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Maiko Sasaki Teichmann Date

Racial and Sex Differences in Surgical Aortic Valve Replacement Short-term Post-Operative Outcomes at a High-Volume Cardiac Surgery Center

by

Maiko Sasaki Teichmann, M.S.

Degree to be awarded: M.P.H.

Executive MPH, AEPI

Thesis Committee Chair: Jose N. Binongo, Ph.D.

Maiko Sasaki Teichmann	Date
Jose N. Binongo, Ph.D.	Date
W. Brent Keeling, M.D.	Date

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n ABSTRACT

Title: **Racial and Sex Differences in Surgical Aortic Valve Replacement Short-term Post-Operative Outcomes at a High-Volume Cardiac Surgery Center**

Maiko Sasaki Teichmann, M.S.

Background: Both African American race and female gender are under-represented in studies investigating on their effects in clinical outcomes after SAVR procedure. Disparities in care in female and African American cohorts are reported in multiple studies. Consensus on racial and gender effects independently on postoperative outcomes have not been reached, and the combined effects of gender and race have not been reported after SAVR.

Objective: This study aimed to investigate sex and race differences in 30-day mortality and postoperative complications among the patients who received surgical aortic valve replacement (SAVR) procedure.

Methods: Retrospective analyses were conducted on all patient data undergoing SAVR obtained from Adult Cardiac Surgery Database Data Collection from Emory University Hospital, St. Joseph's Hospital, and Emory University Hospital Midtown. 3232 patients who underwent surgical procedures between 1/26/2005 to 3/29/2019 (STS data versions 2.52, 2.61, 2.73, 2.81, and 2.9). Associations between both gender and race and the clinical outcomes were investigated using risk-adjusted logistic and linear regression models.

Results: A total of 3232 cases met the inclusion criteria and were included in this study. Black females constituted 6.56% of the sample, white females 32.39%, black males 8.32%, and white males 52.72%. Black patients were on average younger at the time of operation (black female: 63.2 ± 13.7 yo, black male: 59.5 ± 14.41 yo, white female: 69.9 ± 12.7 yo, white male: 66.1 ± 13.7 yo, *p*-value < 0.0001), and had higher frequency of requiring urgent procedures (50 %, 47.2 %, 34.9 %, 32.5 % for black female and male, white female and male respectively, p-value <0.0001). 76 (2.3%) cases were reported for 30-day mortality, a main outcome of this study. Black males had the highest odds of 30-day mortality when compared to white males (aOR 1.677, 95 % CI: 0.793 – 3.550 against white males). Black male also had the most hospital utilization including lengths of post-operative stay in the hospital before discharge (aGMR 1.124, 95 % CI: 1.055 – 1.198).

Conclusions: These results revealed more complex relationship of race/gender and the clinical outcomes after SAVR, and requires careful interpretation of the. After risk adjustment, no significant differences in 30-day mortality were observed for the different sex and race categories. That blacks had a longer length of stay than whites at this high-volume cardiac center could explain the observed similar risk-adjusted mortality rates.

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Table of Contents

1. Introduction

1.1. Cardiovascular valvular disease epidemiology

Cardiovascular disease (CVD) is the leading cause of death globally, and the global death toll is expected to rise from more than 17.6 million deaths in 2016 to over 23.6 million in 2030 [1]. In 2017 in the US alone, over 840,000 deaths have been attributed to cardiovascular diseases [1]. Burden of CVD is also substantial in terms of disability-adjusted-life-years (DALYs) as a metric for healthy years lost. In 2016, it is estimated that DALYs is 3269 per 100,000 persons in the United States. Combating the CVD has been fairly successful specifically in US [2]. The annual mortality rate between 2006 and 2016 has decreased by almost 32 % and the mortality cases by 14.6 %, showing the general declining trend in the US. However, burden of disease remains significant [3]. Economic cost of CVD is estimated to be $218.7 billion in direct and indirect costs in terms of lost productivity and mortality [1].

Aortic valvular heart disease involves semilunar valve located between the left ventricle of the heart and aorta. It is considered to be a degenerative disease in that the prevalence sharply increases in the elder population over 65 years of age [4]. Its prevalence in the US is estimated to be 2.5 %, and valve surgeries account for more than 20 % of all cardiac surgery [5]. Among the aortic valvular diseases, Aortic Stenosis (AS) is one of the most common valve diseases which affect between 2~9 % of the general population over 65 years of age. The main cause of AS especially in the US is calcific degeneration, but is also attributed to rheumatic heart disease, infectious endocarditis, as well as trauma [6]. Mortality rate in severe cases of AS is as high as 50 % within 2 years if left untreated, and long-term prognosis remains poor even with treatment [7-9]. Average life expectancy of the patients who manifest with angina, heart failure, and syncope as symptoms of AS are estimated to be 1 year [10].

There are three strategies for AS treatment: 1) surgical aortic valve replacement (SAVR), 2) transcatheter aortic valve replacement (TAVR), and 3) medical therapy (MT). MT is often reserved for patients who are inoperable, and is not discussed further within this scope here.

1.2. Aortic Valve Replacement (AVR) therapy

1.2.1. TAVR

In November 2011, transcatheter aortic valve replacement (TAVR) has been approved by US Food and Drug Administration (FDA) as an alternative option to traditional surgical aortic valve replacement (SAVR) with similar risk of postoperative mortality, myocardial infarction, and stroke among other clinical outcomes associated with AVR, to treat inoperable AS patients [11,12]. TAVR was subsequently approved for high-risk patients in October 2012, and in August 2016, it was approved for patients with intermediate risk [13]. After the procedure was approved, TAVR quickly gained popularity, and the number of practicing cardiac surgery centers has increased to 348 by the end of 2014 in the 48 US states, and is estimated to be over 500 as of 2019 [14]. Cumulative number of TAVR procedures in the first three years after the launch was over 26,000, and the patients undergoing procedure had median Society of Thoracic Surgery predictive risk of mortality (STS-PROM) score 6.7%, which is considered to be extremely high risk [1]. A national longitudinal study indicated that the patient cohort over 75 years of age and a cohort with high severity score are the fastest growing groups of patients receiving TAVR, surpassing the volume of traditional surgical valve replacement procedures in 2016 [13].

Patients with severe AS who did not have plausible surgical options prior to introduction of TAVR now have access to surgical care. However, TAVR is associated with higher 5-year mortality rate, increased paravalvular leaks, which in turn contribute to increased mortality risk, and higher risk of subsequent need for pacemaker implantation [15,16].

1.2.2. SAVR

Surgical aortic valve replacement (SAVR) has been deemed most effective as opposed to balloon valvotomy which offers temporary relief of symptoms [17]. Due to the invasive nature of SAVR involving sternotomy, burden of comorbidities and complications from the procedure is high, including long length of stay and mediastinitis [12]. General mortality rate of aortic valve replacement surgery was reported to be 2.8 % between 2004 and 2008, but it is estimated to be much higher, approximately 10%, with comorbidities such as chronic renal disease and left ventricular dysfunction [6]. Moreover, over 30 % of the patients requiring valve disease management are estimated to have received previous valve surgery, and the main patient population who are recommended SAVR as a primary surgical option are the low-risk cohorts [18]. Despite the risks, however, SAVR recipients have been shown to improve health-related quality of life (HRQoL) and cognitive disability measured by Mini-Mental State Examination (MMSE), had higher percentage of patients living at home, and improved New York Heart Association class, a metric for heart failure [19]. Thus, management and considerations of the preoperative conditions specific to individual patients are critical in gaining further insights into improving patient care in terms of both morbidity and mortality [5].

1.2.3. Public health implications in access to AVR

While TAVR-performing centers have been increasing as the procedure becomes available even for the moderate risk patients, SAVR is still considered a golden standard for lower risk AS patients, with significant public health implications as TAVR is not universally available in all cardiac centers [9,11]. The Centers for Medicare and Medicaid (CMS) has published an updated decision in March 2019 to expand the coverage of TAVR, defining parameters for requirements the hospitals offering TAVR have to meet prior to program implementation [14]. Such requirements

include the number of total open heart surgical procedures as well as valve replacement surgeries, and the career volume of procedures for cardiovascular surgeons [14], which limits further implementation of TAVR program. Furthermore, distribution of cardiac centers offering TAVR is skewed. The hospitals with TAVR program tend to be more rural, operated by non-profit organization, and more likely to be large, teaching hospitals [20], indicating that the access to care especially for the urban population relying primarily on Medicare program may be limited. However, tendency for rural distribution may be regional, as Goldsweig *et al.* has shown that the implementation of evidence based TAVR practices is the fastest among the large, teaching, urban hospitals using Nationwide Readmissions Database (NRD) [13].

Access to SAVR vs. TAVR is not only dependent on physical, regional aspect of the available hospital care. It has been shown that Medicare limits access to more expensive care such as TAVR by imposing stringent reimbursement requirement [14]. Furthermore, since the healthcare cost associated with TAVR broadly varies among healthcare systems [21], types of insurance the patients may have access to or lack thereof will dictate the type of procedures available to them. Disproportionately affected are the vulnerable populations such as the elderly, minority, and the patients with lower social economic status (SES). In fact, 40.8 % of the black cohort undergoing AVR was in the lowest income quartile while only 24.4 % of the white counterpart was found to be in the lowest income quartile [22]. African Americans are also found to be utilizing the very low volume hospitals compared to the white cohort (25.6 % vs. 19.4 % respectively [22]. Thus, despite the rapid advancement in TAVR technology and access, SAVR remains to be an important and/or the only option available to some patient cohorts.

1.3. Racial/gender disparities in SAVR outcomes: Public health perspectives

There are disparities in health outcomes and access to care among different genders, races, and socioeconomic groups in the US, and it is a serious public health threat. From the standpoint of public health, main focus has been on disparities in access to quality care as discussed above. However, access to care is only estimated to contribute 15 % to 20 % in describing the disparities in mortality and morbidity in the US [23]. Satcher and Higginbotham argue that it is critical to identify other health determinants such as biology, environment, and human behavior [24]. Thus, gaining insights of disparities in surgery outcomes among underserved and/or underrepresented groups, such as the interest of our discussion here regarding SAVR, would contribute to reducing and eventually eliminating the disparities by focusing on biological aspect of the health determinants.

Racial and gender disparities in outcomes and access to treatment in valvular diseases and CVD have been reported. In many of the research studies on valvular surgeries, blacks as well as women are disproportionately underrepresented [9,25-30].

1.3.1. Gender disparities

Despite the fact that men are associated with more risk factors such as higher smoking rate and BMI, overall lifetime risk of disease is similar between men and women. Overall life time risk of CVD in women may even out possibly due to longer lifespan of the females, averaging out the gender differences [31]. Despite the increase in study recruitment and almost 50% representation over the recent years especially studies involving TAVR [13], one longitudinal study recruited only 35% females, indicating that disparities in representation are still a concern [32,33]. Women were found to have higher perioperative mortality risk during aortic valve replacement [34-36], while others have reported that there was no overall postoperative mortality rate difference between men and

women, despite the fact that women undergoing SAVR were older, more frail, and sicker than male counterparts [9,37,38]. Furthermore, women were found to have better postoperative outcomes following TAVR, implying that the gender disparities in overall AVR outcomes not only may depend on the population undergoing the procedure but the types of the valvular procedures chosen [39,40]. Regardless, consensus on gender outcomes disparities has not been reached, and further investigation is warranted.

1.3.2. Racial disparities

Similar to the cases for gender outcome disparities, consensus on racial outcome disparities has not been reached, and the black population is often grossly under-represented. Percentage of African American representation in studies varies between 4 – 10 %, indicating that in many studies, AA are underrepresented compared to the national average population size [26,29,41]. While Ravi *et al.* and McNeely *et al.* have reported that blacks have significantly higher odds of having overall postoperative complications including perioperative renal complications, 30-day readmission, pulmonary complications as well as 30-day mortality in unadjusted analyses, others have found that there is no significant difference in in-hospital outcomes after adjusting for comorbidities [26,29,30,41,42].

Further investigation is warranted due to scarcity of data especially for SAVR as well as inconsistencies, which may stem from the percent population represented in the studies.

1.4. Study aims

Much of the recent valvular disease outcome research stratifying on sex with more female participant involvement has been conducted on the TAVR and not on SAVR. In fact, two of the recent large-scale research studies conducted on the Nationwide Inpatient Sample (NIS) and

German Aortic Valve Registry (GARY) involving over 166,000 and 42,000 patients respectively had only 37 % and 35 % female cohorts included [25,36].

Similarly, many of the contemporary SAVR studies stratifying on minority, especially on AA, is still under-represented at 4.8 %, 6.3 %, 8.4 % and 10 % [26,29,30,43]. Furthermore, to the best of the author's knowledge, a study specifically comparing the SAVR outcomes of both gender and race simultaneously has not been reported to date. Since SAVR remains to be a powerful and important technology to combat AS, which has poor prognosis when left untreated, especially for underserved and/or vulnerable populations, teasing apart the differences in more details among affected population is warranted. Insights into the outcome differences among racial and gender groups undergoing SAVR will aid in better serving the target populations by catering to the unique needs each group of the patients may exhibit.

In this study, we aim to provide further insights into the association of sex and racial differences with short-term postoperative 30-day mortality and other post-operative outcomes among the patients who received SAVR procedures.

2. Methods

2.1. Study Design

A retrospective study was conducted using the Society of Thoracic Surgeons (STS) Adult Cardiac Database at Emory University to investigate the racial and gender effects on clinical outcomes such as short-term, 30-day mortality and complications following the surgical aortic valve replacement treatments All SAVR procedures performed at Emory University Hospital, Emory University Hospital Midtown, and Emory St. Joseph's Hospital from 1/26/2005 to 3/29/2019, representing STS data versions 2.52, 2.61, 2.73, 2.81, and 2.90 are considered. Excluded are the procedures cataloged in STS data versions 2.43 due to incompatible data collection with the later versions of the database. Patients with ambiguous race and gender registration as well as non-whites and non-African Americans have also been excluded. Total of 3232 patients were included in the study. Sample selection and inclusion process is summarized in a flow diagram (Figure 1).

2.2. Study Variable Selection

Study variables were selected according to the previously published studies conducted by the Emory Department of Surgery researchers [44-46]. Preoperative and intraoperative variables including demographic information such as age, race and gender as well as risk factors and comorbidities common among the patients undergoing aortic valve replacement were selected. Some of the covariates and risk factors selected include but not limited to history of smoking, peripheral vascular disease, cerebrovascular diseases, renal failure, lung diseases, diabetes and BMI. STS-predictor of mortality (STS-PROM) score specifically calibrated for isolated aortic valve surgery is a metric to calculate the probabilities of post-operative mortality and major complications such as post-operative stroke after taking the patients' pre-procedural morbidities

into accounts. It is calculated using bivariate logistic regression, considering both the operative mortality and morbidities in a single model. STS-PROM score is used to summarize the predictive covariates to simplify the information in hierarchical statistical models. Here, STS-PROM score is used in lieu of numerous baseline patient covariates to study the relationship between short-term mortality and other major complications and sex/gender. STS-PROM score is described as patient baseline characteristics to indicate the severity of the pre-existing conditions [47]. Some of the known risk factors in aortic valve surgery stemming from the previous surgical procedures such as ejection fraction were also selected and included in the study [33].

End points were defined as commonly observed and traditionally investigated complications including post-operative 30-day mortality, stroke, postoperative renal failure and pneumonia, new onset dialysis, post-operative IABP insertion, location of discharge, lengths of stays at ICU and in-hospital between surgery and discharge, and post-operative additional ventilation time, and were included as clinical outcomes.

2.3. Data Cleaning

Due to the multiple cataloging conventions among the STS data versions, coding scheme was altered to unify and consolidate. The earliest version of STS database (2.43) was removed due to complete exclusion of some of the outcome variables of interest. Data version changes in variable names were cross-checked with the data dictionary as well as missing data information derived from SAS program. When the names of the variables were changed, they were combined under newly assigned name and consolidated (Supplemental Table 1).

All of the dichotomous categorical variables were re-coded to be 0 and 1 dichotomous, 1 representing event while 0 representing non-event. This class of categorical variables are 30-day mortality, smoke, heart failure within two weeks, peripheral arterial disease, previous endocarditis,

previous myocardial infarction, previous valve operation, cerebrovascular diseases, hypertension, dyslipidemia, diabetes, renal failure (both preoperative and postoperative), reoperation, blood products use during procedure, intraoperative RBC use, stroke, postoperative new-onset dialysis, and postoperative pneumonia.

Multi-level categorical variables, NYHA classification code and history of smoking, were consolidated to be dichotomous. The more severe NYHA classifications III and IV were combined as event (1) and less severe categories (I and II) were combined to be non-event (0). Smoking was re-coded to represent any history of smoking to be event (1), while no history of smoking was coded as non-event (0). Chronic lung disease (CLD), a multi-level severity graded variable was simplified to a dichotomous variable with 1 representing any grade of chronic lung disease one 0 representing no chronic lung disease. Procedure status, which are also multi-level categorical variables, was re-coded to represent 0 for elective procedure and 1 for non-elective (urgent, emergent, emergent-salvage status) procedures.

Length of Stay (LOS) in ICU as well as LOS between surgery and discharge both contained datapoints erroneously listed as 0, and these datapoints were converted to missing upon confirmation. LOS-ICU, LOS-surgery to discharge, and additional post-op-ventilation hours were heavily right-skewed due to the outliers. To delineate the distribution better and to derive more meaningful measurements, they were log transformed for the use in adjusted analyses. In descriptive characteristics, however, median, 1^{st} and 3^{rd} quantiles (Q1 and Q3 respectively), which are less sensitive to outliers, were reported using non-log transformed data. STS-PROM score, which is a very well validated predictor of mortality, is also right skewed among the patients who undergo surgical procedures due to patients with high STS-PROM score being excluded from

surgery due to their high probability of postoperative mortality. STS-PROM score is reported both in raw and log-transformed values (median, Q1 – Q3) to describe patient characteristics.

2.4. Statistical Analyses

All the statistical analyses were performed using SAS 9.4 software (SAS Institute Inc., Cary, NC). For descriptive analyses, categorical variables were reported as counts and percent, and the groups were compared using the X^2 test (or Fisher's exact test, as appropriate). Continuous variables were summarized in means ± standard deviation (or mean (Q1-Q3), as appropriate), and the groups were compared using two-sample Student's *t* test (or Mann-Whitney U test, as appropriate).

To study the association between the exposure variables of sex and race, on one hand, and a postoperative outcome variable, on the other, adjusted for risk score, regression models were built: linear regression for continuous outcomes, logistic regression for dichotomous outcomes. To quantify the between-group difference, the difference between group means was estimated for continuous outcomes, and the odds ratio (OR) for dichotomous outcomes. The corresponding 95% confidence interval was also calculated. When the outcome had outliers on the right side of the distribution (e.g., length of hospital stay), the outcome was log transformed, and the geometric mean (instead of the usual arithmetic mean) was reported. The difference between the two groups was quantified using the geometric mean ratio (GMR). Just like OR, when GMR is 1, there is no outcome difference between the two groups being compared.

All tests of hypotheses were two-sided and conducted at a 0.05 level of significance, and SAS Version 9.4 was used to perform the data cleaning and statistical analyses.

3. Results

3.1. Study Sample

STS data base versions 2.52, 2.61, 2.73, 2.81, and 2.90 included 3360 patients who received SAVR between January 26, 2005 and March 29, 2019. Patients who were neither black nor white were excluded, reducing the sample size to 3232.

Overall, blacks were older, had higher NYHA class, more heart failure within two weeks of SAVR, previous endocarditis, hypertension, endocarditis, diabetes, renal failure, immunosuppressive therapy, while they had less hemoglobin and elective SAVR. Black females had the highest BMI, while all the other cohorts had comparable BMI. Female gender is associated with lower STS-PROM score when compared to the male cohorts, males had markedly higher frequency of history of smoking, previous myocardial infarction, and previous peripheral vascular diseases, but had worse ejection fraction percentage. The whites, when compared to the black cohorts, generally had higher frequencies of dyslipidemia. Baseline characteristics of patients are discussed further in details below, and are summarized in Table 1.

3.1.1. Characteristics which are worse in both male and female AA cohorts

Overall, black patients are under-represented at approximately 15 % of total patient population while African American population in Georgia is estimated to be 32.4 % as of July of 2019 [48]. They are younger at the time of presenting at 63.2 ± 13.7 and 59.5 ± 14.41 years old for black females and males respectively, while their white cohorts were significantly older at 69.9 ± 12.7 and 66.1 ± 13.7 years old for females and males respectively. Among both racial groups, females are older than their male counterparts by approximately 3 years. The blacks also presented more frequently with higher NYHA class, which is an indication for the severity of heart failure and its associated symptoms (63.8 % and 68.8 % among black females and males respectively).

60.1 % of white females and 56.9 % of white males had more severe NYHA categories. Blacks also had more cases that were urgent (50 % black females, 47.2 % black males vs. 34.9 % white female and 32.5 % white male), indicating that they received SAVR less frequently as elective procedure. Blacks also had more heart failure within two weeks of SAVR (79.7 % black female, 71.0 % black males vs. 65.6 % white female 65.1 % white male).

More blacks had many of the comorbidities before SAVR. Frequency of endocarditis among black female and male was 15.6 % and 25.3 %, while 3.2 % and 7.6 % of white female and male had endocarditis. Interestingly, black males had markedly high frequency of endocarditis, while white female had much less frequency compared to all the other cohorts. Blacks were more frequently associated with higher frequency of hypertension (92.5 % black female, 88.5 % black male vs. 82.5 % white female and 82.2 % white males). Diabetes was more prevalent among blacks at over 30 % of the population while it was under 30 % for the white cohorts (40.1 % black female, 33.1 % black male vs. 28.74 % white female, 29.0 % white male). What was especially striking was the prevalence of renal failure. While almost 20 % of the black cohorts suffered from renal failure prior to SAVR procedure (18.9 % black female and 20.5 % black male), only less than 3% of the white cohort suffered from previous renal failure (1.8 % white female, 2.8 % white male). Blacks also had more often immunotherapy prior to SAVR than the whites (10.4 % black female, 8.6 % black male vs. 5.3 % white female vs. 4.9 % white male). Hemoglobin is a general measure for overall health status of the patients, and blacks had worse findings in this measure as well (11.6 ± 1.7 g/dL black female, 11.9 ± 2.3 g/dL black male vs. 12.3 ± 1.8 g/dL white female and 13.4 ± 2.2 g/dL for white male).

3.1.2. Characteristics which are markedly worse in female AA cohorts

Black females had highest BMI among all the other cohorts. Black female cohort had higher than 30 BMI (31.6 ±7.6) while the rest of the groups had less than 30 (28.9 ± 7.2, 28.5 ± 6.4, and 28.9 ±5.7 for white female, black male, and white male respectively.

3.1.3. Characteristics which are worse in female cohorts, both black and white

Both black and white females had worse predictive mortality score as measured by the STS predictor of mortality (STS-PROM) score. Log transformed median values as well as 1st and 3rd quartiles are also reported for this characteristic since it is easier to see the distribution which is heavily right-skewed. Black and white women had -3.44 (-2.78 - -3.83) and =-3.49 (-2.92 - -4.04) while black and white males had -3.49 (-3.01 - -4.42) and -3.88 (-3.21 - -3.47).

3.1.4. Characteristics which are worse in white cohorts

More than 70 % of the white cohorts, both female and male, had dyslipidemia when compared to the black cohorts. 71.3 % and 74.1 % of the white females and males respectively had previous dyslipidemia, while 68.9 % and 64.2 % of the black female and male had dyslipidemia.

3.1.5. Characteristics which are worse in male cohorts

In male cohorts, smoking, which is a well-known behavioral risk factor, was more prevalent. 52.8 % and 47.3 % of black and white male had some history of smoking while 42.5 % and 35 % of black and white female cohorts had history of smoking. Among the race, males had higher frequency of history of smoking. Males also had higher frequencies of previous myocardial infarction prior to SAVR. White male especially had high previous incidence of MI at 18.0 %, followed by black male at 16.4 %. 15.6 % and 10.5 % of black and white women experienced prior MI before SAVR. Frequencies of peripheral arterial diseases were also higher among males

than the female counterparts. Males had 13.0 % and 10.8 % for white and black males while 8.5 % and 9.5 % black and white females had peripheral arterial disease comorbidity at the time of procedure. Males also had lower ejection fraction percentage, which is an indication of worse status in the hearts' ability to pump out blood. Black males among all the other cohorts had the least EF percentage at 51.9 ± 11.4, followed by 53.3 ± 12.4 for white male. Women on the other hand, especially white female had markedly higher EF percentage at 57.3 ± 10.8 while black women had 54.4 ± 12.1 %.

3.2. Crude Analysis Results

The primary outcome of this study is post-operative 30-day mortality, and we found that out of the total number of 3232 patients included in this study, 76 deaths within 30 days were recorded. Of those who died within 30 days of surgery, 65 died in hospital before discharge.

Unadjusted post-operative outcomes analyses revealed that none of the outcomes was statistically significant. However, when careful observations are made to compare each of the four groups separately, a pattern emerged showing significance only in certain groups. Most notably, for the main outcome of post-operative short-term 30-day mortality, black male has almost twice as high odds of dying within 30 days of SAVR (cOR 2.084: 95% CI: 1.010 – 4.301), and the finding is significant as the confidence interval excludes 1. Black males also received significantly longer post-operative additional ventilation compared to white male counterpart at cOR 1.587 (95% CI: 1.125 – 2.240).

Both black male and white female cohorts received longer stays in the ICU and in the hospital before discharge after SAVR. Lengths of stay (LOS) in the ICU for white women and black men were cOR 1.177 (95 % CI: 1.104 – 1.256) and cOR (95 % CI: 1.068 – 1.324) respectively. Similarly, LOS between surgery to discharge for white female and black male

cohorts in comparison to white male was cOR 1.108 (95 % CI: 1.065 – 1.153) and cOR 1.155 (95 % CI: 1.080 – 1.235) respectively.

One metric which was significantly different in three of four comparison pairs was location of non-home discharge. When compared to the white male cohort, both white female and black male had higher odds of being discharged to location other than the primary residence of the patients (cOR 1.868, 95% CI: 1.488 – 2.346 and cOR 1.283, 95% CI: 1.090 – 1.324 respectively). Furthermore, when black female cohort was compared to the white female counterpart, the odds of being discharged at the non-home location was 1.249 with 95% CI of 1.040 – 1.499. No significant difference was found between female and male black cohort for this metric. Crude analysis results are summarized in Table 3b.

3.3. Adjusted Analysis Results

When outcomes were adjusted for STS-PROM score, encompassing all the predictive parameters of mortality that have been very well validated, much of the significance disappeared. What remained significant were post-operative additional ventilation time and LOS in ICU and in hospital before discharge. In all cases, black males had longer care in comparison to the white male cohort. Blacks received longer additional ventilation hours at aOR 1.184 (95 % CI: 1.016 – 1.380). They also stayed in the ICU and the hospital longer (aOR 1.119, 95 % CI: 1.012 – 1.237 and aOR 1.124, 95% CI: 1.055 – 1.198 respectively). Black women also received significantly longer postoperative ventilation at aOR 1.189 (95 % CI: 1.001 – 1.413). The adjusted analysis is summarized in Table 3c.

4. Conclusions and Discussion

4.1. Discussion

The current study represents, to our knowledge, the only analysis of clinical outcomes and complications following SAVR stratified by both sex and race. It captured 3232 SAVR patients from three Emory affiliated hospitals in the metro Atlanta region over a span of 14 years, including 49.0 % female and 14.9 % African American patients. Despite the fact that African Americans are not represented at the rate the regional demographics in the State of Georgia indicates, it is well above national population of 11 %, surpassing black representation rate of many SAVR as well as cardiac surgery outcomes studies conducted [29,42,48,49].

4.2. Descriptive analyses

We found that there is a general trend of blacks presenting with higher frequencies of comorbidities before SAVR procedures when compared to white cohorts. They were younger, had higher NYHA score, higher frequencies of heart failure two weeks before SAVR, diabetes, and alarmingly higher frequency of renal failure. African American males had the significantly highest resource utilization including postoperative ventilation hours, length of stays in ICU as well as in the hospital post-surgery before discharge as summarized in Table 1.

Lucas *et al*. has also found that admission of African American patients with urgent status is higher than white counterparts (28.0 % vs. 24.4 %), which is in general agreement with our findings of black population receiving more urgent procedures (50.3 % vs. 38.2 % within race) [22]. As in the case with disparities in care and underrepresentation, causes are likely to be multifactorial. Our study findings of differences in odds of clinical outcomes reflect complexities of involvement of multiple factors that are inherent in race and gender.

In terms of gender association, women were generally older, had higher mortality risk score calculated as STS-PROM, indicating that they may be frailer, and had higher frequencies of

postoperative complications including 30-day mortality and stroke. However, when logistic regression was performed to investigate the effects of gender and race, all significance on gender/race association was lost.

Female gender alone has been shown as a significant risk factor using euroSCORE and STS-PROM score even though males have much higher prevalence of comorbidities such as diabetes, coronary and peripheral arterial diseases as our studies have also shown. This might be attributed to the fact that at the time of symptom manifestation, females are older, weaker, and have more severe grades for the NYHA score [50]. Yet, after adjusting for propensity score or other comorbidities, many researchers have found that female gender does not significantly predict short-term mortality [51,52]. However, Onorati *et al.* has found that in Italian cohort, adjusted odds ratio of 30-day mortality in women is 2.34, *p*-value 0.043 when compared to male counterpart [50]. Our finding on short-term mortality is in agreement with many of the previous studies showing no significant association, despite the fact that our female cohort is further stratified by race.

4.2.1. Crude analyses

Our study was stratified not only by gender or race alone but by both in the hopes of teasing apart the delicate differences that may lie among the four groups of our patient cohort, black female, black male, white female, and white male. Upon crude logistic analyses, it was shown that the risk of short-term 30-day mortality is significantly higher for black male when compared to the white male cohort (cOR 2.084, 95% CI: 1.010 – 4.301). Unlike any other groups of the patient population, African American male also had the highest odds of hospital resource utilization including prolonged, additional ventilation utilization (cOR 1.587, 95 % CI: 1.125 – 2.240) and its usage time (cOR 1.283, 95 % CI: 1.090 – 1.509) as well as the longer lengths of stay in both ICU (cOR 1.189, 95 % CI 1.068 – 1.324) and in-hospital (cOR 1.155, 95 % CI: 1.080 – 1.235). Akin

to the black male counterpart, white female group also had significantly higher hospital resource utilization when compared to the white male group, though the association is weaker than that of the black male in comparison to the white males. Also, black females received significantly longer postoperative ventilation usage as shown by the cOR 1.249 (95 % CI: 1.040 – 1.499) when compared within gender but across race.

When collectively investigated, gender or race alone did not show the entire tendencies which separate and define in finer details each of the four groups studied here. Only by closer inspection of the postoperative outcomes using further stratification investigating both the effects of gender and race, we were able to detect more detailed differences.

4.2.2. Adjusted outcomes

In the adjusted analyses, all the post-operative outcomes were adjusted for STS-PROM score to control for the severity of the comorbidities and the risk factors present before the SAVR procedure. Upon adjustment, the significance of the effects of race and gender together was not found in any of the outcomes, but the significant increase in odds of hospital resource utilization for the black male group remained. Black female was found to have higher odds of receiving longer postoperative ventilation. Together, our findings indicate that race is a stronger predictor in hospital resources than gender. Again, without further stratification, we would not have been able to detect the differences.

4.2.3. Investigation on loss of significance

What appeared striking in this study was that at every step of the analyses, it appeared that there are strong indications that blacks may have higher propensity for the worse outcomes than the whites. African American group had more deaths within 30 days of SAVR, postoperative stroke, longer additional ventilation use, and longer ICU stay. Black male had higher incidents of

experiencing postoperative pneumonia, while black female group had higher incidents of postoperative renal failure. Combined with all the increased frequencies of pre-existing comorbidities as well as the risk factors for worsened outcomes, we predicted that we would see significant differences among the groups.

In attempt to explain this seeming paradox of having many indications to do worse in surgical outcomes, especially in short-term mortality, and not exhibiting any significant differences compared to the groups with less propensity indications, we have set out to investigate what gives the African American cohort a survival edge after SAVR.

We propose that the differences in 30-day mortality associations with the gender/race among four groups diminish due to the higher likelihood of hospital resource utilization among the more vulnerable: the blacks and the females. This is illustrated in the fact that the differences become attenuated once the associations are adjusted for the risk score of each group.

In most cases, in order to make valid comparisons, adjustment of all the comorbidities is necessary. However, when clear indication exists that there are underlying causes that mask the true nature of the relationship between the problem (30-day mortality) and the exposure (gender/race), re-evaluation of necessity for adjustment needs to be made. As discussed briefly above, the reason why there is an improved edge for survival among white female and black male groups may be lie in the relationship between the hospital resource utilization and the risks that the models were adjusted for.

In order to investigate this possibility, we have extracted the means and medians of the length of stay post-procedure compared among the four groups (Table 4). We have found that the prolonged length of post-operative stay in the hospital is correlated to the worse risk score of each of the compared groups. STS-PROM score is described in the log from. Due to the right skewed

nature of the STS-PROM score, unless it is described in log scale, the differences cannot be appreciated. White male has the lowest mean/median STS-PROM score (-3.795 and -3.877 respectively) while having the shortest mean/median lengths of stay (1.866 and 1.792). Black female group had the highest STS-PROM score (-3.298 and -3.439) and longer median length of stay at 1.946. Interestingly, all three non-reference groups had the same median value for the log-LOS discharge to surgery. This finding supports our hypothesis that lengths of stay after SAVR is longer because it is correlated to the patients' risk score. The higher the risks, the worse the comorbidities, and thus the longer the stay in the hospital before discharge. In turn, the longer care they receive may give the vulnerable population an edge for survival, masking the significance of association between sex and gender.

Implicit bias in healthcare system has been long suspected and studied, focusing mainly on the negative impacts the bias may impose on the patient populations [53]. However, our data implies that the positive implicit bias may exist from the observations we have made with white female and black males receiving longer hospital resource utilization. This can be seen from the fact that the black female is the group which has the worst of the comorbidities before SAVR procedure, as indicated by the particularly higher STS-PROM score compared to any of the groups. However, black females received the same median length of stay in the hospital, as the two other vulnerable groups of white females and black males, diminishing the significance of association when compared to either the black male cohort or the reference group, white males.

4.2.4. Limitations and strengths

Limitations of this study stems from the retrospective study design involving single-center procedural data. Selection bias is likely present caused by referral patterns, which is a known

factor in underrepresentation of both race and gender disparities, which are the major exposures we sought to study. The population does not completely represent general population of greater metropolitan Atlanta area, as AA population especially is underrepresented. Furthermore, due to the limited sample size of the main outcome of 30-day mortality, stringent statistical analysis was not achievable. There are only 76 total deaths within 30 days after the SAVR procedure, and notably, all the 10 black males who have died within 30 days died in the hospital before discharge. This fact alone limited us in making observations using logistic regression, adding to the difficulty of low death counts.

Strengths of our studies lies in the more broadly represented patient demographics. Unlike many of the recent studies, we have attained almost 50 % female cohort inclusion, and almost 15 % of African American cohort. To the author's knowledge, there has not been a single SAVR outcomes study that had this scale of AA involvement, casting further light into the needs of this often under-represented and vulnerable group.

4.3. Discussion on the findings and their important implications in public health

This study represents the only SAVR outcomes research investigating the effects of both gender and race simultaneously. The power of this study also lies in the fact that the vulnerable and under-represented population is relatively well represented in comparison with the existing studies. Women have almost equal representation as men, and more than the national average of black population is included. Furthermore, upon realization of the skewed distribution of comorbidities as well as generally worse outcomes compared to the white males, we have decided to investigate whether other factors aside from the biological aspects are at play behind the higher mortality rate and worse surgical outcomes.

Due to the nature of the database utilized to access patient information, direct metric measuring the socioeconomic status is not available. However, location of discharge is traditionally used as a proxy metric which has been shown to correlate and predict the social economic standing of the population while correlating strongly with worse outcomes after SAVR in women[54]. Mehilli *et al.* has found that the women discharged at non-home locations, such as nursing home, rehabilitation center, or other hospitals, had significantly and alarmingly higher hazards ratio of cardiovascular death (HR 2.0, 95 % CI: 1.1 – 3.6) and stroke (HR 8.5, 95 % CI: 2.9 – 25.6) within 1 year after the TAVR procedure. Considering the fact that women in general have been found to have better TAVR outcomes, short-term mortality and other perioperative outcomes, compared to the male cohort, these findings of discharge location and mortality by Mehilli *et al.* are disturbing [39,40,54]. In our study, we have found that while 90 % of the white male group was discharged to home, the home discharge frequencies were much lower in other cohorts. 85.6 % of black men were discharged to home, and had the second highest home discharge percentage. Women on the other hand, had much higher likelihood of getting discharged to non-home location, black female having the highest non-home discharge rate (19.7 % black female vs. 17.2 % white female compared to 14.4 % black male vs. 10 % white male non-home discharge frequencies). This correlates well with the STS predictor of mortality scores that are highest among black women while white women have the second highest score when compared to the male counterparts (-3.44 vs. -3.49 for black women and white women respectively). Crude odds ratios comparing the four contrast pairs showed significant differences between the genders among whites and between the race among males (Figure 5). When compared to the white male, white female had cOR 1.868 (95 % CI: 1.488 – 2.346), while black male had cOR 1.507 (95 % CI: 1.027 – 2.210). Crude odds ratio is reported for this metric as well, as SES may directly or indirectly

contribute to worsening the risk of mortality, inadvertently masking the true relationship as with the case in the lengths of stay in the hospital.

Also, of interest to note is that the black population is presenting at younger age for SAVR procedure (63.2 ± 13.7 and 59.5 ± 14.4 years old for black female and male, and 69.9 ± 12.7 and 66.1 ±13.7 years old for white female and male respectively) but requires higher percentage of urgent SAVR. White counterparts are older and have higher likelihood of having elective SAVR (urgent status of 50 %, 47.2 %, 34.9 %, and 32.5 % for black female, black male, white female, and black male respectively). These number may reflect a few possible, unique challenges the black cohorts face that are unrelated to biological differences among races. Sleder *et al*. has shown that African American population has lower referral rate to cardiologists, and when referred, they have higher rate of refusal of care [36,55]. They also are reported to be more likely to be lost from the follow-up [55]. This tendency of refusal of care is observed by other researchers, and in turn, they attribute these behavioral differences to potentially cultural and historical reasons [27,56].

From the historical perspectives, black population appears to have inherent distrust in white medical communities and teams, still feeling the impact from the Tuskegee syphilis experiment [16,57,58]. Moreover, African Americans and other minorities are also known to consult family members more frequently than the white cohorts to make important medical decisions, which leads to higher refusal of care especially for patients at older age with higher risk/impact procedures such as cardiac intervention [56]. This, in turn has been described as one of the reasons why black populations are not as well represented in important clinical trials that would help gain insights into specific needs of the cohorts [56]. Combined with the aforementioned challenges as well as the biological and socio-economical differences, we begin to understand the complexity of the surgical outcome differences among different racial and gender groups.

In the recent years, advancement of TAVR as an alternative to SAVR has seen incredible strides, becoming more accessible to patients not only presenting with the most severe forms of AS, but for moderate to even lower risk patients. However, for the most vulnerable populations of interest within the scope of this study, blacks and females, access to care to such innovative technology may be difficult for multiple reasons. 40.8 % of blacks as opposed to 24.4 % of whites belong to lowest income quartile, and attendance of blacks at the very low volume hospital is much higher than the white cohorts (25.6 % vs. 19.4 % respectively) [22]. Despite the fact the insurance coverage disparity has been diminishing after the Affordable Care Act has gone into effect as of January 1, 2014, the uninsured population among blacks is still higher than the whites (17 % blacks vs. 11 % whites) [59]. Since the cost of TAVR to the patients vary greatly depending on the types of insurance and healthcare systems utilized, this is an additional layer of challenge which needs to be addressed in terms of access to alternative care [13]. In fact, as of 2015, only 3.8 % of the total patients undergoing TAVR nationwide is blacks. In a single center experience where the black population comprises 38 % of the total patients, the percent TAVR recipients only reaches 10 %, illustrating the disparities [10].

These limitations strengthen the argument that continuing research on SAVR demographics and outcomes is necessary.

Public health studies often focus disproportionately on access to care, while biological investigations primarily focus on biology of the patients and the diseases. In this study, we attempted to incorporate all aspects important in public health of surgical outcomes by discussing the biology and the insights into access to care available to the more vulnerable populations.

4.4. Conclusions and further direction

After risk adjustment, there was no difference observed in 30-day mortality among four different racial and gender groups. The fact that the black male cohort had longer length of stay may explain the observed risk-adjusted 30-day mortality rates that are similar among all the groups.

There are clear and significant differences among the gender and racially stratified cohorts of patients. Dissecting the relationship between the demographics and the outcomes of SAVR and other cardiological intervention such as TAVR would be invaluable in understanding the needs and risks specific to each of the cohorts. Combined with the insights describing the comorbidities and non-biological determinants of health, these findings will be important in better serving the patient population as a whole, diminishing the disparities of health care both access and outcomes, aiming towards elimination of disparity entirely.

In light of our findings, we recommend and aim to perform survival analysis measuring the time to discharge as the main outcome with competing risk of death to more appropriately assess the relationship of race and gender to 30-day mortality to better understand the underlying causes of differences observed in SAVR outcomes.

5. Figures

Figure 1. Study Flow Diagram

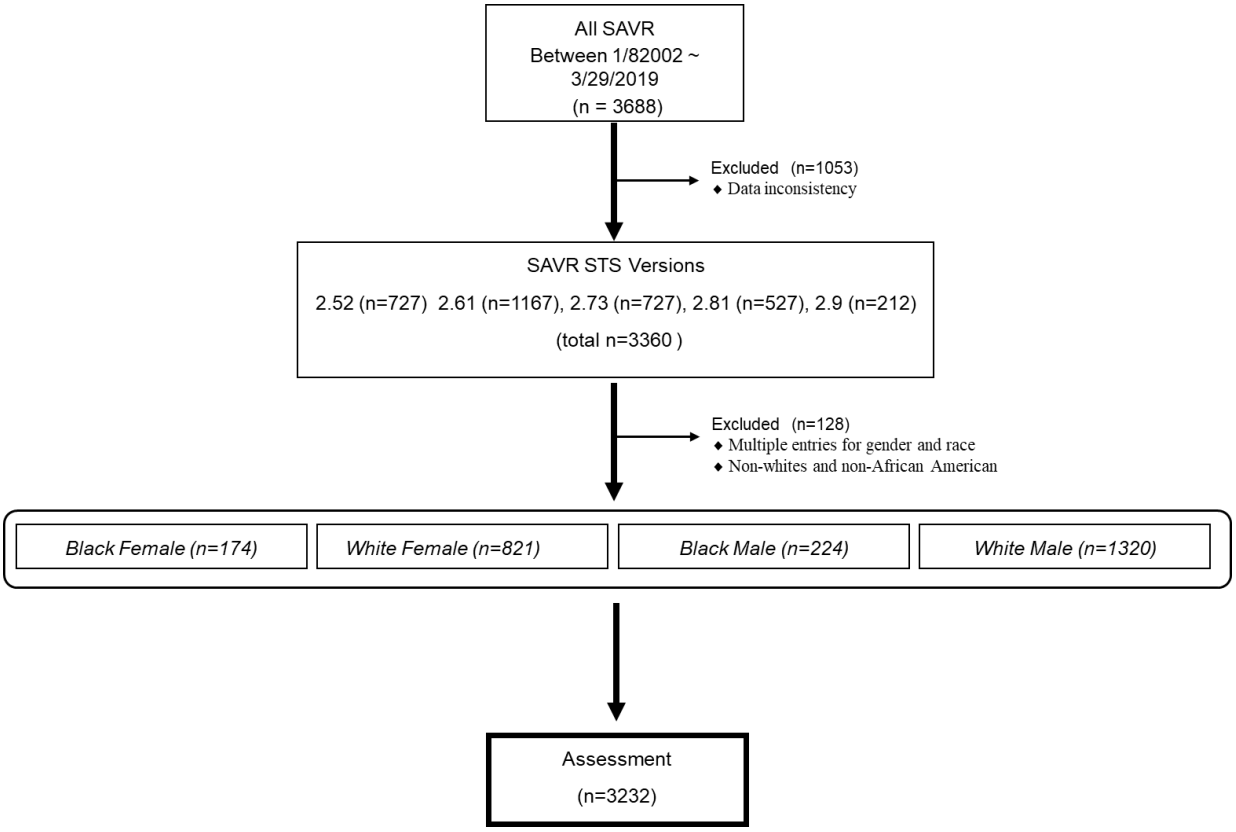


Table 1. Patient Characteristics

Table 1. Preoperative Characteristics

Characteristics	**Black Female n = 212 (6.56 %)**	**White Female n = 1047 (32.39 %)**	**Black Male n = 269 (8.32 %)**	**White Male n = 1704 (52.72 %)**	***p* value***
Age, mean ± SD	63.2 ± 13.7	69.9 ± 12.7	59.5 ± 14.41	66.11 ± 13.7	<0.01
Body mass index (BMI), kg/m^2	31.6 ± 7.6	28.9 ± 7.2	28.5 ± 6.4	28.9 ± 5.7	<0.001
STS PROM Score, median (Q1 — Q3)	0.03 (0.02 — 0.06)	0.03 (0.02 — 0.05)	0.03 (0.01 — 0.05)	0.03 (0.02 — 0.04)	<0.0001
LOG STS PROM Score, median (Q1 — Q3)	-3.44 (-2.78 — -3.83)	-3.49 (--2.92 — -4.04)	-3.65 (-3.01 — -4.42)	-3.88 (-3.21 — -3.47)	<0.0001
New York Heart Associaton class III or IV, n (%)	113 (63.8)	487 (60.1)	143 (68.8)	727 (56.9)	0.01
Urgent/Emergent Status, n (%)	106 (50.0)	365 (34.9)	127 (47.2)	553 (32.5)	<0.001
Any history of smoking, n (%)	90 (42.5)	366 (35.0)	142 (52.8)	806 (47.3)	<0.001
Heart failure within 2 weeks, n (%)	169 (79.7)	687 (65.6)	191 (71.0)	1056 (65.1)	<0.01
Peripheral vascular disease, n (%)	018 (8.5)	99 (9.5)	29 (10.8)	221 (13.0)	0.02
endocarditis, n (%)	33 (15.6)	33 (3.16)	68 (25.3)	129 (7.6)	<0.001
Previous myocardial infarction, n (%)	33 (15.6)	110 (10.5)	44 (16.4)	306 (18.01)	<0.001
Previous valve opearation, n (%)	22 (10.4)	79 (7.6)	24 (8.9)	146 (8.6)	0.52
Hypertension, n (%)	196 (92.5)	863 (82.5)	238 (88.5)	1399 (82.2)	<0.01
Cerebrovascular disease, n (%)	41 (19.3)	162 (15.52)	38 (14.13)	317 (18.6)	0.074
Dyslipidemia, n (%)	146 (68.9)	744 (71.3)	172 (64.2)	1260 (74.1)	<0.01
Diabetes, n (%)	85 (40.1)	300 (28.7)	89 (33.1)	494 (29.0)	<0.01
Chronic lung disease, n (%)	51 (24.4)	270 (26.1)	72 (27.1)	418 (24.8)	0.78
Renal failure, n (%)	40 (18.9)	19 (1.8)	55 (20.5)	48 (2.8)	<0.001
Immunosuppressive therapy, n (%)	22 (10.4)	55 (5.3)	23 (8.6)	83 (4.9)	<0.01
Redo Operation, n (%)	31 (14.6)	142 (13.6)	39 (14.5)	394 (23.1)	<0.001
Hemoglobin, g/dL, mean ± SD	11.6 ± 1.7	12.3 ± 1.8	11.9 ± 2.3	13.4 ± 2.2	<0.001
Hemoglobin A1c, mean ± SD	6.1 ± 1.5	5.8 ± 0.9	5.9 ± 1.0	5.9 ± 1.0	0.08
Ejection fraction, mean ± SD	54.4 ± 12.1	57.3 ± 10.8	51.9 ± 11.4	53.3 ± 12.4	<0.001

* The p-value indicates the significance of the differences among the four groups. The null hypothesis is that all the group means or proportions are the same For continuous variables, means and SD are reported; for categorical variables, the chi-square test was used.

Table 2. Intraoperative Details by Race and Gender

Table 2. Intraoperative Characteristics

Characteristics	**Black Female n = 212 (6.56 %)**	**White Female n = 1047 (32.39 %)**	**Black Male n = 269 (8.32 %)**	**White Male n = 1704 (52.72 %)**	***p* value***
Circulatory Arrest, n (%)	0 (0)	4 (0.5)	0 (0)	4 (0.3)	0.57
Aortic cross-clamp time, minutes, mean ± SD	87.4 ± 29.5	83.0 ± 25.6	85.7 ± 27.4	88.2 ± 28.3	<0.0001
Intraoperative intraaortic balloon pump insertion, n (%)	12 (5.7)	35 (3.4)	8 (3.0)	74 (4.4)	0.26
CPB Utilization, n (%)	207 (97.6)	985 (94.1)	264 (98.1)	1625 (95.42)	0.01
Cardiopulmonary bypass time, minutes, mean ± SD	113.8 ± 36.4	109.1 ± 33.6	116.1 ± 42.0	118 ± 38.4	<0.001
Intraoperative blood product use, n (%)	152 (72.4)	647 (61.9)	142 (53.0)	6744 (39.7)	<0.001
Intraoperative PRBCs, mean ± SD	2.0 ± 1.8	1.5 ± 2	1.1 ± 1.8	0.7 ± 1.6	<0.001

* The p-value indicates the significance of the differences among the four groups. For continuous variables, means and SD are reported; for categorical variables, the chi-square test was used.

Table 3a. Descriptive Postoperative Outcomes by Race and Gender

Table 3a. Postoperative Characteristics

Characteristics	*Black Female* n = 174 (6.85 %)	*White Female* n = 821 (32.34 %)	*Black Male* n = 224 (8.82 %)	*White Male* n = 1320 (51.99 %)	*p* value*
MACE (death, stroke, or MI)					
30-day mortality, n (%)	9 (4.3)	29 (2.8)	10 (3.7)	31 (1.8)	<0.05
Stroke, n (%)	8 (3.8)	29 (2.8)	5 (1.9)	37 (2.2)	0.40
Postop renal failure, n (%)	10 (4.7)	30 (2.9)	7 (2.6)	49 (2.9)	0.48
New-onset dialysis, n (%)	5 (2.4)	18 (1.7)	6 (2.2)	28 (1.6)	0.82
Postoperative pneumonia, n (%)	5 (2.4)	31 (3.0)	13 (4.8)	52 (3.1)	0.37
Postoperative IABP insertion, n (%)	1 (0.5)	8 (0.8)	4 (1.5)	8 (0.5)	0.25
Location of Discharge, Home, n (%)	167 (80.7)	844 (82.8)	220 (85.6)	1505 (90.0)	<0.0001
Prolonged ventilation, n (%)	41 (19.3)	152 (14.5)	48 (17.8)	205 (12.0)	<0.01
Postoperative ventilator hours, median (Q1-Q3)	12.30 (5.25 — 21.05)	7.50 (4.58 — 20.00)	9.00 (4.85 — 19.365)	7.00 (4.10 — 17.27)	0.40
Postoperative length of stay, median (Q1-Q3)					
ICU, h	51.05 (27.80 — 100.60)	49.30 (26.40 — 94.00)	48.75 (27.00 — 96.65)	45.50 (25.20 — 75.65)	<0.01
Operation to disharge, d	7.00 (5.00 — 10.00)	6.00 (5.00 — 9.00)	7.00 (5.00 — 10.00)	6.00 (5.00 — 8.00)	0.31

* The p-value indicates the significance of the differences among the four groups. For continuous variables with right-skewed distribution, the outcome was log-transformed, and medians and Q1 and Q3 are reported; for categorical variables, the chi-square test was used.

Table 3b. Crude Postoperative Outcomes

Table 3b. Crude Postoperative Characterics tics

Characteristics	White Female vs White Male	Black Female vs Black Male	Black Male vs White Male	Black Female vs White Female	*p* value*
MACE (death, stroke, or MI)					
30-day mortality	1.537 (0.921 — 2.566)	1.148 (0.458 — 2.879)	2.084 (1.010 — 4.301)	1.557 (0.726 — 3.338)	0.59
Stroke	1.283 (0.784 — 2.100)	2.071 (0.667 — 6.424)	0.853 (0.332 — 2.189)	1.377 (0.620 — 3.055)	0.45
Postop renal failure	1.000 (0.628 — 1.579)	1.853 (0.693 — 4.953)	0.902 (0.404 — 2.012)	1.678 (0.808 — 3.488)	0.26
New-onset dialysis	1.046 (0.576 — 1.901)	1.059 (0.319 — 3.518)	1.365 (0.560 — 3.328)	1.381 (0.507 — 3.761)	0.98
Postoperative pneumonia	0.969 (0.617 — 1.522)	0.476 (0.167 — 1.356)	1.612 (0.866 — 3.003)	0.792 (0.304 — 2.060)	0.22
Postoperative IABP insertion	1.631 (0.610 — 4.358)	0.314 (0.035 — 2.830)	3.191 (0.954 — 10.670)	0.614 (0.076 — 4.938)	0.18
Prolonged ventilation	1.241 (0.990 — 1.556)	1.104 (0.695 — 1.752)	1.587 (1.125 — 2.240)	1.412 (0.964 — 2.068)	0.66
Location of Discharge, non-Home	1.868 (1.488 — 2.346)	1.424 (0.872 — 2.325)	1.507 (1.027 — 2.210)	1.149 (0.784 — 1.682)	0.33
Postoperative ventilator hours, mean (CL)	1.167 (1.056 — 1.289)	1.135 (0.908 — 1.420)	1.283 (1.090 — 1.509)	1.249 (1.040 — 1.499)	0.83
Postoperative length of stay					
ICU	1.177 (1.104 — 1.256)	1.072 (0.922 — 1.246)	1.189 (1.068 — 1.324)	1.083 (0.957 — 1.225)	0.26
Operation to discharge	1.108 (1.065 — 1.153)	1.033 (0.940 — 1.134)	1.155 (1.080 — 1.235)	1.077 (0.997 — 1.163)	0.18

*The p-value indicates the significance of the difference of the odds ratio or geometric mean ratio. To determine the significance of each of the four comparisons, (white female vs white male, black female vs. black male, black male vs. white male, and black female vs. white female), the 95% confidence interval is provided. For continuous variables with right-skewed distribution, the outcome was log-transformed.

Table 3c. Adjusted Postoperative Outcomes

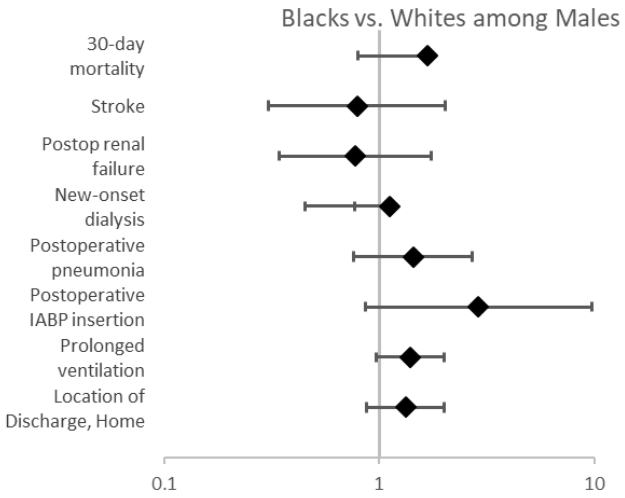
Table 3c. Adjusted Postoperative Characterics tics

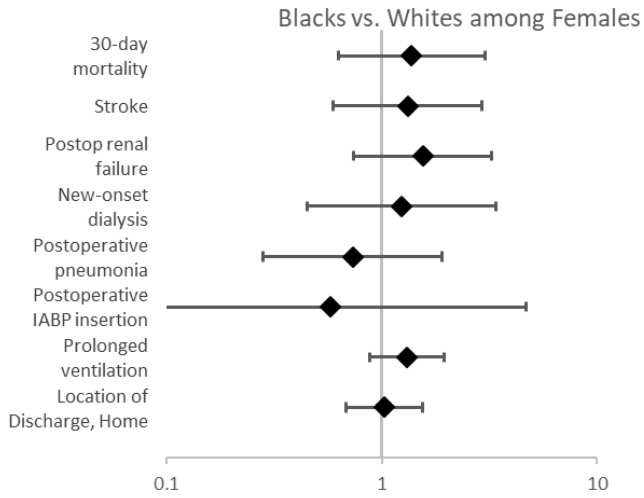
Characteristics †	**White Female vs White Male**	**Black Female vs Black Male**	**Black Male vs White Male**	**Black Female vs White Female**	***p* value***
MACE (death, stroke)					
30-day mortality	1.165 (0.691 — 1.964)	0.954 (0.370 — 2.462)	1.677 (0.793 — 3.550)	1.373 (0.628 — 3.002)	0.72
Stroke	1.122 (0.682 — 1.847)	1.871 (0.601 — 5.823)	0.789 (0.307 — 2.032)	1.316 (0.592 — 2.927)	0.42
Postop renal failure	0.802 (0.502 — 1.279)	1.601 (0.594 — 4.320)	0.776 (0.345 — 1.748)	1.551 (0.741 — 3.246)	0.22
New-onset dialysis	0.808 (0.442 — 1.479)	0.891 (0.264 — 3.003)	1.120 (0.453 — 0.772)	1.234 (0.449 — 3.395)	0.89
Postoperative pneumonia	0.797 (0.505 — 1.259)	0.408 (0.142 — 1.170)	1.435 (0.764 — 2.693)	0.733 (0.281 — 1.912)	0.25
Postoperative IABP insertion	1.387 (0.514 — 3.734)	0.277 (0.031 — 2.508)	2.893 (0.860 — 9.735)	0.579 (0.072 — 4.660)	0.19
Prolonged ventilation	0.946 (0.747 — 1.200)	0.889 (0.546 — 1.449)	1.391 (0.965 — 2.005)	1.306 (0.876 — 1.948)	0.82
Location of Discharge, Home	1.444 (1.135 — 1.837)	1.118 (0.662 — 1.888)	1.325 (0.878 — 1.999)	1.026 (0.685 — 1.536)	0.38
Postoperative ventilator hours	0.988 (0.898 — 1.087)	0.992 (0.803 — 1.225)	1.184 (1.016 — 1.380)	1.189 (1.001 — 1.413)	0.97
Postoperative length of stay					
ICU	1.034 (0.972 — 1.100)	0.959 (0.833 — 1.103)	1.119 (1.012 — 1.237)	1.038 (0.925 — 1.164)	0.25
Operation to discharge	1.027 (0.989 — 1.067)	0.959 (0.878 — 1.048)	1.124 (1.055 — 1.198)	1.050 (0.977 — 1.128)	0.16

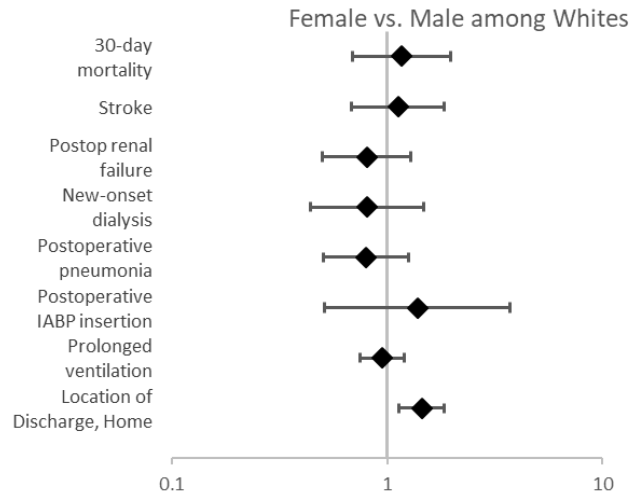
*The p-value indicates the significance of the difference of the odds ratio or geometric mean ratio. To determine the significance of each of the four comparisons, (white female vs white male, black female vs. black male, black male vs. white male, and black female vs. white female), the 95% confidence interval is provided. For continuous variables with right-skewed distribution, the outcome was log-transformed.

† All the post-operative outcomes were adjusted for the STS-PROM score

Figure 2. Forest Plots Summarizing the Adjusted Outcomes







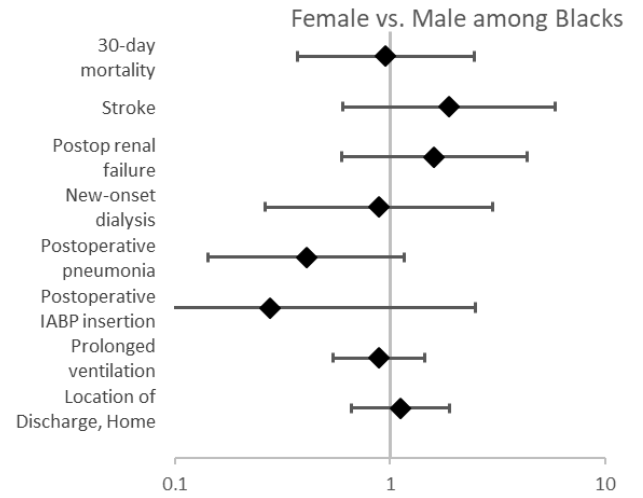
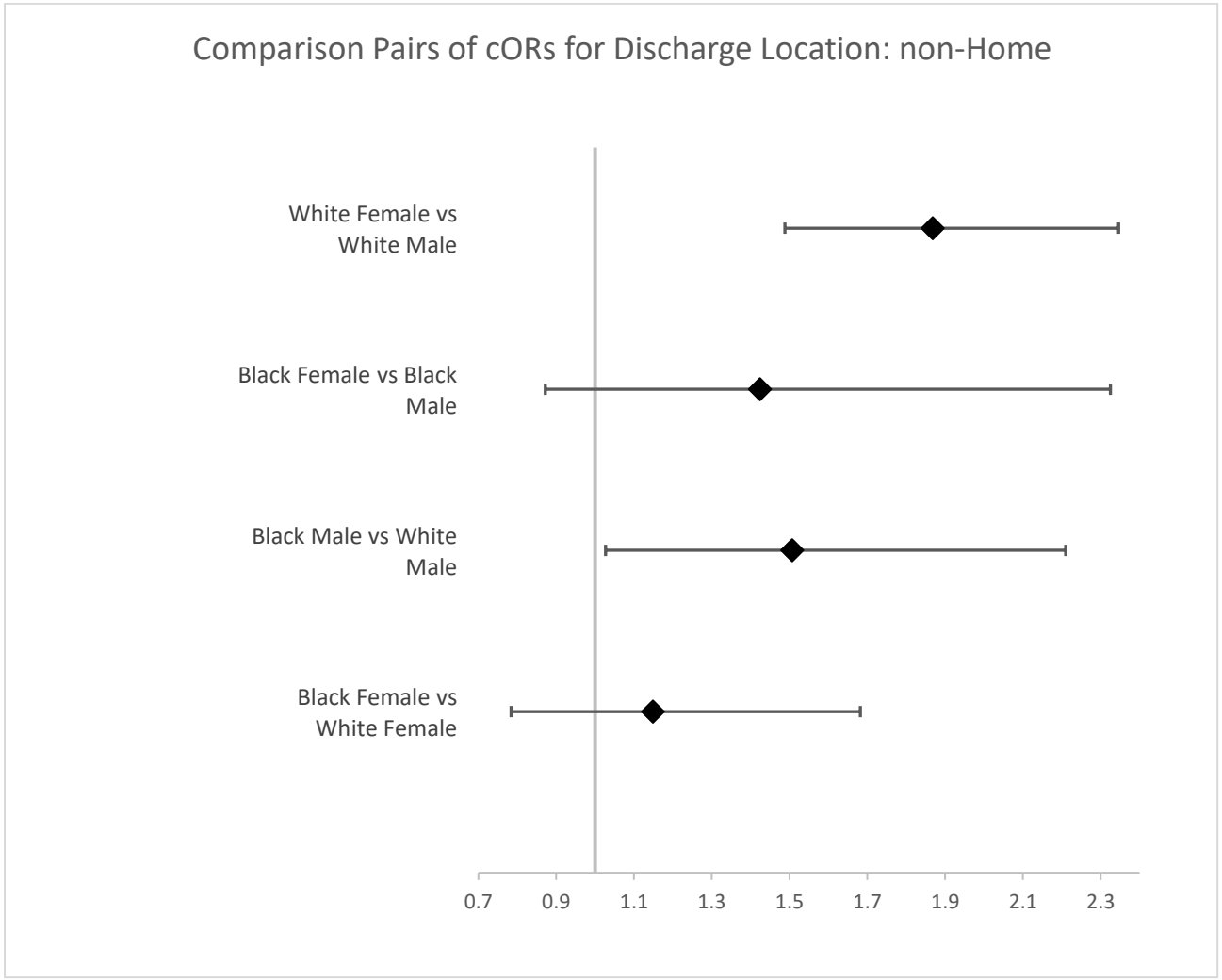


Table 4. Description of post-procedural length of stay in hospital and the risk score

exposure	N	Variable	Mean	Median
Black Female	212	Log STS-PROM	-3.298	-3.439
		Log LOS-surgery to discharge	2.028	1.946
White Female	1047	Log STS-PROM	-3.425	-3.485
		Log LOS-surgery to discharge	1.967	1.946
Black Male	269	Log STS-PROM	-3.631	-3.654
		Log LOS-surgery to discharge	2.032	1.946
White Male	1704	Log STS-PROM	-3.795	-3.877
		Log LOS-surgery to discharge	1.866	1.792

Table 5. Comparison pairs of cORs for non-home discharge location



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7. Appendix

Supplemental Table 1. Determination of variable and version selection

	Variables	Versions (% missing)						
		Version 2.41	Version 2.52	Version 2.61	Version 2.73	Version 2.81	Version 2.90	NOTES
	Preoperative							
✓	Patient_Age	0	0	0	0	0	0	
✓	Sex	0	0	0	0	0	0	
	Race___Black___African_American	100	100	0.09	0	0	0	
✓	Race___White	100	100	0	0	0	0	
	Race	0	0	100	100	100	100	
✓	CTS___Body_Mass_Index	0	0.14	0	0	0	0	
✓	Classification_NYHA	0	0.27	36.01	29.06	20.64	15.02	
✓	Status	0	0.14	0.26	0	0	0	
	Ejection_Fraction_Measured_Post	100	100	100	100	100	5.16	*which variable to use? (read the proc contets "label" column)
✓	Hemo_Data_EF	7.41	7.69	4.79	2.2	0.95	0	
✓	Cardiopulmonary_Bypass_Time	0	0.69	12.66	0.14	0.19	0	
	CPB_Utilization	60.49	0	0.09	0	0	0	
	Conversion_to_CPB	0	47.8	42.17	49	0.38	0	
	Valve_Orifice_Area___Aortic	54.32	66.07	46.26	100	100	100	*Any other variable? Variable missing in the dataset
	STS_Risk_Calculator_Score_Discus	100	100	100	100	100	0	*Any other variable? "Predicted_Risk_of_Mortality, PROM"
	RF_Smoker	0	0.14	100	100	100	100	
	RF_Smoker_Current	43.83	48.76	100	100	100	100	
✓	Cigarette_Smoker	100	100	0.34	0	100	100	
	Cigarette_Smoker_Current	100	100	100	86.36	100	100	
	RF_Tobacco_Use	100	100	100	100	0	0	
✓	IABP	0	0.14	0.6	0	0	0	
	Blood_Glucose	100	81.87	29.34	17.22	0.19	0	*No other RF glucose; only peri/post-op variables
✓	RF_Hemoglobin	100	100	100	100	0	0	
	Pre-operative hemoglobin	2.47	47.25	29.17	16.67	100	100	
?	RF_Last_A1c_Level	100	100	75.19	3.99	3.03	1.41	*Maybe? They are both inconclusive
	Pre_Operative_Hemoglobin_A1C	30.25	51.79	41.49	100	100	100	
	Heart Failure	100	100	100	100	100	0	
?	Prior_Heart_failure	100	100	100	0.28	0	100	
	Heart_Failure_within_2_weeks	0	0.14	0	0	0	100	
✓	RF_Peripheral_Arterial_Disease	0	0.55	0.6	0	0	0	
✓	RF__Endocarditis	0	0.41	0.6	0	0	0	
	Angina	0	0.27	100	100	100	100	
?	Anginal Classification within 2 weeks	100	100	100	0.14	0	100	*Missing from versions 2.61 and 2.90--True
	Unst_Angina_Parenteral_NTG	98.15	97.25	96.83	100	100	100	
✓	Prior_MI	100	100	0.17	0	0.38	0	
	MI	0	0.41	100	100	100	100	
	Prev_Valve	72.53	73.76	63.22	63.64	68.18	65.26	
?	Prev_Valve_Procedure_1	100	100	100	100	87.5	87.79	*No variable appears to be completely inclusive-- STS database contain "parent field". For instance, only when "Prev_Cardiac_Intervent=Yes" mean pt had previous cardiac surgery, then "Prev_Valve" or "Prev_CAB" indicate the surgery is on "valve" or a "CABG".
	Prev_Valve_Procedure_2	100	100	100	100	87.5	87.79	
	Prev_Valve_Repair	91.98	95.47	94.95	100	100	100	
	Prev_Valve_Replace	91.98	95.47	94.95	100	100	100	
	VS-Aortic Valve	100	100	100	0	0	0	
	VS-Aortic Vavle Procedure	100	100	100	0	0	0	
	RF_Prior_CVA	0	0.41	81.52	82.23	82.95	81.69	history of stroke not resolved within 24h
✓	RF_Cerebrovascular_Dis	0	0.41	0.26	0	0	0	Include CVA, TIA, Non-invasive carotid test with > 79% diameter occlusion.; or Prior carotid surgery or stenting or prior cerebral aneurysm clipping or coil. Does not include neurological disease processes such as metabolic and/or anoxic ischemic encephalopathy.
✓	RF_Dyslipidemia	100	100	0.51	0	0	0	
	RF-Dislipidemia 2.73	0	0.41	100	100	100	100	
✓	RF_Diabetes	0	0.27	0.34	0	0	0	
✓	RF_Chronic_Lung_Disease	0	0.41	0.43	0	0	0	
✓	RF_Renal_Fail	0	0.41	29.6	100	100	100	
	RF_Renal_Fail_Dialysis	92.28	91.21	0.43	0	0	0	
✓	RF_Immunocompromise	0	0.55	0.6	0	0	0	
?	Incidence (first reop coded 2)	100	0.14	0	0	0	0	*one version missing
	Perioperative	Version 2.41	Version 2.52	Version 2.61	Version 2.73	Version 2.81	Version 2.90	
✓	Cross_Clamp_Time__min_	0	0.55	13.26	0.28	0	0	
✓	Cardiopulmonary_Bypass_Time	0	0.69	12.66	0.14	0.19	0	
	Circulatory_Arrest	100	100	0.09	0	0	0	*It doesn't appear to have any more relevant variables
	Intraop_Blood_Products	100	0.41	0.43	0	0.57	0.47	*one version missing--v2.41
	Intraop_Blood_Products___RBC_Uni	100	49.86	41.92	48.76	62.12	69.48	
	Intraop_Blood_Products___Platele	100	50.96	41.92	48.76	62.12	69.48	
	Blood_Prod___Platelet_Units	100	55.91	36.01	44.9	53.41	53.99	
✓	IABP	0	0.14	0.6	0	0	0	
	Postoperative	Version 2.41	Version 2.52	Version 2.61	Version 2.73	Version 2.81	Version 2.90	
✓	Mort_30d_Status	5.25	0	0	0	0	2.82	
	Comps_Reop_MI	52.78	100	100	100	100	100	*which other variable for MI?
	MI-When (coded 3)	89.51	88.32	81.86	84.99	86.93	87.32	
	PostOp-Stroke	52.78	55.22	51.67	44.35	36.55	38.97	
	PostOp-Mediastinitis	100	100	100	100	99.24	99.53	*is there any other variable?
	PostOp-mediastinitis2	52.78	55.22	51.67	99.04	100	100	
	PostOp-RenalFailure	52.78	55.22	51.67	44.35	36.55	38.97	
	PostOp_DialReq_discharge	100	100	100	98.76	98.86	98.12	*is there any other variable?
	PostOp_DialysisReq	52.78	95.47	96.24	98.35	98.86	98.12	
	PostOp-Pneumonia	52.78	55.22	51.67	44.35	36.55	38.967	
	IABP_When_Inserted (coded 3)	96.6	96.7	95.12	95.45	93.37	93.43	
	Predicted_Prolonged_Ventilation	100	99.18	0	0	0.19	0	-- never use those "predicted" values in analysis unless sepcifically indicated
✓	Total_Postoperative_Ventilation	100	100	100	100	0	0	
	Postop Vent Hours - Total	1.23	0.82	29.26	15.98	100	100	
✓	Total_Hrs_ICU	0.31	0.96	0.51	0	0.38	0	
✓	LOS_Admit_Discharge	0	0	0	0	0	0	-- not admit to discharge, surgery to discharge

Supplemental Figure 2. SAS Codes

i. Data Cleaning

```
libname y 'T:\biosprojs\Cardiac Surgery\New Files\Brent Keeling\2019 Racial
and Sex Differences in SAVR Outcomes\August';

proc contents data=y.toby2 varnum; run;

proc freq data=y.toby2;
tables Mort_DC_Status  Discharge___Mortality_Status Mort_30d_Status/missing;
run;


data y.prep;
 set y.toby2;
*remove data points with too many missing variables;
 if STS_Data_Version = 2.41 then delete;

*Male Female;
 if sex=1 then do;
      Male=1;
      Female=0;
      end;
 else do;
      Male=0;
      Female=1;
      end;

*Caucasian;
if STS_Data_Version in (2.41,2.52) then do;
 if race=. then Caucasian=.;
  else if race=1 then Caucasian=1;
   else Caucasian=0;
end;

if STS_Data_Version in (2.61, 2.73, 2.81, 2.9) then do;
 if Race___White=1 then Caucasian=1;
  else if Race___White=2 then Caucasian=0;
   else  Caucasian=.;
end;

*AA;
if STS_Data_Version in (2.41,2.52) then do;
 if race=. then Black=.;
  else if race=2 then Black=1;
   else Black=0;
end;

if STS_Data_Version in (2.61, 2.73, 2.81, 2.9) then do;
 if Race___Black___African_American=1 then Black=1;
  else if Race___Black___African_American=2 then Black=0;
   else  Black=.;
end;

*Remove inconsistent race data;
```

```
if Caucasian=black then delete;
if Caucasian=. then delete;
if Black=. then delete;

*BMI;
 * 3 subject had weight/height switched;
 * Their CTS___Body_Mass_Index > 100;
 if Record_ID in ('V33109568', 'V3347122', 'V3393588') then do;
    height_m=Weight__kg_/100;
      weight=Height__cm_;
      BMI_cal=weight/(height_m**2);
 end;
 else BMI_cal=CTS___Body_Mass_Index;

 *Classification_NYHA harvest code
  1=ClassI
  2=Class II
  3=Class III
  4=Class IV
  5=Not documented;
 if Classification_NYHA=. or Classification_NYHA=5 then NYHA34=. ;
  else if Classification_NYHA in (3,4) then NYHA34=1;
      else NYHA34=0;

*status harvest code
 1=Elective
 2=Urgent
 3=Emergent
 4=Emergent Salvage
 ;
 if Status =. then Status_urgent=.;
      else if Status =1 then Status_urgent=0;
            else Status_urgent=1;

***********************************************;
*MI;
 if STS_Data_Version in (2.41,2.52) then do;
 if MI=1 then Pre_MI=1;
  else if MI=2 then Pre_MI=0;
   else Pre_MI=.;
end;

else if STS_Data_Version in (2.61,2.73,2.81, 2.9) then do;
 if Prior_MI=1 then Pre_MI=1;
  else if Prior_MI=2 then Pre_MI=0;
   else Pre_MI=.;
end;
***********************************************;
*CLD harvest code:
 1 No
 2 Mild
 3 Moderate
 4 Severe
 5 Lung disease documented, severity unknown
 6 Unknown;

if RF_Chronic_Lung_Disease=. then CLD=.;
```

```
 else if RF_Chronic_Lung_Disease=5 then CLD=.;
  else if RF_Chronic_Lung_Disease=1 then CLD=0;
   else if RF_Chronic_Lung_Disease=2 then CLD=1;
    else if RF_Chronic_Lung_Disease=3 then CLD=1;
       else if RF_Chronic_Lung_Disease=4 then CLD=1;

*smoke;
*RF_Tobacco_Use harvest code
 1 Never smoker
 2 Current every day smoker
 3 Current some day smoker
 4 Smoker, current status (frequency) unknown
 5 Former smoker
 6 Smoking status unknown;
if RF_Tobacco_Use in (2, 3, 4, 5) then RF_Tobacco_Use_1=1;
if Cigarette_Smoker = 1 or Cigarette_Smoker_Current = 1 or
  rf_smoker_current = 1 or rf_smoker=1 or RF_Smoker_Yrs > 0
  or  RF_Tobacco_Use_1 = 1 then smoke=1;
else smoke=0;

*preop IABP;
*IABP_When_Inserted harvest code
 1 Preop
 2 Intraop
 3 Postop;
if IABP=. then IABP_1=.;*overall IABP;
 else if IABP=1 then IABP_1=1;
  else IABP_1=0;

if IABP_1=. then IABP_Pre=. ;
 else if IABP_1=1 and IABP_When_Inserted=1 then IABP_Pre=1;
  else IABP_Pre=0;

*Hemoglobin;
if STS_Data_Version in (2.41,2.52, 2.61, 2.73) then
Pre_Hemoglobin=Pre_Operative_Hemoglobin;
 else if STS_Data_Version in (2.81, 2.9) then Pre_Hemoglobin=RF_Hemoglobin;

*HbA1c;
if STS_Data_Version in (2.41,2.52, 2.61 ) then
Pre_HbA1c=Pre_Operative_Hemoglobin_A1C;
 else if STS_Data_Version in (2.73, 2.81, 2.9) then
Pre_HbA1c=RF_Last_A1c_Level;

*Heart failure within 2 weeks, harvest code
 1 Yes
 2 No
 3 Unknown;
if Heart_Failure_within_2_weeks=. then HF_2wk=.;
 else if Heart_Failure_within_2_weeks=3 then HF_2wk=.;
  else if Heart_Failure_within_2_weeks=1 then HF_2wk=1;
   else HF_2wk=0;

if Heart_Failure=. then HF=.;
 else if Heart_Failure=1 then HF=1;
  else HF=0;
```

```
if STS_Data_Version in (2.41,2.52, 2.61, 2.73, 2.81) then HF_2wks_1=HF_2wk;
 else if STS_Data_Version in (2.9) then HF_2wks_1=HF;
/*in Version 2.9, Heart_Failure_within_2_weeks complete missing
 therefore has to use "Heart Failure", which did not limit the time of heart
failure
 were within 2 wks. This is not the most accurate resutls, but the best we
can do*/

*Peripheral arterial disease;
if RF_Peripheral_Arterial_Disease=. then per_PAD=.;
 else if RF_Peripheral_Arterial_Disease=1 then per_PAD=1;
  else per_PAD=0;

*Endocarditis;
if RF__Endocarditis=. then per_endo=.;
 else if RF__Endocarditis=1 then per_endo=1;
  else per_endo=0;

/*Angina
 Angina 2.41-2.52
 Anginal_Classification_within_2 2.73-2.81*/

if Angina=. then Angina_1=.;
 else if Angina=1 then Angina_1=1;
  else  Angina_1=0;

if Anginal_Classification_within_2=. then Angina_Modsev=.;
 else if Angina in (4,5) then Angina_Modsev=1;
  else Angina_Modsev=0;
*Moderate to severe Angina;

if STS_Data_Version in (2.41,2.52, 2.61 ) then Pre_Angina=Angina_1;
 else if STS_Data_Version in (2.73, 2.81, 2.9) then Pre_Angina=Angina_Modsev;

*MI;
 if STS_Data_Version in (2.41,2.52) then do;
 if MI=1 then Pre_MI=1;
  else if MI=2 then Pre_MI=0;
   else Pre_MI=.;
end;

else if STS_Data_Version in (2.61,2.73,2.81, 2.9) then do;
 if Prior_MI=1 then Pre_MI=1;
  else if Prior_MI=2 then Pre_MI=0;
   else Pre_MI=.;
end;

*Previous valve opearation;
*Prev_Cardiac_Intervent is the parent field;
if Prev_Cardiac_Intervent=. then Pre_car_int=.; *n=1;
 else if Prev_Cardiac_Intervent=1 then Pre_car_int=1;
  else Pre_car_int=0;

if Pre_car_int=. then Prev_Valve_1=.;
 else if Pre_car_int=0 then Prev_Valve_1=0;
  else if Pre_car_int=1 and Prev_Valve=1 then Prev_Valve_1=1;
   else if Pre_car_int=1 and Prev_Valve=2 then Prev_Valve_1=0;
```

```
    else Prev_Valve_1=.;

*Cerebrovascular disease;
if RF_Cerebrovascular_Dis=. then Pre_CV_D=.;
 else if RF_Cerebrovascular_Dis=2 then Pre_CV_D=0;
  else if RF_Cerebrovascular_Dis=1  then Pre_CV_D=1;

*Hypertension;
if RF_Hypertension=. then Hypertension=.; *nmiss=4;
 else if RF_Hypertension=1 then Hypertension=1;
 else Hypertension=0;

*Dyslipidemia;
if RF_Dyslipidemia=1 or RF_Dyslipidemia_2_73=1 then Dyslipidemia=1;
 else if RF_Dyslipidemia=2 or RF_Dyslipidemia_2_73=2 then Dyslipidemia=0;
  else  Dyslipidemia=.;

*diabetes;
if RF_Diabetes= . then Diabetes=.;
 else if RF_Diabetes=1 then Diabetes=1;
  else Diabetes=0;

*renal failure
RF_Renal_Fail_Dialysis harvest code:
1 Yes
2 No
3 Unknown;

if STS_Data_Version in (2.41,2.52) then do;
 if RF_Renal_Fail=1 then Pre_renalfail=1;
  else if RF_Renal_Fail=2 then Pre_renalfail=0;
   else Pre_renalfail=.;
end;

else if STS_Data_Version in (2.61, 2.73, 2.81, 2.9) then do;
 if RF_Renal_Fail_Dialysis=1 then Pre_renalfail=1;
  else if RF_Renal_Fail_Dialysis=2 then Pre_renalfail=0;
   else Pre_renalfail=.;
end;

*Immunosuppressive;
if RF_Immunocompromise=. then Immuno=.;
 else if RF_Immunocompromise=1 then Immuno=1;
  else Immuno=0;

*Reoperation
incidence harvesting code:
1 = First cardiovascular surgery
2 = First re-op cardiovascular surgery
3 = Second re-op cardiovascular surgery
4 = Third re-op cardiovascular surgery
5 = Fourth or more re-op cardiovascular surgery;

if STS_Data_Version in (2.41) then do;
 if Reoperative_Incident=. then Redo_op_J=.;
  else if Reoperative_Incident=1 then Redo_op_J=0;
   else Redo_op_J=1;
```

```
end;

else if STS_Data_Version in (2.52, 2.61, 2.73, 2.81, 2.9) then do;
 if Incidence=. then Redo_op_j=.;
  else if RF_Renal_Fail_Dialysis=1 then Redo_op_j=0;
   else Redo_op_J=1; *harvesting code 2-5;
end;

if STS_Data_Version in (2.52, 2.61, 2.73, 2.81, 2.9) then do;
 if Incidence=. then Redo_op=.;
  else if incidence=1 then Redo_op=0;
   else Redo_op=1; *harvesting code 2-5;
end;

*************************************************************************
**;


*Intra-operative;
*Intra-op;
*CPB utilization harvest code
 1=none
 2=Combination
 3=Full
 ;
if CPB_Utilization=. then CPB_Utl=.; *nmiss=197;
 else if CPB_Utilization=1 then CPB_Utl=0;
  else if CPB_Utilization=2 then CPB_Utl=1;
   else CPB_Utl=1;

*************************************************************************
*****;
*Intraoperative Cirulatory arrest;
if STS_Data_Version in (2.61,2.73, 2.81, 2.9)then do;
 if Circulatory_Arrest= . then Circular_Arrest=.;
  else if Circulatory_Arrest= 1 then Circular_Arrest=1;
   else Circular_Arrest=0;
end;

*blood products;
*data missing from v2.41;
if Intraop_Blood_Products=. then Intra_blood=.;
 else if Intraop_Blood_Products=1 then Intra_blood=1;
  else Intra_blood=0;

*RBC;
if Intra_blood=. then Intra_RBC=.;
 else if Intra_blood=0 then Intra_RBC=0; *if no blood products used, then RBC
used equal to zero;
  else if Intra_blood=1 then Intra_RBC=Intraop_Blood_Products___RBC_Uni;
   else Intra_RBC=.;

if Intra_RBC=. then Intra_RBC_used=.;
 else if Intra_RBC=0 then Intra_RBC_used=0;
  else if Intra_RBC>0 then Intra_RBC_used=1;

*Intraop IABP;
```

```
if IABP_1=. then IABP_Intra=. ;
 else if IABP_1=1 and IABP_When_Inserted=2 then IABP_Intra=1;
  else IABP_Intra=0;

*************************************************************************
******;
*Post-operative;
*30-day mortality;
if Mort_30d_Status=. then Mort_30d=.;
 else if  Mort_30d_Status=3 then Mort_30d=.;
  else if  Mort_30d_Status=1 then Mort_30d=0;
   else Mort_30d=1;

   if Mort_30d=. then MOrt_30d=0;

*poriop_MI;
if In_Hospital_Post_Op_Events=. then periop_MI=.;
 else if In_Hospital_Post_Op_Events=2 then periop_MI=0;
  else if In_Hospital_Post_Op_Events=1 and Comps_Op_Perioperative_MI=. then
periop_MI=.;
   else if In_Hospital_Post_Op_Events=1 and Comps_Op_Perioperative_MI=2 then
periop_MI=0;
    else if In_Hospital_Post_Op_Events=1 and Comps_Op_Perioperative_MI=1 then
periop_MI=1;

*stroke;
*V2.41-2.9;
*PostOp_stroke harvest code:
1 Yes
2 No
3 Yes, hemorrhagic
4 Yes, ischemic
5 Yes, undetermined type;
if  PostOp_stroke=. then stroke_perm=.;
 else if PostOp_stroke in (1, 3, 4, 5) then stroke_perm=1;
  else stroke_perm=0;

if In_Hospital_Post_Op_Events=. then postop_stroke=.;
 else if In_Hospital_Post_Op_Events=2 then postop_stroke=0;
  else if In_Hospital_Post_Op_Events=1 and stroke_perm=. then
postop_stroke=.;
   else if In_Hospital_Post_Op_Events=1 and stroke_perm=0 then
postop_stroke=0;
    else if In_Hospital_Post_Op_Events=1 and stroke_perm=1 then
postop_stroke=1;
     else postop_stroke=.;



*new renal failure;
if In_Hospital_Post_Op_Events=. then postop_renal_failure=.;
 else if In_Hospital_Post_Op_Events=2 then postop_renal_failure=0;
  else if In_Hospital_Post_Op_Events=1 and PostOp_RenalFailure=. then
postop_renal_failure=.;
   else if In_Hospital_Post_Op_Events=1 and PostOp_RenalFailure=2 then
postop_renal_failure=0;
```

```
    else if In_Hospital_Post_Op_Events=1 and PostOp_RenalFailure=1 then
postop_renal_failure=1;
     else postop_renal_failure=.;

*new dialysis;
if postop_renal_failure=. then postop_dialysis=.;
 else if postop_renal_failure=0 then postop_dialysis=0;
  else if postop_renal_failure=1 and PostOp_DialysisReq=. then
postop_dialysis=.;
   else if postop_renal_failure=1 and PostOp_DialysisReq=2 then
postop_dialysis=0;
    else if postop_renal_failure=1 and PostOp_DialysisReq=1 then
postop_dialysis=1;
     else postop_dialysis=.;

*Pneumonia;
if In_Hospital_Post_Op_Events=. then postop_Pneumonia_1=.;
  else if In_Hospital_Post_Op_Events=2 then postop_Pneumonia_1=0;
   else if In_Hospital_Post_Op_Events=1 and PostOp_Pneumonia=. then
postop_Pneumonia_1=.;
    else if In_Hospital_Post_Op_Events=1 and PostOp_Pneumonia=2 then
postop_Pneumonia_1=0;
      else if In_Hospital_Post_Op_Events=1 and PostOp_Pneumonia=1 then
postop_Pneumonia_1=1;
     else postop_Pneumonia_1=.;

*postop IABP;
if IABP_1=. then IABP_postop=. ;
 else if IABP_1=1 and IABP_When_Inserted=3 then IABP_postop=1;
  else IABP_postop=0;

*Prolonged ventilation;
*rename VAR357=Post_Op_Pulm_Vent_Prolonged;
if In_Hospital_Post_Op_Events=. then Vent_Prolonged=.;
 else if In_Hospital_Post_Op_Events=2 then Vent_Prolonged=0;
  else if In_Hospital_Post_Op_Events=1 and VAR357=2 then Vent_Prolonged=0;
   else if In_Hospital_Post_Op_Events=1 and VAR357=1 then Vent_Prolonged=1;
    else Vent_Prolonged=.;

*Location of discharge as proxy for SES;
*@@@Additional variable not included in earlier analyses@@@;
*Location of discharge harvest code:
incidence harvesting code:
1 = Home
2 = Extended Care/Transitional
3 = Other acute care hospital
4 = Nursing Home
5 = Hospice
6 = Left AMA
777 = Other;

if  Discharge_Location=. then Discharge_Location_2=. ;
  else if Discharge_Location=1 then Discharge_Location_2=1;
   else discharge_location_2=0;

*postop vent hours;
```

```
if STS_Data_Version in (2.41,2.52,2.61,2.73) then
Postop_Vent=Postop_Vent_Hours___Total ;
 else if STS_Data_Version in (2.81,2.9) then
Postop_Vent=Total_Postoperative_Ventilation ;

*postop_LOS-Surgery to discharge;
if LOS_Surgery_Discharge=. then LOS_Surgery_Discharge_2=.;
 else if LOS_Surgery_Discharge=0 then LOS_surgery_Discharge_2=.;
  else LOS_surgery_Discharge_2=LOS_Surgery_Discharge;


*Postop_LOS_ICU;
if Total_hrs_ICU=. then LOS_ICU=.;
 else if Total_Hrs_ICU=0 then LOS_ICU=.;
  else LOS_ICU=Total_Hrs_ICU;
if LOS_ICU=0.2 then LOS_ICU=.;
if LOS_ICU=0.8 then LOS_ICU=.;
if LOS_ICU=1.4 then LOS_ICU=.;
if LOS_ICU=2 then LOS_ICU=.;
if LOS_ICU=6.8 then LOS_ICU=.;
if LOS_ICU=11.7 then LOS_ICU=.;


sts_prom_log=log(predicted_risk_of_mortality);
logVent=log(postop_vent);
logicu=log(LOS_icu);
logstd=log(LOS_surgery_Discharge_2);

if STS_Data_Version =2.9 then do;
 if Discharge___Mortality_Status=. then   do;
            dead_at_discharge=.;*@@@@@@@@@@@@@@@@@@@@;
            live_at_discharge=.;
      end;
      else if Discharge___Mortality_Status=2 then do;
                  dead_at_discharge=1;
                  live_at_discharge=0;
            end;
      else do;
            dead_at_discharge=0;
            live_at_discharge=1;
      end;
end;
else do;


if mort_DC_status=. then Dead_at_discharge=.;
   else if mort_DC_status=1 then dead_at_discharge=0;
    else dead_at_discharge=1;


if mort_DC_status=. then live_at_discharge=.;
   else if mort_DC_status=2 then live_at_discharge=0;
    else live_at_discharge=1;
end;
```

```
run;

proc contents data=y.prep;
run;
*******************************************************************************
*****************************;
*******************************************************************************
*****************************;
*******************************************************************************
*****************************;
*Macro zero to confirm the missing values;
data part;
set y.prep;
run;

%let data=part;
%let version=STS_Data_Version; *if this variable does not exist, create it
with XXX as value before running the macro;
%let id=Record_ID;
*no need to specify sample size;

%include "T:\biosprojs\Cardiac Surgery\Macros\Codes\macro zero v3.sas";

dm "clear log";
dm "clear output";
ods html;

proc datasets;
delete results;
run;

proc contents data=&data;
run;

%macro_zero(name="STS version", var=&version); *this has to be the FIRST
variable listed, no exceptions;
*preop variables;

%macro_zero(name="Female",var=female);
%macro_zero(name="Black",var=black);
%macro_zero(name="NYHA Class",var=NYHA34);
%macro_zero(name="Status",var=Status_urgent);
%macro_zero(name="Discharge Location",var=Discharge_location_2);
%macro_zero(name="Smoker",var=Smoke);
%macro_zero(name="Heart Failure within 2 weeks",var=HF_2wks_1);
%macro_zero(name="Previous Myocardial Infarction",var=Pre_MI);
%macro_zero(name="Peripheral Arterial Disease",var=Per_PAD);
%macro_zero(name="Endocarditis",var=per_endo);
%macro_zero(name="Previous cerebrovascular disease",var=pre_CV_D);
%macro_zero(name="Hypertension",var=Hypertension);
%macro_zero(name="Dyslipidimia",var=Dyslipidemia);
%macro_zero(name="Diabetes",var=Diabetes);
%macro_zero(name="Chronic Lung Diseases",var=CLD);
%macro_zero(name="Renal Failure",var=pre_renalfail);
%macro_zero(name="Immunosuppresion Therapy",var=Immuno);
%macro_zero(name="Redo Operation",var=Redo_op);
%macro_zero(name="Redo Operation_original",var=Incidence);
```

```
*continuous variables;
%macro_zero(name="Age",var=Patient_Age);
%macro_zero(name="BMI",var=BMI_cal);
%macro_zero(name="STS PROM",var=predicted_risk_of_mortality);
%macro_zero(name="STS PROM LOG",var=STS_Prom_log);
%macro_zero(name="Hemoglobin",var=pre_Hemoglobin);
%macro_zero(name="Hemoglobin HbA1c",var=Pre_Hb1Ac);
%macro_zero(name="Ejection Fraction",var=Hemo_Data_EF);

*Periop variables;
%macro_zero(name="Aortic Cross Clamp Time",var=Cross_Clamp_Time__min_);
%macro_zero(name="CPB Utilized",var=CPB_Utl);
%macro_zero(name="Intraop IABP",var=IABP_Intra);
%macro_zero(name="IntraopCirculatory Arrest",var=circulatory_arrest);
%macro_zero(name="Intraop RBC",var=Intra_blood);
%macro_zero(name="Intraop RBC",var=Intra_RBC);
%macro_zero(name="Cardiopulmonary Bypass
Time",var=Cardiopulmonary_Bypass_Time);

*Postop Variables;
%macro_zero(name="MACE Death",var=mort_30d);
%macro_zero(name="MACE Death",var=dead_at_discharge);
%macro_zero(name="MACE Stroke",var=Postop_stroke);
%macro_zero(name="Postop renal failure",var=postop_renal_failure);
%macro_zero(name="Postop Dialysis",var=postop_renal_failure);
%macro_zero(name="Postop Pneumonia",var=postop_Pneumonia_1);
%macro_zero(name="Postop IABP insertion",var=IABP_postop);
%macro_zero(name="Prolonged Ventilation_cat",var=Vent_Prolonged);
%macro_zero(name="Home Discharge Location",var=discharge_location_2);
%macro_zero(name="Postop ventilation time",var=Postop_Vent);
%macro_zero(name="LOS-total ICU",var=LOS_ICU);
%macro_zero(name="LOS-surgery to discharge",var=LOS_surgery_Discharge_2);

proc print data=results;run;

PROC EXPORT DATA=RESULTS
OUTFILE="T:\biosprojs\Cardiac Surgery\Macros\macro zero.csv"
DBMS=CSV REPLACE;
PUTNAMES=YES;
RUN;
```

ii. Basic Characteristics: Table 1, 2, and 3a

```
libname y 'T:\biosprojs\Cardiac Surgery\New Files\Brent Keeling\2019 Racial
and Sex Differences in SAVR Outcomes\August';

data new;
set y.prep;
if black=1 and male=1 then exposure="male/black";
else  if black=1 and male=0 then exposure="female/black";
else if black=0 and male=1 then exposure="male/white";
else  if black=0 and male=0 then exposure="female/white";

run;

proc sgplot data=new;
hbox sts_prom_log / group=exposure;
```

```
run;


ods graphics on;
/*@@@@@@@*/
ods excel file="\\Client\C$\Users\Maiko\Documents\EXCEL
SAS\073019_reasons.xlsx"
options (
sheet_interval="proc"
flow="text"
sheet_name="means"
);
proc means data=new n nmiss mean median;
class exposure;
var sts_prom_log logstd logICU;
run;
ods excel close;/*@@@@@ This is the end, my friend*/
quit;


*****************************************;
*Proc FREQ for Categorical Variables for Tables 1-3a;
*****************************************;

*Table 1: Preoperative Categorical variables;
ods graphics on;
/*@@@@@@@*/
ods excel file="\\Client\C$\Users\Maiko\Documents\EXCEL
SAS\072719_BasicCharacteristics.xlsx"
options (
sheet_interval="proc"
flow="text"
sheet_name="Freq-Tb1"
);
proc freq data=new;
tables NYHA34*exposure
       status_urgent*exposure
         smoke*exposure
         HF_2wks_1*exposure
         per_PAD*exposure
         per_endo*exposure
         Pre_MI*exposure
         Prev_Valve_1*exposure
         Hypertension*exposure
         Pre_CV_D*exposure
         Dyslipidemia*exposure
         Diabetes*exposure
         CLD*exposure
         pre_renalfail*exposure
         immuno*exposure
         Redo_op*exposure
       /chisq;
run;

*Table 2: Intraoperative Categorical Variables;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"Freq-Tb2"
```

```
);
proc freq data=new;
tables Intra_blood*exposure
       Circulatory_Arrest*exposure
         CPB_Utl*exposure
         IABP_intra*exposure
         /chisq;
run;

*Table 3a: Postoperative Categorical Variables;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"Freq-Tb3a"
);
proc freq data=new;
tables Mort_30d*exposure
         Postop_stroke*exposure
         Postop_renal_failure*exposure
         postop_dialysis*exposure
         Postop_pneumonia_1*exposure
       IABP_postop*exposure
         Vent_prolonged*exposure
         discharge_location_2*exposure
         /chisq;
run;

*********************************************************;
*********************************************************;
*Proc MEANS for Continuous Variables for Tables 1-3a;
*********************************************************;

*Table 1: Preopeartive Continuous Variables;
*Proc means to report characteristics;
*Combined Proc Means for all continuous variables in Table1;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"Means_Tb1"
);
proc means data=new Mean STD N NMISS MIN MAX Q1 Median Q3 maxdec=2;
class exposure;
var Patient_Age
    BMI_cal
      predicted_risk_of_mortality
      STS_PROM_log
    Pre_HbA1c
    Pre_hemoglobin
    Hemo_Data_EF;
      run;


*Table 2: Intraopeartive Continuous Variables;
*Proc means to report characteristics;
*Combined Proc Means for all continuous variables in Table2;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"Means_Tb2"
);
proc means data=new Mean STD N NMISS MIN MAX Q1 Median Q3 maxdec=2;
class exposure;
var Intra_RBC
```

```
      Cardiopulmonary_Bypass_Time
      Cross_Clamp_Time__min_;
      run;


*Table 3a: Postopeartive Continuous Variables;
*Proc means to report characteristics;
*Log10 transformed for the broad range of data (max=~2000)
*Combined Proc Means for all continuous variables in Table3;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"Means_Tb3"
);
proc means data=new Mean STD N NMISS MIN MAX Q1 Median Q3 maxdec=2;
class female black;
var Postop_vent
      LOS_ICU
      LOS_surgery_discharge_2;
      run;

ods excel close;/*@@@@@ This is the end, my friend*/
quit;

*************************************************************************
******;


*Proc GLMs for Table 1: Preoperative Variables;
*Proc GLM to report p-values;
*Age;
proc glm data=new;
class exposure;
model Patient_Age=exposure /*clparm*/;
lsmeans exposure/cl pdiff;
run;quit;


*BMI;
proc glm data=new;
class exposure;
model BMI_cal=exposure;
lsmeans exposure/cl pdiff;
run;

*STS_PROM_Raw;
proc glm data=new;
class exposure;
model predicted_risk_of_mortality=exposure;
lsmeans exposure/cl pdiff;
run;

*STS_PROM_Log;
proc glm data=new;
class exposure;
model STS_prom_log=exposure;
lsmeans exposure/cl pdiff;
run;
```

```
*Preoperative hemoglobin HbA1c;
proc glm data=new;
class exposure;
model Pre_HbA1c=exposure;
lsmeans exposure/cl pdiff;
run;

*Preoperative Hemoglobin;
proc glm data=new;
class exposure;
model Pre_hemoglobin=exposure;
lsmeans exposure/cl pdiff;
run;

*Preoperative Ejection Fraction;
proc glm data=new;
class exposure;
model Hemo_data_EF=exposure;
lsmeans exposure/cl pdiff;
run;


*Proc GLMs for Table 2: Intraoperative Variables;
*Proc GLM to report p-values;
*RBC unit;

proc glm data=new;
class exposure;
model Intra_RBC=exposure;
lsmeans exposure/cl pdiff;
run;

*Cardiopulmonary Bypass Time;
proc glm data=new;
class exposure;
model Cardiopulmonary_Bypass_Time=exposure;
lsmeans exposure/cl pdiff;
run;

*Cross clamp Time;
proc glm data=new;
class exposure;
model Cross_Clamp_Time__min_=exposure;
lsmeans exposure/cl pdiff;
run;


*Proc GLMs for Table 3: Postoperative Variables;
*Proc GLM to report p-values;
*Postop log transformed Vent hours;
proc glm data=new;
class exposure;
model Postop_vent=exposure;
lsmeans exposure/cl pdiff;
run;

*Postop log transformed LOS_ICU;
```

```
proc glm data=new;
class exposure;
model LOS_ICU=exposure;
lsmeans exposure/cl pdiff;
run;

*Postop log transformed LOS_surgery to discharge;
proc glm data=new;
class exposure;
model LOS_surgery_discharge_2=exposure;
lsmeans exposure/cl pdiff;
run;

*************************************************************************
************************;
*descriptive chart to dissect frequencies of deaths among those who died
within 30days;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"Extra"
);
proc freq data=new;
tables mort_30d*dead_at_discharge*exposure/chisq;
run;

ods excel close;/*@@@@@ This is the end, my friend*/
quit;
```

iii. Crude Outcomes

```
libname y 'T:\biosprojs\Cardiac Surgery\New Files\Brent Keeling\2019 Racial
and Sex Differences in SAVR Outcomes\August';

*************************************************************************;
*Crude Outcomes;
*Postop 30-day mortality;
*| to replace * to shorten the code for interaction terms;
*Comparison based upon Black and Female;
ods graphics on;
/*@@@@@@*/
ods excel file="\\Client\C$\Users\Maiko\Documents\EXCEL SAS\072719Crude.xlsx"
options (
sheet_interval="proc"
flow="text"
sheet_name="mort_30d"
);
proc logistic data=y.prep
plots(only)=(effect oddsratio (type=horizontalstat)) ;
class female (param=ref ref="0")
     black (param=ref ref="0");
model mort_30d (event="1")= female|black
/clodds=both;
oddsratio female / at (black= '0' '1');
oddsratio black / at (female= '0' '1');
run;
```

```
*************************************************************************;

*Postop postoperative stroke;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"Postop_Stroke"
);
proc logistic data=y.prep
plots(only)=(effect oddsratio (type=horizontalstat)) ;
class female (param=ref ref="0")
     black (param=ref ref="0");
model Postop_Stroke (event="1")= female|black
/clodds=both;
oddsratio female / at (black= '0' '1');
oddsratio black / at (female= '0' '1');
run;

************************************************************;
*Postop renal_failure;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"postop_renal_failure"
);
proc logistic data=y.prep
plots(only)=(effect oddsratio (type=horizontalstat)) ;
class female (param=ref ref="0")
     black (param=ref ref="0");
model postop_renal_failure (event="1")= female|black
/clodds=both;
oddsratio female / at (black= '0' '1');
oddsratio black / at (female= '0' '1');
run;

************************************************************;

*Postop dialysis;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"postop_dialysis"
);
proc logistic data=y.prep
plots(only)=(effect oddsratio (type=horizontalstat)) ;
class female (param=ref ref="0")
     black (param=ref ref="0");
model postop_dialysis (event="1")= female|black
/clodds=both;
oddsratio female / at (black= '0' '1');
oddsratio black / at (female= '0' '1');
run;

************************************************************;
*Postop_Pneumonia_1;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"postop_Pneumonia_1"
);
proc logistic data=y.prep
plots(only)=(effect oddsratio (type=horizontalstat)) ;
class female (param=ref ref="0")
```

```
     black (param=ref ref="0");
model postop_Pneumonia_1 (event="1")= female|black
/clodds=both;
oddsratio female / at (black= '0' '1');
oddsratio black / at (female= '0' '1');
run;

*************************************************************************;
*Postop IABP_postop;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"IABP_postop"
);
proc logistic data=y.prep
plots(only)=(effect oddsratio (type=horizontalstat)) ;
class female (param=ref ref="0")
     black (param=ref ref="0");
model IABP_postop (event="1")= female|black
/clodds=both;
oddsratio female / at (black= '0' '1');
oddsratio black / at (female= '0' '1');
run;

*************************************************************************;
*Home: Location of discharge;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"LOC_discharge"
);
proc logistic data=y.prep
plots(only)=(effect oddsratio (type=horizontalstat)) ;
class female (param=ref ref="0")
     black (param=ref ref="0");
model discharge_location_2 (event="1")= female|black
/clodds=both;
oddsratio female / at (black= '0' '1');
oddsratio black / at (female= '0' '1');
run;
*************************************************************************;

*Postop Vent_Prolonged;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"Vent_Prolonged"
);
proc logistic data=y.prep
plots(only)=(effect oddsratio (type=horizontalstat)) ;
class female (param=ref ref="0")
     black (param=ref ref="0");
model Vent_Prolonged (event="1")= female|black
/clodds=both;
oddsratio female / at (black= '0' '1');
oddsratio black / at (female= '0' '1');
run;


*************************************************************************
****;
*************************************************************************
****;
```

```
*LogVent Crude;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"logvent"
);
proc glm data=y.prep;
model logvent= black female black*female/clparm;
estimate "means black male" intercept 1 black 1 female 0 black*female 0;
estimate "means white male" intercept 1 black 0 female 0 black*female 0;
estimate "difference black vs white among males" black 1;

estimate "means black female" intercept 1 black 1 female 1 black*female 1;
estimate "means white female" intercept 1 black 0 female 1 black*female 0;
estimate "difference black vs white among females" black 1 black*female 1;

estimate "means female black" intercept 1 black 1 female 1 black*female 1;
estimate "means male black" intercept 1 black 1 female 0 black*female 0;
estimate "difference female vs male among blacks" female 1 black*female 1;

estimate "means female white" intercept 1 black 0 female 1 black*female 0;
estimate "means male white" intercept 1 black 0 female 0 black*female 0;
estimate "difference female vs male among whites" female 1;

ods output  Estimates=est;
run;quit;

ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"logvent est"
);
proc print data=est;
run;

data est2;
set est;
gm=exp(estimate);
gm_left=exp(lowercl);
gm_right=exp(uppercl);
keep parameter gm gm_left gm_right;
run;

ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"logvent est GM"
);
proc print data=est2;
run;
*************************************************************************
*******;
*Logicu Crude;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"logicu"
);
proc glm data=y.prep;
model logicu = black female black*female/clparm;
estimate "means black male" intercept 1 black 1 female 0 black*female 0;
estimate "means white male" intercept 1 black 0 female 0 black*female 0;
estimate "difference black vs white among males" black 1;

estimate "means black female" intercept 1 black 1 female 1 black*female 1;
```

```
estimate "means white female" intercept 1 black 0 female 1 black*female 0;
estimate "difference black vs white among females" black 1 black*female 1;

estimate "means female black" intercept 1 black 1 female 1 black*female 1;
estimate "means male black" intercept 1 black 1 female 0 black*female 0;
estimate "difference female vs male among blacks" female 1 black*female 1;

estimate "means female white" intercept 1 black 0 female 1 black*female 0;
estimate "means male white" intercept 1 black 0 female 0 black*female 0;
estimate "difference female vs male among whites" female 1;

ods output  Estimates=est;
run;quit;

ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"logicu est"
);
proc print data=est;
run;

data est2;
set est;
gm=exp(estimate);
gm_left=exp(lowercl);
gm_right=exp(uppercl);
keep parameter gm gm_left gm_right;
run;

ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"logicu est GM"
);
proc print data=est2;
run;

*************************************************************************
*;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"logstd"
);
proc glm data=y.prep;
where dead_at_discharge ne 1;
model logstd = black female black*female/clparm;
estimate "means black male" intercept 1 black 1 female 0 black*female 0;
estimate "means white male" intercept 1 black 0 female 0 black*female 0;
estimate "difference black vs white among males" black 1;

estimate "means black female" intercept 1 black 1 female 1 black*female 1;
estimate "means white female" intercept 1 black 0 female 1 black*female 0;
estimate "difference black vs white among females" black 1 black*female 1;

estimate "means female black" intercept 1 black 1 female 1 black*female 1;
estimate "means male black" intercept 1 black 1 female 0 black*female 0;
estimate "difference female vs male among blacks" female 1 black*female 1;

estimate "means female white" intercept 1 black 0 female 1 black*female 0;
estimate "means male white" intercept 1 black 0 female 0 black*female 0;
estimate "difference female vs male among whites" female 1;
```

```
ods output  Estimates=est;
run;quit;

ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"logstd est"
);
proc print data=est;
run;


data est2;
set est;
gm=exp(estimate);
gm_left=exp(lowercl);
gm_right=exp(uppercl);
keep parameter gm gm_left gm_right;
run;

ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"logstd est GM"
);
proc print data=est2;
run;

************************************************************************;
ods excel close;/*@@@@@ This is the end, my friend*/
quit;
```

iv. Adjusted Outcome

```
libname y 'T:\biosprojs\Cardiac Surgery\New Files\Brent Keeling\2019 Racial
and Sex Differences in SAVR Outcomes\August';

************************************************************************;
*Adjusted Outcomes;
*Postop 30-day mortality;
*| to replace * to shorten the code for interaction terms;
*Comparison based upon Black and Female;
ods graphics on;
/*@@@@@@*/
ods excel file="\\Client\C$\Users\Maiko\Documents\EXCEL
SAS\072719_Adjusted.xlsx"
options (
sheet_interval="proc"
flow="text"
sheet_name="mort_30d"
);
proc logistic data=y.prep
plots(only)=(effect oddsratio (type=horizontalstat)) ;
class female (param=ref ref="0")
     black (param=ref ref="0");
model mort_30d (event="1")= female|black sts_prom_log
```

```
/clodds=both;
oddsratio female / at (black= '0' '1');
oddsratio black / at (female= '0' '1');
run;


*************************************************************************;

*Postop postoperative stroke;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"Postop_Stroke"
);
proc logistic data=y.prep
plots(only)=(effect oddsratio (type=horizontalstat)) ;
class female (param=ref ref="0")
     black (param=ref ref="0");
model Postop_Stroke (event="1")= female|black sts_prom_log
/clodds=both;
oddsratio female / at (black= '0' '1');
oddsratio black / at (female= '0' '1');
run;

*************************************************************;
*Postop renal_failure;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"postop_renal_failure"
);
proc logistic data=y.prep
plots(only)=(effect oddsratio (type=horizontalstat)) ;
class female (param=ref ref="0")
     black (param=ref ref="0");
model postop_renal_failure (event="1")= female|black sts_prom_log
/clodds=both;
oddsratio female / at (black= '0' '1');
oddsratio black / at (female= '0' '1');
run;

*************************************************************;

*Postop dialysis;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"postop_dialysis"
);
proc logistic data=y.prep
plots(only)=(effect oddsratio (type=horizontalstat)) ;
class female (param=ref ref="0")
     black (param=ref ref="0");
model postop_dialysis (event="1")= female|black sts_prom_log
/clodds=both;
oddsratio female / at (black= '0' '1');
oddsratio black / at (female= '0' '1');
run;

*********************************************************;
*Postop_Pneumonia_1;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"postop_Pneumonia_1"
```

```
);
proc logistic data=y.prep
plots(only)=(effect oddsratio (type=horizontalstat)) ;
class female (param=ref ref="0")
     black (param=ref ref="0");
model postop_Pneumonia_1 (event="1")= female|black sts_prom_log
/clodds=both;
oddsratio female / at (black= '0' '1');
oddsratio black / at (female= '0' '1');
run;

*************************************************************************;
*Postop IABP_postop;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"IABP_postop"
);
proc logistic data=y.prep
plots(only)=(effect oddsratio (type=horizontalstat)) ;
class female (param=ref ref="0")
     black (param=ref ref="0");
model IABP_postop (event="1")= female|black sts_prom_log
/clodds=both;
oddsratio female / at (black= '0' '1');
oddsratio black / at (female= '0' '1');
run;

*************************************************************************;
*Home: Location of discharge;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"LOC_discharge"
);
proc logistic data=y.prep
plots(only)=(effect oddsratio (type=horizontalstat)) ;
class female (param=ref ref="0")
     black (param=ref ref="0");
model discharge_location_2 (event="1")= female|black sts_prom_log
/clodds=both;
oddsratio female / at (black= '0' '1');
oddsratio black / at (female= '0' '1');
run;
*************************************************************************;

*Postop Vent_Prolonged;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"Vent_Prolonged"
);
proc logistic data=y.prep
plots(only)=(effect oddsratio (type=horizontalstat)) ;
class female (param=ref ref="0")
     black (param=ref ref="0");
model Vent_Prolonged (event="1")= female|black sts_prom_log
/clodds=both;
oddsratio female / at (black= '0' '1');
oddsratio black / at (female= '0' '1');
run;
```

```
*************************************************************************
****;
*************************************************************************
****;
*LogVent Crude;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"logvent"
);
proc glm data=y.prep;
model logvent= black female black*female sts_prom_log/clparm;
estimate "means black male" intercept 1 black 1 female 0 black*female 0;
estimate "means white male" intercept 1 black 0 female 0 black*female 0;
estimate "difference black vs white among males" black 1;

estimate "means black female" intercept 1 black 1 female 1 black*female 1;
estimate "means white female" intercept 1 black 0 female 1 black*female 0;
estimate "difference black vs white among females" black 1 black*female 1;

estimate "means female black" intercept 1 black 1 female 1 black*female 1;
estimate "means male black" intercept 1 black 1 female 0 black*female 0;
estimate "difference female vs male among blacks" female 1 black*female 1;

estimate "means female white" intercept 1 black 0 female 1 black*female 0;
estimate "means male white" intercept 1 black 0 female 0 black*female 0;
estimate "difference female vs male among whites" female 1;

ods output  Estimates=est;
run;quit;

ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"logvent est"
);
proc print data=est;
run;

data est2;
set est;
gm=exp(estimate);
gm_left=exp(lowercl);
gm_right=exp(uppercl);
keep parameter gm gm_left gm_right;
run;

ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"logvent est GM"
);
proc print data=est2;
run;
*************************************************************************
*******;
*Logicu Crude;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"logicu"
);
proc glm data=y.prep;
model logicu = black female black*female sts_prom_log/clparm;
estimate "means black male" intercept 1 black 1 female 0 black*female 0;
```

```
estimate "means white male" intercept 1 black 0 female 0 black*female 0;
estimate "difference black vs white among males" black 1;

estimate "means black female" intercept 1 black 1 female 1 black*female 1;
estimate "means white female" intercept 1 black 0 female 1 black*female 0;
estimate "difference black vs white among females" black 1 black*female 1;

estimate "means female black" intercept 1 black 1 female 1 black*female 1;
estimate "means male black" intercept 1 black 1 female 0 black*female 0;
estimate "difference female vs male among blacks" female 1 black*female 1;

estimate "means female white" intercept 1 black 0 female 1 black*female 0;
estimate "means male white" intercept 1 black 0 female 0 black*female 0;
estimate "difference female vs male among whites" female 1;

ods output  Estimates=est;
run;quit;

ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"logicu est"
);
proc print data=est;
run;

data est2;
set est;
gm=exp(estimate);
gm_left=exp(lowercl);
gm_right=exp(uppercl);
keep parameter gm gm_left gm_right;
run;

ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"logicu est GM"
);
proc print data=est2;
run;

**************************************************************************
*;
ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"logstd"
);
proc glm data=y.prep;
where dead_at_discharge ne 1;
model logstd = black female black*female sts_prom_log/clparm;
estimate "means black male" intercept 1 black 1 female 0 black*female 0;
estimate "means white male" intercept 1 black 0 female 0 black*female 0;
estimate "difference black vs white among males" black 1;

estimate "means black female" intercept 1 black 1 female 1 black*female 1;
estimate "means white female" intercept 1 black 0 female 1 black*female 0;
estimate "difference black vs white among females" black 1 black*female 1;

estimate "means female black" intercept 1 black 1 female 1 black*female 1;
estimate "means male black" intercept 1 black 1 female 0 black*female 0;
estimate "difference female vs male among blacks" female 1 black*female 1;
```

```
estimate "means female white" intercept 1 black 0 female 1 black*female 0;
estimate "means male white" intercept 1 black 0 female 0 black*female 0;
estimate "difference female vs male among whites" female 1;

ods output  Estimates=est;
run;quit;

ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"logstd est"
);
proc print data=est;
run;


data est2;
set est;
gm=exp(estimate);
gm_left=exp(lowercl);
gm_right=exp(uppercl);
keep parameter gm gm_left gm_right;
run;

ods excel options (sheet_name= /*@@@@@ Choose your name of choice*/
"logstd est GM"
);
proc print data=est2;
run;
*************************************************************************
******************;
ods excel close;/*@@@@@ This is the end, my friend*/
quit;
```