multiethnic patients than for Whites, Blacks, and Hispanics (p < 0.0001) (**Supplementary Table 9**) (Table 2).

Total hospitalization charges

The total hospitalization charges for Blacks, Hispanics, and other ethnicities were significantly higher than for Whites (p < 0.0001) (**Supplementary Table 10**) (Table 2).

Discussion

This study underscores noticeable racial disparities in TPVR outcomes among ethnic minorities, including Blacks and Hispanics. In comparison to Whites, a greater in-hospital mortality prevalence was observed among multiethnic patients. Notably, patients with Hispanic and Black backgrounds had no event of inpatient mortality. These findings correlate with significant variations in morbidities, comorbidities, and healthcare quality for patients who were treated in the inpatient settings.

Importantly, while White patients did not experience any episode of cardiac arrest, this condition was highly prevalent in patients with multiple ethnicities and Black patients. Accordingly, person-centered healthcare approaches are warranted to address and mitigate this racial disparity in TPVR outcomes among ethnic minorities [23–25]. In comparison to White patients, a greater prevalence of major bleeding episodes was observed among those with multiple ethnicities, as well as in Hispanic and Black patients. This result underscores the need for enhancing patient monitoring and therapeutic management for ethnic minorities, treated with TPVR in the in-hospital settings [26–28].

Noticeably, in comparison to patients of other races, greater total hospitalization costs correlate with a higher prevalence of prolonged hospital stay duration for patients with multiple ethnicities. This result emphasizes the need for substantial improvements in healthcare processes to enhance postoperative/inpatient management for multiethnic patients [29–32].

Despite its robust design, this study has several potential limitations that should not be ignored while deciphering its outcomes. First, the data extracted from the NIS database did not include outpatient cases. It also excluded treatments for comorbid conditions. Additionally, inconsistencies in the ICD-10 codes could have impacted the reporting of TPVR outcomes. Importantly, the NIS data did not include provider biases and socioeconomic attributes impacting TPVR outcomes in ethnically diverse patient populations.

Conclusion

This study underscores several potential TPVR outcome-related racial disparities that warrant prompt attention from the medical community. In comparison to White patients, prolonged hospital stays duration, major bleeding events, cardiac arrest episodes, and inpatient mortality had a higher prevalence among multiethnic patients. Accordingly, prospective studies should focus on developing equitable person-centered approaches to minimize racial disparities and their underlying causes impacting TPVR outcomes in the healthcare sector.

Abbreviations

TPVR
Transcatheter Pulmonary Valve Replacement
AHA/ACC
American Heart Association / American College of Cardiology
RVOT

Right Ventricular Outflow Tract

NIS

National Inpatient Sample

AHRQ

Agency for Healthcare Research and Quality

Declarations

Ethics approval and consent to participate:

As this analysis was conducted on publicly available deidentifed data, it was exempted from ethics committee approval (https://hcup-us.ahrq.gov/)

Consent for publication:

not applicable

Clinical trial number

not applicable

Competing interests:

The authors declare that they have no competing interests

Funding:

No funding was received for this study

Author Contribution

DU & IJO worked to conceive and design the study, analyze and interpret data, draft and revise the manuscript, and approve the final manuscript. KEO and IJO conceived and designed the study, helped draft and revise the manuscript, and approved the final manuscript. OA developed the study protocol, analyzed and interpreted the data, revised the manuscript, and approved the final manuscript. NN, KO, MTN helped with the analysis and interpretation of the data, revised the manuscript for important intellectual content, and approved the final manuscript. The authors (DU, IJO, NN, KO, MTN, LTM, AI, LLSK, BN, NJ) are solely responsible for the design and conduct of this study, all study analyses, the drafting and editing of the paper and its final contents. All authors (DU, IJO, NN, KO, MTN, LTM, AI, LLSK, BN, AA, EO, NJ) wrote and approved the first and final manuscript.

Data Availability

The dataset analyzed during the current study is available at the HCUP website: https://hcup-us.ahrq.gov/.

Code availability:

Not applicable

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Tables

Table–1a: Baseline Prevalence of Comorbidities in patients treated with transcatheter pulmonary valve replacement

Comorbidities	Whites	Blacks	Hispanics	Others	P–Value
Chronic lung disease, %	8.22	7.41	7.69	4.76	0.6680
Hypertension, %	15.07	18.52	15.38	28.57	0.0060
Diabetes mellitus, %	8.90	7.41	15.38	9.52	0.1024
Hyperlipidemia, %	12.95	6.12	10.20	6.06	0.0017
Obesity, %	12.33	22.22	26.92	14.29	<.0001
Smoking, %	11.15	6.12	8.16	12.12	0.0566
Coronary artery disease, %	8.27	4.08	8.16	15.15	0.0012
Coagulopathy, %	6.16	7.41	11.54	14.29	0.0093
Atrial fibrillation, %	19.42	16.33	12.24	15.15	0.0320
Prior Conduction disorder, %	15.47	18.37	16.33	15.15	0.7026
Peripheral artery disease, %	2.74	0	3.85	0	0.0515
Chronic kidney disease, %	6.12	2.04	6.12	3.03	0.0307
End-stage renal disease, %	1.08	2.04	2.04	0	0.17

Table 2: In-hospital mortality and clinical outcomes

	White (1390, 67.9%)	Blacks (245,11.9%)	Hispanics (245,11.9%)	Others (165,8.07%)	P Value
In Hospital Mortality	0.36	0	0	6.06	
Respiratory Failure requiring mechanical ventilation	1.80	4.08	2.04	3.03	0.1311
Cardiac Arrest	0.00	4.08	2.04	6.06	<.0001
Cardiogenic shock	2.16	2.04	0.00	3.03	0.1029
Stroke	0.72	0.00	2.04	3.03	3.03
Major Bleeding	3.24	6.12	6.12	6.06	0.0267
Renal Failure	5.40	4.08	4.08	6.06	0.6593
Disposition					<.0001
Routine home	96.40	93.88	95.92	93.94	
Transfer to Skilled Nursing Facility	0.72	4.08	0.00	0.00	
Home Health Care	0.72	0.00	0.00	0.00	
Length of stay (median days, IQR)	1 (1-2)	1 (1-2)	1 (1-2)	2 (1-4)	<.0001
Total Hospitalization Charges in $ (IQR)	48951.18 (35557.20-63318.75)	51322.93 (36562.40-72946.88)	58931.15 (43749.01-80327.04)	52096.82 (40699.16-66519.42)	<.0001

Figures

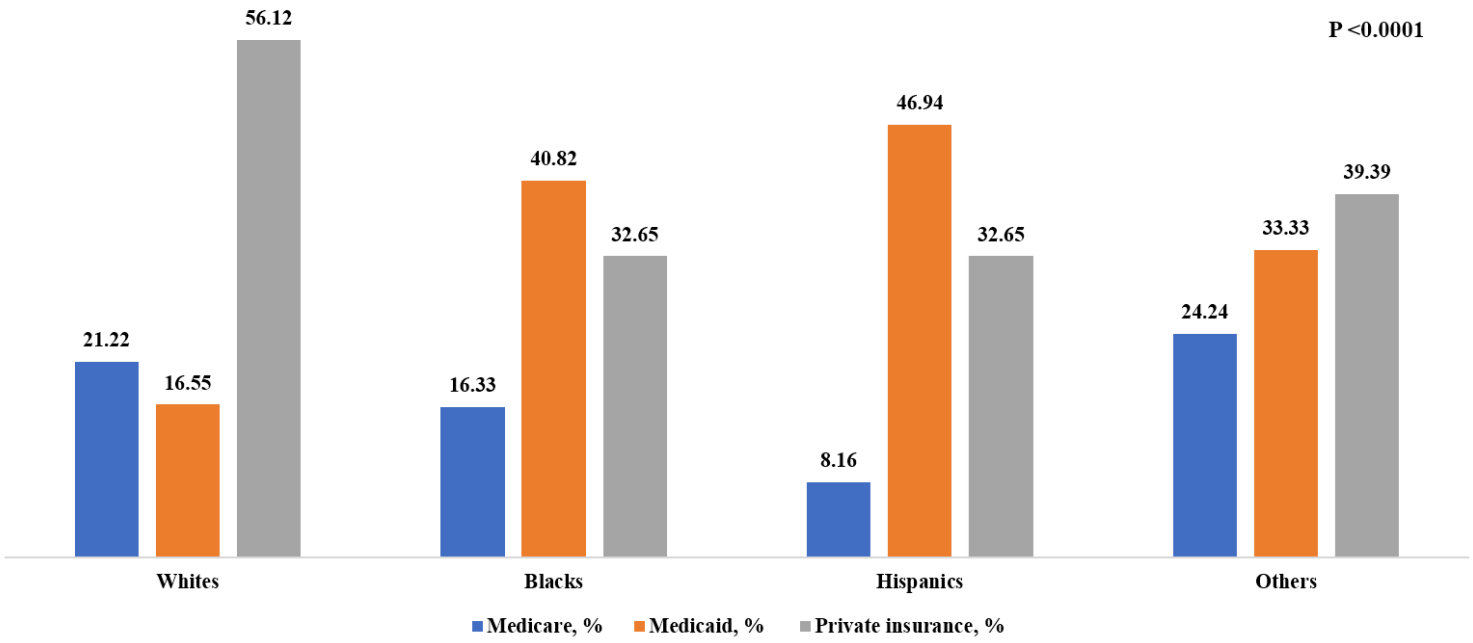


Figure 1

Health insurance coverage in Whites, Blacks, Hispanics, and Other Ethnicities treated with transcatheter pulmonary valve replacement

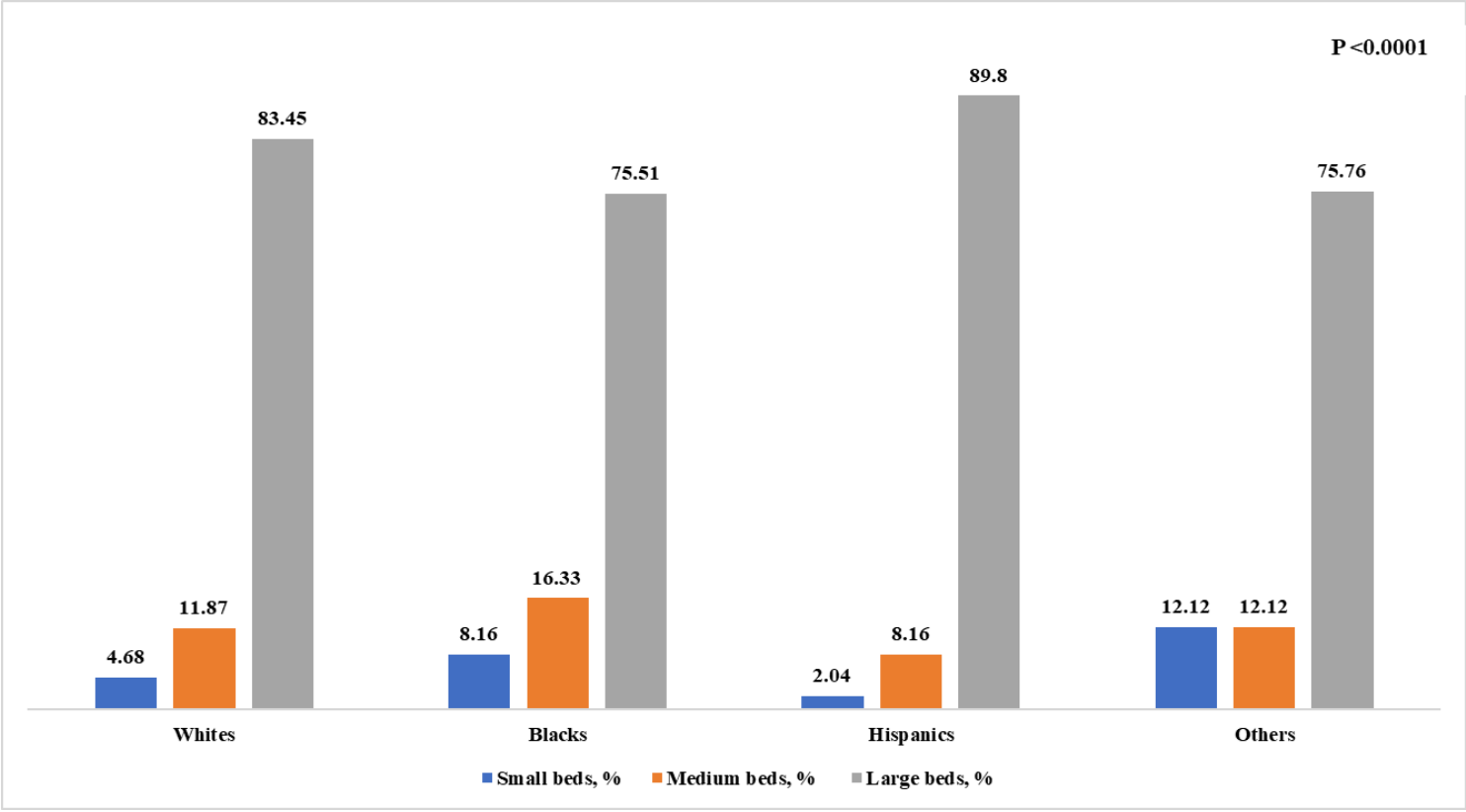


Figure 2

Bed size distribution patterns in patients receiving transcatheter pulmonary valve replacement

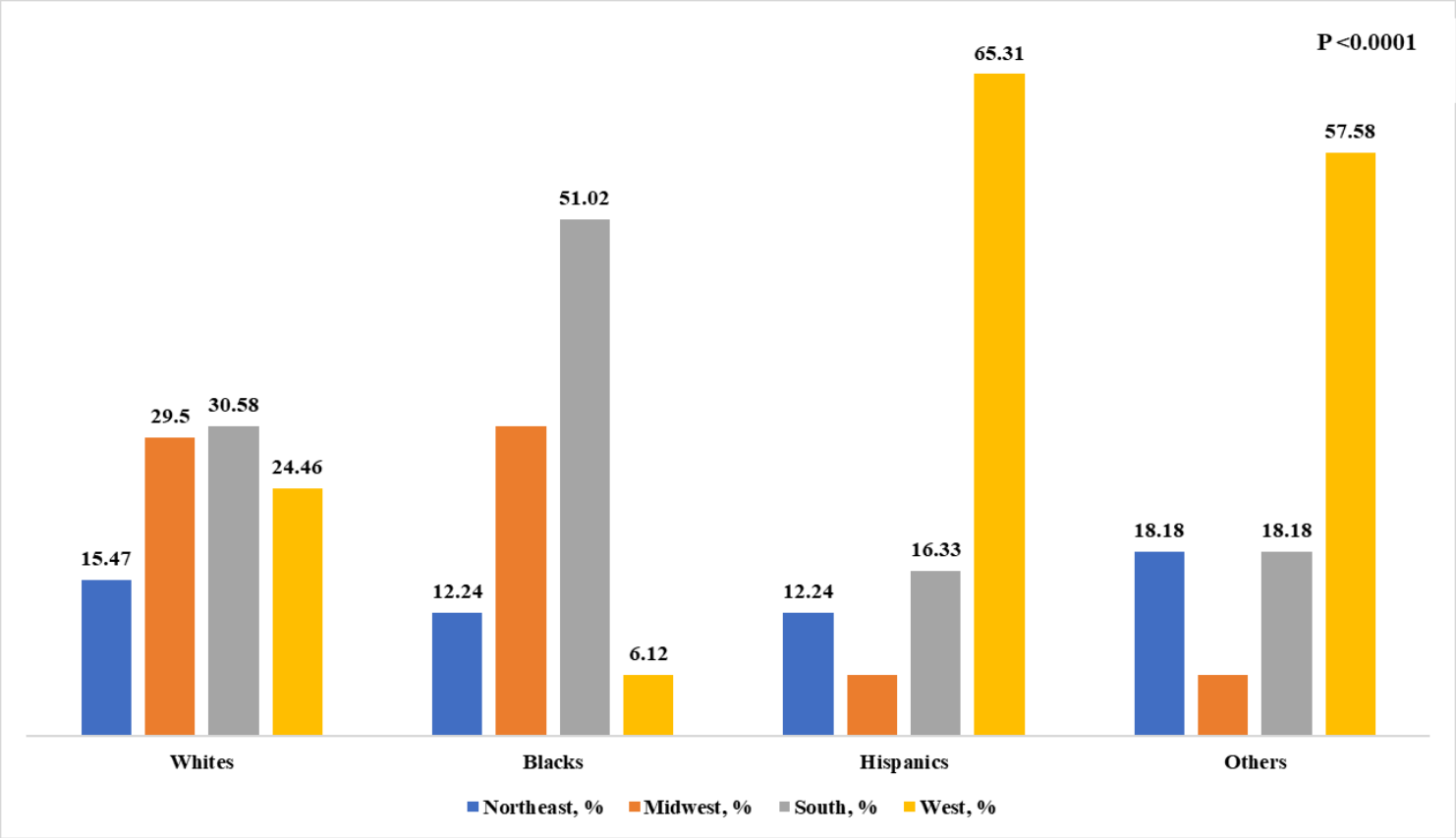


Figure 3

Hospital region-based transcatheter pulmonary valve replacement provisions

Supplementary Files

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