Racial Disparities in Surgical Outcomes after Mastectomy in 223,000 Female Breast Cancer Patients - A Retrospective Cohort Study

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Abstract: BACKGROUND: Breast cancer mortality and treatment differ across racial groups. It remains unclear whether such disparities are also reflected in perioperative outcomes of breast cancer patients undergoing mastectomy. STUDY DESIGN: We reviewed the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database (2008-2021) to identify female patients who underwent mastectomy for oncological purposes. The outcomes were stratified by five racial groups (white, Black/African American, Asian, American Indian/Alaska Native, and Native Hawaiian/Pacific Islander) and included 30-day mortality, reoperation, readmission, surgical and medical complications, and non-home discharge. RESULTS: The study population included 222,947 patients, 68% (n=151,522) of whom were white, 11% (n=23,987) Black/African American, 5% (n=11,217) Asian, 0.5% (n=1,198) American Indian/Alaska Native, and 0.5% (n=1,018) Native Hawaiian/Pacific Islander. While 136,690 (61%) patients underwent partial mastectomy, 54,490 (24%) and 31,767 (14%) women received simple and radical mastectomy, respectively. Overall, adverse events occurred in 17, 222 (7.7%) patients, the largest portion of which were surgical complications (n=7,246; 3.3%). Multivariable analysis revealed that being of Asian race was protective against perioperative complications (OR=0.71; P<0.001), whereas American Indian/Alaska Native women were most vulnerable to the complication occurrence (OR=1.41; P<0.001). Black/African American patients had a significantly lower risk of medical (OR=0.59; P<0.001) and surgical complications (OR=0.60; P<0.001) after partial and radical mastectomy, respectively, their likelihood of readmission (OR=1.14; P=0.045) following partial mastectomy was significantly increased. CONCLUSION: We identified American Indian/Alaska Native women as particularly vulnerable to complications following mastectomy. Asian patients experienced the lowest rate of complications in the perioperative period. Our analyses revealed comparable confounder-adjusted outcomes following partial and complete mastectomy between Black and white races. Our findings call for care equalization in the field of breast cancer surgery.

DOI: https://doi.org/10.1097/JS9.0000000000000909

Originally published at:
Knoedler, Samuel; Kauke-Navarro, Martin; Knoedler, Leonard; Friedrich, Sarah; Matar, Dany Y; Diatta, Fortunay; Mookerjee, Vikram G; Ayyala, Haripriya; Wu, Mengfan; Kim, Bong-Sung; Machens, Hans-Guenther; Pomahac, Bohdan; Orgill, Dennis P; Broer, P Niclas; Panayi, Adriana C (2023). Racial Disparities in Surgical Outcomes after Mastectomy in 223,000 Female Breast Cancer Patients - A Retrospective Cohort Study. International Journal of Surgery:Epub ahead of print.
DOI: https://doi.org/10.1097/JS9.0000000000000909

International Journal of Surgery Publish Ahead of Print
DOI:10.1097/JS9.0000000000000909

OPEN

Racial Disparities in Surgical Outcomes after Mastectomy in 223,000 Female Breast Cancer Patients – A Retrospective Cohort Study

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Brief title: Racial Disparities in Mastectomy

Highlights:

- Based on multi-institutional data of 223,000 female breast cancer patients, we investigated whether racial disparities exist in postoperative outcomes after mastectomy.
- 136,690 (61%) patients underwent partial mastectomy, while 54,490 (24%) and 31,767 (14%) women received simple and radical mastectomy, respectively.
- Postoperative complications occurred in 17,222 (7.7%) patients, the largest portion of which were surgical adverse events (n=7,246; 3.3%).
- Multivariable analysis revealed that being of Asian race was protective against postoperative complications (OR=0.71; p<0.001).
- American Indian/Alaska Native women were most vulnerable to the complication occurrence (OR=1.41; p<0.001).
- Black/African American patients had a significantly lower risk of medical (OR=0.59; p<0.001) and surgical complications (OR=0.60; p<0.001) after partial and radical mastectomy, respectively, whereas their likelihood of readmission (OR=1.14; p=0.045) following partial mastectomy was significantly increased.

Data Statement

The datasets presented in this article are not readily available because formal restrictions apply to the availability of these data. Requests to access the datasets should be directed to American College of Surgeons—National Surgical Quality Improvement Program, https://accreditation.facs.org/programs/nsqip.

Graphical abstract
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ABSTRACT

Background

Breast cancer mortality and treatment differ across racial groups. It remains unclear whether such disparities are also reflected in perioperative outcomes of breast cancer patients undergoing mastectomy.

Study Design

We reviewed the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database (2008-2021) to identify female patients who underwent mastectomy for oncological purposes. The outcomes were stratified by five racial groups (white, Black/African American, Asian, American Indian/Alaska Native, and Native Hawaiian/Pacific Islander) and included 30-day mortality, reoperation, readmission, surgical and medical complications, and non-home discharge.

Results

The study population included 222,947 patients, 68% (n=151,522) of whom were white, 11% (n=23,987) Black/African American, 5% (n=11,217) Asian, 0.5% (n=1,198) American Indian/Alaska Native, and 0.5% (n=1,018) Native Hawaiian/Pacific Islander. While 136,690 (61%) patients underwent partial mastectomy, 54,490 (24%) and 31,767 (14%) women received simple and radical mastectomy, respectively. Overall, adverse events occurred in 17, 222 (7.7%) patients, the largest portion of which were surgical complications (n=7,246; 3.3%). Multivariable analysis revealed that being of Asian race was protective against perioperative complications (OR=0.71; $p<0.001$), whereas American Indian/Alaska Native women were most vulnerable to the complication occurrence (OR=1.41; $p<0.001$). Black/African American patients had a significantly lower risk of medical (OR=0.59; $p<0.001$) and surgical complications (OR=0.60; $p<0.001$) after partial and radical mastectomy, respectively, their likelihood of readmission (OR=1.14; $p=0.045$) following partial mastectomy was significantly increased.

Conclusion

We identified American Indian/Alaska Native women as particularly vulnerable to complications following mastectomy. Asian patients experienced the lowest rate of complications in the perioperative period. Our analyses revealed comparable confounder-adjusted outcomes following partial and complete mastectomy between Black and white races. Our findings call for care equalization in the field of breast cancer surgery.

Keywords: Mastectomy; Breast Cancer; Breast Surgery; Racial Disparities; ACS-NSQIP; Big Data Database

BACKGROUND

Breast cancer is the most frequently diagnosed non-cutaneous malignancy, accounting for one in eight cancer diagnoses worldwide. Each year, more than two million women are diagnosed with breast cancer and nearly 700,000 patients die from it [1]. In the US, the lifelong risk of developing breast cancer is 12.9%, with an annual incidence and mortality of more than 300,000 cases and 42,000 patients, respectively [2]. Importantly, fatality varies among racial groups—the age-adjusted breast cancer-related death rate is significantly higher in Black women than in white patients [3]. While Black women have also been found to have an increased risk of developing breast cancer at an early age (<40 years), American Indian/Alaska Natives as well as Asians and Pacific Islanders show the lowest breast cancer incidence and mortality [4]. The underlying mechanisms driving racial disparities in breast cancer frequency and outcomes remains to be fully elucidated. In this context, a variety of potential reasons have been discussed, ranging from differences in socioeconomic status and access to health care to biological and genetic variations in tumors. In addition, racial bias and mistrust may echo in a divergent willingness to seek primary care and surgical treatment [5].

The therapeutic strategies for the treatment of breast cancer are constantly evolving, yet the surgical removal of breast tissue remains a mainstay, with the decision of either breast conservation surgery (including lumpectomy/partial mastectomy) or complete mastectomy being both disease-driven and patient-preferred [6-8]. Of note, despite robust data indicating similar survivability between breast conservation surgery and mastectomy, in recent years mastectomy rates have been continuously growing [6,9]. Interestingly, the acceptance of mastectomy seems to differ between races: while Asians and Pacific Islanders are more likely to seek total mastectomy, Black women tend to undergo breast conservation surgery and partial mastectomy more frequently [10,11]. In general, mastectomy rates have been noted to be significantly lower in Black women compared with white women [12]. This inequity is also reflected in a prolonged time-to-surgery in Black breast cancer patients [12,13].

Although breast cancer vulnerability and skepticism toward mastectomy are well documented in Black women, it remains unclear whether their perioperative mastectomy outcomes are worse [14-16]. In general, the evidence regarding racial disparities in the complication rates of mastectomies is scarce. This paucity may be due to research on mastectomy outcomes being mainly derived from retrospective analyses of single-institution or single-surgeon series – with poor external validity, transferability and comparability between races. Analyses of multi-center databases can help overcome such limitations and mitigate bias by pooling patient data of

geographical, institutional, and racial variance. Based on a diverse patient population, robust data regarding the post-mastectomy course among different racial groups can be identified. Specifically, we hypothesize that the variance in breast cancer mortality and treatment may also be reflected in the postoperative outcomes following mastectomy surgery, with racial minorities experiencing higher complication rates.

The National Surgical Quality Improvement Program (NSQIP) of the American College of Surgeons (ACS) captures validated data from more than 700 U.S. hospitals, thereby providing a broad and diverse patient registry. To the best of our knowledge, the ACS-NSQIP database has not been utilized to determine racial disparities in the surgical outcomes of patients undergoing mastectomy. Therefore, this analysis aimed to fill this research gap and shed light on racial inequities in mastectomy care. Ultimately, these insights can be leveraged in the clinical setting and at the public health level: while the breast surgeon may refine the surgical decision-making, necessary initiatives and health care policies can be introduced to achieve equality in surgical care.

METHODS

Data Source

Data were collected over a 14-year period (2008 to 2021 inclusive) from the ACS-NSQIP database. At the time of analysis, more recent data were not available. All records prior to 2008 were excluded due to a different data structure and capture scheme. The ACS-NSQIP, available exclusively to participating sites, represents a validated, multi-institutional, and risk-adjusted data collection of surgical patients and their procedures. As such, this clinical registry pools information from over 700 hospitals on more than 150 pre-, peri-, and postoperative parameters for patients undergoing surgery. Trained personnel are delegated to enter the data directly from the medical chart of randomly selected patients. In addition, peer reviews and spot audits ensure the validity, reliability, and quality of the captured data points. The records analyzed contain strictly de-identified information. Ethical approval to complete this retrospective cohort study was obtained from our institution (protocol #: 2013P001244). This study was conducted in accordance with the STROCSS guidelines [17], Supplemental Digital Content 1, http://links.lww.com/JS9/B498.

Patient Selection

The ACS-NSQIP database only captures surgical cases of patients aged 18 years and older. Therefore, a priori, non-surgical cases and pediatric or adolescent patients were not included in this study. For the purpose of optimal comparability and data homogeneity, only female patients were eligible, with all men and non-binary patients being excluded from any analyses. In order to identify

all adult female breast cancer patients, 14 annual data sets were filtered for the codes ICD-9-CM 174 ("Malignant neoplasm of female breast"), 233.0 ("Carcinoma in situ of breast"), and V10.3 ("Personal history of malignant neoplasm of breast") as well as ICD-10-CM C50 ("Malignant neoplasm of breast"), D05 ("Carcinoma in situ of breast"), and Z85.3 ("Personal history of malignant neoplasm of breast"). Cases with other and/or more far-reaching diagnoses, such as metastases from non-breast malignancies were not eligible. We then filtered this cohort, extracting all cases in which an isolated mastectomy – either partial, simple, or radical – was performed. Eligible Current Procedural Terminology (CPT) codes are listed in Figure 1. We excluded all cases with the CPT code 19304 as these patients might have been recorded inaccurately [18]. In addition, we excluded all patients undergoing any invasive (concurrent) surgery other than mastectomy. All cases with physiologically impossible body mass indices (<7 kg/m^2 or >250 kg/m^2) were deemed miscoding and, therefore, not considered in subsequent analyses. Finally, the generated patient pool was manually reviewed by two investigators (S.K. and A.C.P), and, for each case, the performed surgery was verified as isolated mastectomy. A third investigator (L.K.) was consulted in order to resolve any discrepant assessments. As a result, we compiled a cohort of adult female patients who had been diagnosed with breast cancer and underwent isolated mastectomy. Figure 1 illustrates the flow diagram of the screening and selection process.

Variable Extraction

We extracted pre-, peri-, and thirty-day postoperative variables.

i) Preoperative data included patient demographics (race, sex, age, height in inches, and weight in pounds), comorbidities (diabetes mellitus, history of chronic obstructive pulmonary disease [COPD], congestive heart failure [CHF], sepsis, hypertension, active dialysis treatment, renal insufficiency, corticosteroid use, dyspnea, nicotine abuse in the past year, weight loss of more than 10% of body weight in the 30 days prior to surgery, metastatic cancer, wound infection, ascites, and functional health status), as well as preoperative scores (the American Society of Anesthesiology (ASA) physical status classification [score 1-4], and wound classification [score 1-4]. Furthermore, using the formula [weight (pounds) / height (inches)^2 x 703], we calculated the body mass index (BMI) for all patients. All preoperative variables extracted are presented in Table 1. It is important to note that, in the ACS-NSQIP database, the racial identity is either self-reported by the patients or assigned by institutional personnel as per internal practices. Regarding the classification of the racial groups (white, Black/African American, Asian, American Indian/Alaska Native, and Native Hawaiian/Pacific Islander), we adhered to the official standards of the U.S. Census Bureau [19].

ii) In terms of perioperative data, we analyzed the surgical setting (in- or outpatient), the type of anesthesia (general, monitored anesthesia care, and other/unknown), the specialty (general surgery, plastic surgery, and other/unknown), and the year of surgery. All perioperative information is listed in Table 2. For in-depth assessment, we manually reviewed all cases of mastectomy and classified them into partial, simple (including skin- and nipple-sparing variants), or (modified) radical mastectomy. When specifying the types of mastectomy, we closely followed the official CPT coding and the nomenclature entered in the NSQIP database. If more than one type of mastectomy was entered, we classified the case according to the procedure with the highest invasiveness (radical > simple > partial mastectomy).

(iii) As 30-day postoperative outcomes we evaluated the operative time in minutes, the length of hospital stay (LOS), and the destination after discharge (home, non-home, and other/unknown). LOS was calculated as the difference in days between the date of admission and the date of discharge. Any complication was defined as the occurrence of either patient mortality and/or reoperation and/or readmission and/or unplanned readmission and/or any surgical and/or any medical complication. All surgical complications that are captured in the ACS-NSQIP database were analyzed (i.e., superficial and deep incision site infections, organ space infections, dehiscence, and bleeding). Likewise, we considered all medical complications recorded in the ACS-NSQIP database (i.e., pulmonary embolism, pneumonia, reintubation, ventilator dependence >48 hours, progressive renal insufficiency, acute renal failure, urinary tract infection, deep vein thrombosis/thrombophlebitis, stroke/cerebral vascular accident, cardiac arrest, myocardial infarction, sepsis, septic shock). The postoperative outcomes following mastectomy are shown in Table 3.

Statistical analysis

The raw data of the ACS-NSQIP annual datasets were converted into analyzable Microsoft Excel (Version 16, Microsoft Corporation, Redmond, WA, USA) files via IBM SPSS Statistics for Windows, version 29 (IBM Corporation, Armonk, NY, USA). Subsequently, all ACS-NSQIP datasets between 2008 and 2021 were standardized into a consistent format. These data were collected and saved in an electronic laboratory notebook (LabArchives, LLC, San Marcos, CA, USA), and analyzed using R statistical software (version 4.1.2). Categorical data are presented as absolute numbers (n) and percentages (%), continuous variables as mean ± standard deviation. Racial disparities between the binary outcomes were analyzed by multivariable logistic regression. We compared unadjusted odds ratios (OR) to odds ratios adjusted for all pre-operative parameters as stated above (i.e., all variables listed in Table 1). All p values obtained through logistic

regression are nominal and a value < 0.05 was considered statistically significant. Non-binary outcomes (i.e., operative time and LOS) were analyzed in a two-way ANOVA setting with factors "race" and "type of surgery". To account for non-normality and variance heterogeneity, a modified ANOVA-type test statistic with resampling-based p values as implemented in the R-package MANOVA.RM was considered [20,21]. Analyses in the subgroups defined by the type of surgery were conducted analogously and post-hoc procedures for pairwise comparisons were based on Tukey-contrasts and adjusted for multiple testing [21].

RESULTS

Patient Demographics

The study population included 222,947 female breast cancer patients, of whom 151,522 (68%) were recorded as white and 23,987 (11%) as Black/African American patients. While the racial background remained unknown in 15% of all cases (n=34,005), 11,217 (5.0%) patients were Asians and about one in 200 patients were American Indian/Alaskan Native (n=1,198; 0.5%) or Native Hawaiian/Pacific Islander (n=1,018; 0.5%). The mean age and BMI amounted to 63 ± 13 years and 30 ± 7.2 kg/m^2, respectively. On average, white patients were five years older (64 ± 12 years) than Asians (59 ± 12 years) and American Indians/Alaska Natives (59 ± 12 years). In the Black/African American population, the mean BMI of 32 ± 7.9 kg/m^2 translated to an obesity rate of 57% (n=13,701), whereas only 1,912 Asian women were classified as obese (BMI ≥ 30 kg/m^2; 17%). Hypertension (n=115,447; 52%) accounted for the most common comorbidity, with the highest proportion among Black/African American patients (16,179; 67%) and the lowest percentage in Asian women (4,864; 43%; Table 1). The diabetes rate was twice as high among Native Hawaiian/Pacific Islander women (26%; n=269) than in white patients (13%; n=20,394)

Surgical Characteristics

In total, 136,690 (61%) patients underwent partial mastectomy, 54,490 (24%) simple mastectomy, and 31,767 (14%) radical mastectomy. The frequency of partial mastectomy was highest in white patients (63%; n=95,512) and lowest in Asians (49%; n=5,487). Vice versa, more than one-third (35%; n=3,875) of all Asian patients underwent simple mastectomy, whereas less than 25% of white (24%; n=35,993) and Black/African American (24%; n=5,703) patients received this surgery. Radical mastectomy was most common in American Indian/Alaska Native patients (19%; n=233; Table 2).

Peri- and Postoperative Outcomes

On average, patients spent 90 ± 59 minutes in the operating room. The duration increased with surgical invasiveness (70 ± 41 minutes for partial mastectomy versus 129 ± 66 minutes for radical mastectomy) and varied between racial groups (lowest in white patients at 90 ± 59 minutes and highest in American Indians/Alaskan Natives at 108 ± 61 minutes) (Figure 2; Supplementary Table 1, Supplemental Digital Content 2, http://links.lww.com/JS9/B499 and Supplementary Table 2, Supplemental Digital Content 2, http://links.lww.com/JS9/B499). A similar pattern was seen for LOS (Figure 3; Supplementary Table 3, Supplemental Digital Content 2, http://links.lww.com/JS9/B499 and Supplementary Table 4, Supplemental Digital Content 2, http://links.lww.com/JS9/B499). After a mean LOS of 0.7 ± 3.4 days, 84% (n=188,330) of patients were discharged home. In total, 17,222 (7.7%) patients experienced any adverse event (Table 3). While 221 (0.1%) patients died within the 30-day postoperative period, reoperations and readmissions were reported in 6,972 (3.1%) and 5,422 (2.4%) cases, respectively. The lowest reoperation (2.2%) and readmission (1.8%) rates were noted in Asian patients – versus 4.3% and 4.2% in American Indians/Alaska Natives, respectively. Surgical and medical complications occurred most often in American Indian/Alaskan Native patients (6.3% and 1.6%, respectively) and least frequently in Asian patients (1.9% and 0.5%, respectively). The incidence of surgical and medical adverse events was comparable in white patients (3.1% and 1.0%, respectively), Blacks/African Americans (3.5% and 1.0%, respectively), and Native Hawaiian/Pacific Islanders (3.1% and 1.0%, respectively). Overall, surgical complications occurred in 7,246 (3.3%) cases, with superficial incisional infection (n=4,343; 1.9%) accounting for the majority. Medical complications were generally rare, amounting to 2,124 (1.0%) cases in total.

Uni- and multivariable Analyses

In the total study population, Asian patients were seen to experience lower rates of any complication (p<0.001; OR=0.64), reoperation (p<0.001; OR=0.67), readmission (p<0.001; OR=0.70), unplanned readmission (p=0.005; OR=0.65), surgical (p<0.001; OR=0.62) and medical (p<0.001; OR=0.50) complications, and a lower likelihood of non-home discharge (p <0.001). In contrast, statistically significant positive correlations were noted between the Black/African American race and the frequency of any complication (p<0.001; OR=1.11), reoperation (p=0.03; OR=1.08), readmission (p<0.001; OR=1.27), surgical complication (p=0.001; OR=1.14), and non-home discharge (p<0.001; OR=1.29). Patients from the American Indian/Alaska Native race were at a significantly higher risk for all complications (p<0.001; OR=1.64), reoperation (p=1.35; OR=0.036), and readmission (p<0.001; OR=1.92) as well as for the occurrence of surgical

(p<0.001; OR=2.13) and medical (p=0.004; OR=1.85) complications. We found similar trends across the three different types of mastectomy. Table 4 shows all results of the univariable analyses.

Multivariable analyses confirmed better outcomes in Asian patients (Table 5; Figure 4): in partial, simple, and radical mastectomy, we calculated significant correlations between the Asian race and the occurrence of any complication (OR=0.78; OR=0.61; OR=0.60, respectively, all p<0.001. Asian patients were significantly less likely to experience reoperation (OR=0.61; p<0.001), readmission (OR=0.70; p<0.001), surgical complications (OR=0.60; p<0.001), and non-home discharge (OR=0.53; p<0.001) when undergoing simple mastectomy. Similarly, Asian patients receiving radical mastectomy had a significantly lower risk of reoperation (OR=0.46; p<0.001) as well as surgical (OR=0.67; p=0.006) and medical complications (OR=0.36; p=0.005). Multivariable analysis revealed a significantly decreased risk of medical complications (OR=0.59; p<0.001) but an increased probability of readmission (OR=1.14; p=0.045) in Black/African American patients undergoing partial mastectomy. In the same cohort, American Indians/Alaska Natives were more likely to experience any complication (OR=1.49; p=0.007) and any surgical adverse event (OR=2.19; p<0.001), whereas Asians had a lower risk of reoperation (OR=0.70; p<0.001). Regardless of the type of surgery, the Asian race was associated with a significantly decreased risk for any complication (OR=0.71; p<0.001), while the American Indian/Alaska Native race was a significant risk factor for complication occurrence (OR=1.41; p<0.001).

DISCUSSION

Increased Risk Among American Indians/Alaska Native Women Undergoing Mastectomy

In 2000, the age-adjusted incidence of breast cancer among American Indian/Alaska Native women was estimated to be 88 per 100,000 citizens. In 20 years, this ratio significantly rose to 124/100,000 with an annual percent change of 1.4% and, concerningly, this trend shows no sign of abating [22]. Accordingly, it is expected that increasing numbers of American Indian/Alaska Native patients will require surgical management of breast cancer, including partial and complete mastectomy. It is, therefore, essential to optimize breast cancer surgery in this racial minority. Such preparation for future surgical care delivery largely depends on analyses of past practices and procedures.

In our study, we found that American Indian/Alaska Native women are less likely to undergo partial mastectomy/lumpectomy than white patients (54% versus 63%). This finding is in line with a recent report by Erdrich et al., revealing a significantly lower prevalence of partial mastectomy among American Indians/Alaska Natives than in white women [23]. Consistent also with

the available literature, we noted higher rates of complete mastectomy in this minority compared to white patients (46% versus 37%) [23]. Of note, among all racial groups in our study population, American Indian/Alaska Native women had the highest percentage of radical mastectomy at 19%. The reasons for these surgical disparities are thought to be multifactorial, ranging from geographically limited access to healthcare services (such as radiation therapy) through cultural barriers in tribal, rural regions to inadequate insurance coverage [23].

Across all three types of mastectomy, American Indians/Alaska Native patients showed the poorest outcomes with the highest risk of postoperative adverse events: in univariable analysis, we found a significant correlation between this population and the likelihood of any complication occurrence (OR=1.64; Table 4). In addition, American Indian/Alaska Natives women were prone to readmission, with the OR ranging from 1.73 for simple mastectomy through 1.76 for partial mastectomy to 2.07 for radical mastectomy. Our analyses revealed a significantly increased risk of surgical complications – both following partial (OR=2.89) and simple mastectomy (OR=1.60). When comparing the preoperative health characteristics, the proportion of active smokers was 8.4- and 2.3-fold higher in American Indian/Alaska Native women compared to Asian and white patients, respectively (Table 1). This difference in nicotine abuse/consumption may, partly, explain the poorer postoperative outcomes. In accordance with this assumption, such a correlation between smoking status and elevated complication rates has already been established in the field of breast (cancer) surgery [24-28].

However – even after adjustment for confounders such as smoking – our multivariable analysis revealed significantly increased risks of any complications (OR=1.49) and surgical adverse events (OR=2.19) in American Indian/Alaska Native women undergoing partial mastectomy (Figure 4; Table 5). Regardless of the type of surgery, being of American Indians/Alaska Native race was found to be a risk factor for the occurrence of any adverse event (OR=1.41), readmission (OR=1.69), surgical (OR=1.75) and medical complications (OR=1.69). Therefore, the poorer outcomes cannot be solely due to nicotine abuse but are likely related to a variety of factors: while race itself is not necessarily an independent risk factor, belonging to a group may put one at a higher risk for poorer health outcomes. For example, 68% of American Indians reside in close proximity to reservations or tribal territories, where healthcare facilities are typically managed by the Indian Health Service (IHS) [29]. Unfortunately, these establishments frequently struggle with insufficient staffing, funding, and up-to-date treatment protocols. To be more specific, the IHS received an allocation of $2,849 per capita for patient expenditures, in contrast to the national average of $7,717 per capita for healthcare spending; on average, IHS-operated centers were understaffed by 25% [30]. Further research has proposed that cultural barriers hinder timely access to cancer care and

preventative services within American Indian/Alaska Native communities, which is (partially) attributed to historical distrust of the healthcare system and poorer health literacy [31]. American Indians/Alaska Natives are also often diagnosed with cancer at more advanced stages and suffer from longer wait times from diagnosis to therapy [32]. Evidently, all these aforementioned factors (and an array of others) contribute to the worse outcomes noted amongst American Indian/Alaska Native patients. Active efforts should thus be undertaken to reverse the trend of skepticism in American Indian/Alaska Native communities, circumvent social issues such as limited educational and professional opportunity as well as geographical isolation and inadequate funding.

Lower Risk of Complications in Asian Women after Mastectomy Surgery

The most recent data from the American Cancer Institute suggest that Asian patients fare better against breast cancer. Across all racial groups, Asian women have the lowest age-adjusted incidence rates of breast cancer [22]. Their lifelong risk of developing breast cancer is nearly 20% lower than that of white women [33]. Such protective racial differences are even more striking in the field of breast cancer-related deaths, with Black and white patients facing a 147% and 77% higher age-adjusted mortality risk, respectively [34]. Accordingly, Asian Americans also experienced improved long-term survival rates compared to the overall U.S. breast cancer patient population [35,36].

This racial imbalance was also reflected in our study. Asian patients had the lowest rates of death, reoperation, (unplanned) readmission, surgical and medical complications, and non-home discharge. These significant findings were seen for both partial mastectomy and complete (simple and radical) mastectomy (Table 4). Multivariable analysis confirmed the decreased complications risk of Asian patients undergoing mastectomy surgery (Figure 4; Table 5). Our findings are in line with the existing literature: Blankensteinjn et al. documented an overall lower complication rate among Asian patients undergoing autologous and prosthetic breast reconstruction compared to white and African American women [37]. Similarly, analyzing racial inequities in implant-based breast cancer reconstruction, Neej et al. reported a significantly higher risk of wound complications in African American patients than in Asians [38]. The causalities for this difference in the perioperative success across racial groups need to be elucidated in future studies. We hypothesize a combination of three factors to explain our findings: (i) Asian women stereotypically have a slim silhouette and smaller breasts with low-to-moderate volume [39-42]. Volumetric mammographic analyses indicated a strong correlation between BMI and breast size [43-46]. In line with cross-sectional population data, in our study, Asian patients had a lower BMI than patients in other racial groups (Table 1) [47]. It is, therefore, reasonable to assume that the Asian women were thinner and had smaller breasts. These anatomical characteristics can facilitate intraoperative access, minimize

surgical invasiveness, with finer incisions and less traumatized tissue allowing patients a shorter, complication-free recovery period. (ii) Navarro et al. identified racial differences in time to breast cancer surgery [48]. Asian patients were more likely to receive surgery within 30 days of diagnosis compared to white women. The delay in surgical management may result in an advanced cancer stage and/or necessitate a more complicated surgical approach, thereby increasing the risk for perioperative adverse events. (iii) Analyses of the Surveillance, Epidemiology, and End Results (SEER) Program revealed that Asian patients received the highest rate of guideline-concordant primary treatment across all breast cancer subtypes [49]. It is, therefore, reasonable to assume that Asian patients received the optimal surgical treatment – which, in turn, may be reflected in the lowest complication rates and the highest home-discharge rate.

Ideally, patient eligibility for the type of mastectomy should be critically reviewed and a variety of factors such as cancer size and location, as well as patient preoperative health and preference should be considered. Both surgeon and patient must be closely involved in the process of surgical decision-making and choosing between partial mastectomy (in the sense of breast-conservation therapy) and complete mastectomy. In this context, it is worth noting that, in our study, the percentage of partial mastectomies was found to be lowest in Asian patients (49%; Table 2), whereas the rate of complete mastectomy was 14% higher in Asians (51%) than in white patients (37%). While this finding that Asian patients were more likely to seek complete mastectomy corroborates previous reports, it also calls for an investigation to uncover the reasoning behind this racial disparity in surgical treatment preference [10,40,50]. Notably, Grimmer et al. demonstrated that Asian breast cancer patients have the lowest rate of contralateral prophylactic mastectomy and were 50% less likely to undergo this procedure compared to white women [51]. A plethora of reasons may underlie this reluctance, one of which may be the concern about a potential increase in surgical complications. In this context, our findings could be understood as an encouraging sign for Asian breast cancer patients to consider contralateral prophylactic mastectomy at a relatively low perioperative risk.

Perioperative Outcomes of Black/African American Women Undergoing Mastectomy

The age-adjusted 5-year mortality rate for breast cancer among Black women is 28 per 100,000 patients, 40% and 56% higher than the risk in white and American Indian/Alaska Native patients, respectively [14]. The etiology of this racial disparity is believed to be multifactorial, ranging from structural (i.e., socioeconomic status, educational level, and financial treatment barriers) through systemic (such as geographically limited access to healthcare services) to disease-related reasons (disproportionately higher incidence of aggressive cancer subtypes and adverse tumor

biology) [3,5,52-55]. Moreover, the choice of breast cancer treatment and surgical decision-making can significantly impact survival rates. In this context, personal and cultural patient preferences play an essential role: the well-documented mistrust Blacks/African Americans have toward the medical establishment may even culminate in a refusal of recommended and potentially life-saving breast cancer surgery [15,16]. Accordingly, Black women are significantly more likely to refuse surgical treatment at rising rates in the last decade [15,56,57]. This skepticism is reflected in studies investigating breast cancer treatment patterns across racial groups, with significantly lower rates of partial and complete mastectomy among Black and African American women compared to white patients [12]. There are also well-documented disparities in access to targeted oncologic therapy and time to surgery (TTS) after breast cancer diagnosis, which disproportionately affects Black/African American patients. Chen et al. reported that the median TTS for Black women was 39 days compared to 32 days for White women. This gap has also widened from 2010 to 2019 – a concerning tendency [58]. Sukniam et al. noted a similar trend in access to chemotherapy and radiation therapy [59]. Importantly, Chen et al. found that Black patients had similar TTS in minority-serving hospitals compared with non-minority-serving hospitals, suggesting systemic issues that transcend geographical proximity to a specialized cancer center.

In our study, univariable analyses substantiated these concerns at first glance: Black/African American women who underwent partial, simple, or radical mastectomy showed a significantly increased risk of postoperative complications compared to white patients (Table 4). However, after adjusting for potential confounders (i.e., all preoperative parameters recorded in the ACS-NSQIP database; Table 1), the outcomes of Black/African American women were similar to those of white women (Figure 4; Table 5). Interestingly, being of Black/African American race was associated with a significantly decreased likelihood of any complications (OR=0.90) and surgical adverse events (OR=0.80) following simple mastectomy. Likewise, Black/African American women undergoing partial mastectomy were less likely to experience medical complications (OR=0.59). While our study is the first to reveal equivalent confounder-adjusted outcomes in Black/African American patients undergoing mastectomy, previous reports have yielded analogous results in the field of breast cancer surgery. Berlin et al. and Butler et al. documented comparable complication rates following post-mastectomy breast reconstruction between Black/African American women and white patients [60,61]. Still, it is important to mention that our multivariable analysis of partial mastectomy showed a significant correlation between being Black patient and a higher frequency of readmission after surgery (OR=1.14). This outcome should not be ignored, given that readmissions can be associated with poorer long-term outcomes and satisfaction.

The herein presented insights are relevant through three lenses: first, they deliver empirical evidence that race, particularly in the context of Black/African American individuals, is not inherently associated with an increased risk of surgical and medical complications following mastectomy surgery. Thus, these robust data provide a qualitative counterweight to possible misconceptions and ill-founded health beliefs regarding the value of breast cancer surgery among racial minorities. Instead, patients are encouraged to take our evidence-based insights into account when making surgical decisions. Second, these findings should sensitize physicians/surgeons to seek preoperative health optimization of Black/African American and American Indian/Alaska Native breast cancer patients – with the intention of minimizing the risk of perioperative complications. In this regard, a valuable (preemptive) approach involves strengthening primary care engagement through outreach initiatives. In this way, patients can establish an ongoing and trusting relationship with a primary care physician well before their initial visit for cancer therapy. As Roberts et al. explained, individuals from Black/African American and white backgrounds who seek primary care services more frequently prior to hospitalization tend to experience better postoperative results. This finding is mainly attributed to the benefit of timely screenings, effective medication management, and improved perioperative optimization [62]. Third, from a public health perspective, our study may serve as motivation to raise awareness about comprehensive breast cancer treatment (especially within the Black/African American and American Indian/Alaska Native communities) and launch educational efforts regarding mastectomy surgery in a culturally and socially sensitive manner.

LIMITATIONS

This study is the first to analyze racial disparities in the perioperative outcomes of female breast cancer patients undergoing mastectomy – based on multi-institutional and diversified data collected over 14 years. However, when interpreting the results and drawing conclusions, its limitations should be considered. The retrospective nature of the ACS-NSQIP database is associated with inherent biases and confounders [63]. Herein, we report only statistical correlations, whereas underlying causal-effect relationships need to be investigated in future prospective studies. The quality and accuracy of the data input depends on subjective assessment and may, thus, vary both between and within institutions. However, prior research has identified low variance in the database's heterogeneity [64]. In addition, the standardized data collection results in a lack of potentially relevant, such as socioeconomic patient characteristics or location of the hospitals (rural versus (sub)urban). It is important to note that information neither on (neo)adjuvant chemotherapeutic regimen nor radiotherapy were available. The laterality of breast removal and the

time from diagnosis to surgery were also not recorded. In 15% (n=34,005) of all patients, the racial background could not be determined. These cases were excluded from all further analyses. We categorized all cases (n=5,189; 2.3%) with more than one type of mastectomy recorded based on the procedure with the highest invasiveness (i.e., radical > simple > partial mastectomy). The ACS-NSQIP database lacks details on short-term (<30 days) complications including hematoma, lymphedema and seroma, as well as on long-term (>30 days) outcomes, for example, aesthetic results and sensation [65,66]. Racial aggregation may be inaccurate, as it does not account for variance (such as varying treatment responses and clinicopathological profiles) in a transnational collection of heterogenous sub-populations [67].

CONCLUSION

Our analysis of 222,947 female breast cancer patients undergoing mastectomy shed light on racial disparities in perioperative outcomes. More specifically, we identified American Indian/Alaska Native women as particularly vulnerable to the occurrence of adverse events. In contrast, Asian patients showed the lowest risk of experiencing complications. In addition, our analyses revealed comparable confounder-adjusted outcomes following both partial and complete mastectomy between the Black and white races. These insights pave the way for the preparation of tomorrow's surgical care whilst calling for equalization of racial imbalances in the field of breast cancer surgery.

ACKNOWLEDGMENTS

We would like to thank our Quality Program Manager Jill Steinberg MPH, RN, for her help with the ACS NSQIP data acquisition. American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS NSQIP are the sources of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

AUTHOR CONTRIBUTION

Conceptualization, S.K., PN.B., and A.C.P.; Methodology, S.K., M.K.-N., PN.B., and A.C.P.; Formal analysis, S.K., S.F., and A.C.P.; Investigation, S.K., M.K.-N., and A.C.P.; Data curation, S.K., D.Y.M., D.P.O., and A.C.P.; Writing—original draft, S.K..; Writing—review & editing, M.K.-N., L.K., F.D., V.G.M., H.A., M.W., B.S.-K., H.-G.M., B.P., D.P.O., PN.B., and A.C.P; Visualization, S.F. and A.C.P.; Supervision, H.-G.M., B.P., D.P.O., PN.B., and A.C.P.; Project administration, S.K., D.P.O., and A.C.P. All authors have read and agreed to the published version of the manuscript.

ETHICAL APPROVAL

Ethical approval to complete this retrospective cohort study was obtained from our institution (Brigham and Women's Hospital, Boston, MA, USA; protocol #: 2013P001244).

CONFLICT OF INTEREST STATEMENT

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

FINANCIAL SUPPORT STATEMENT

None of the authors have financial interest in any of the products, devices, or drugs mentioned in this manuscript.

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Figure 1. Flow diagram of the screening and selection process.

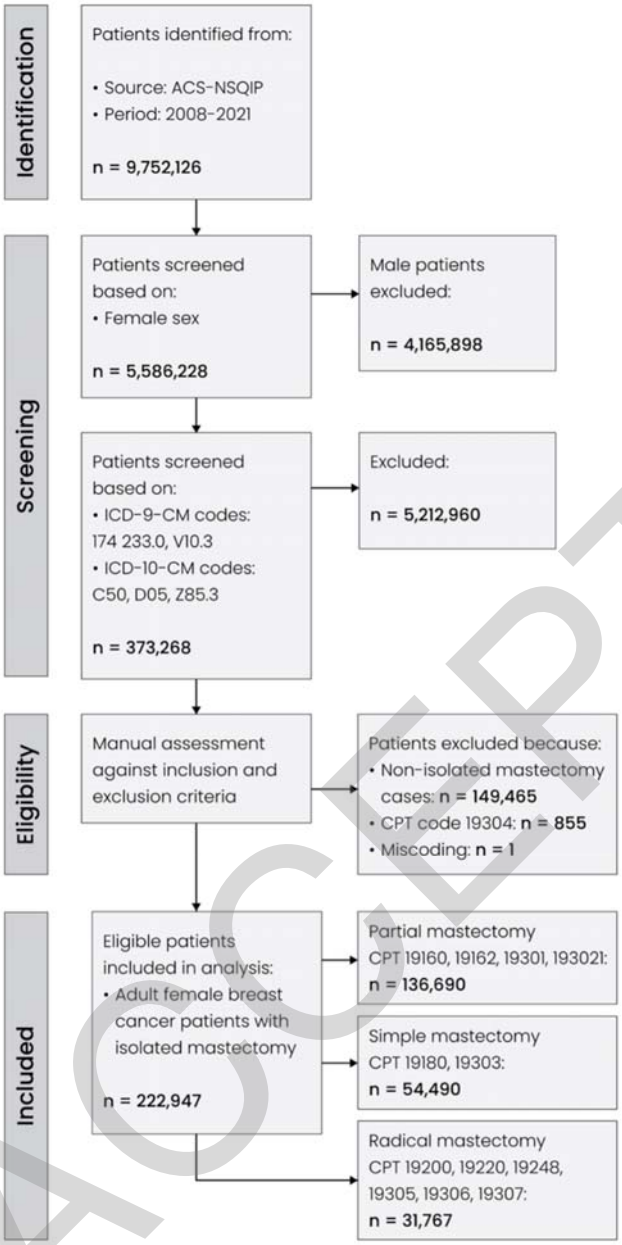

Figure 2. Racial comparison of the operative time in partial, simple, and radical mastectomy. Exact numbers and statistical comparisons are provided in the Supplementary Table 1 and 2.

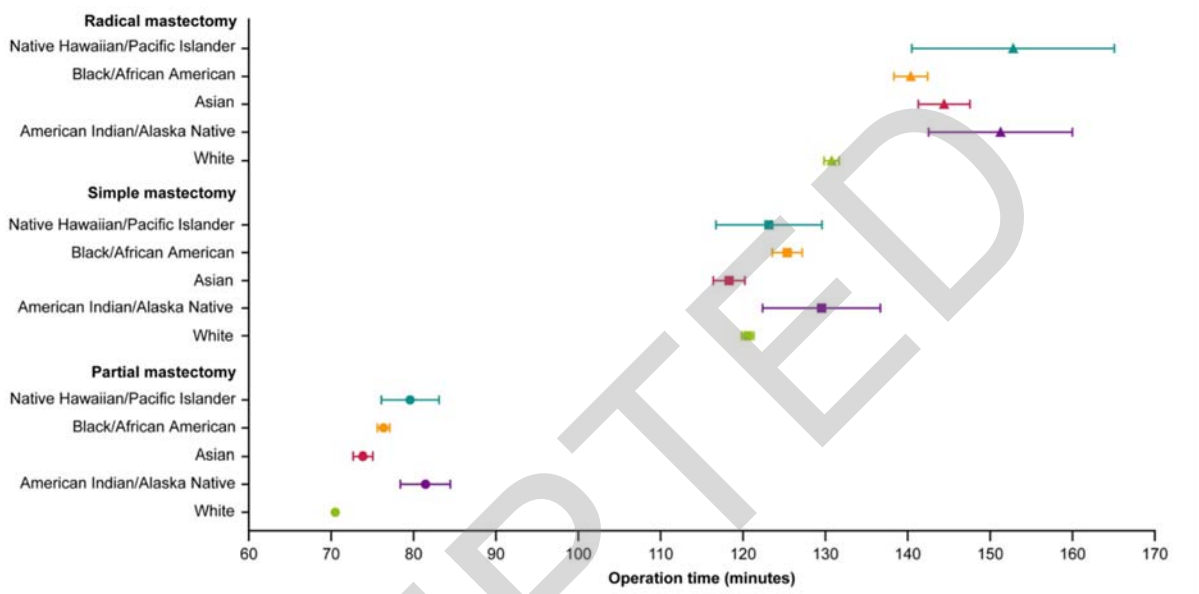

Figure 3. Racial Comparison of the length of hospital following the three different types of mastectomy. Exact numbers and statistical comparisons are provided in the Supplementary Table 3 and 4.

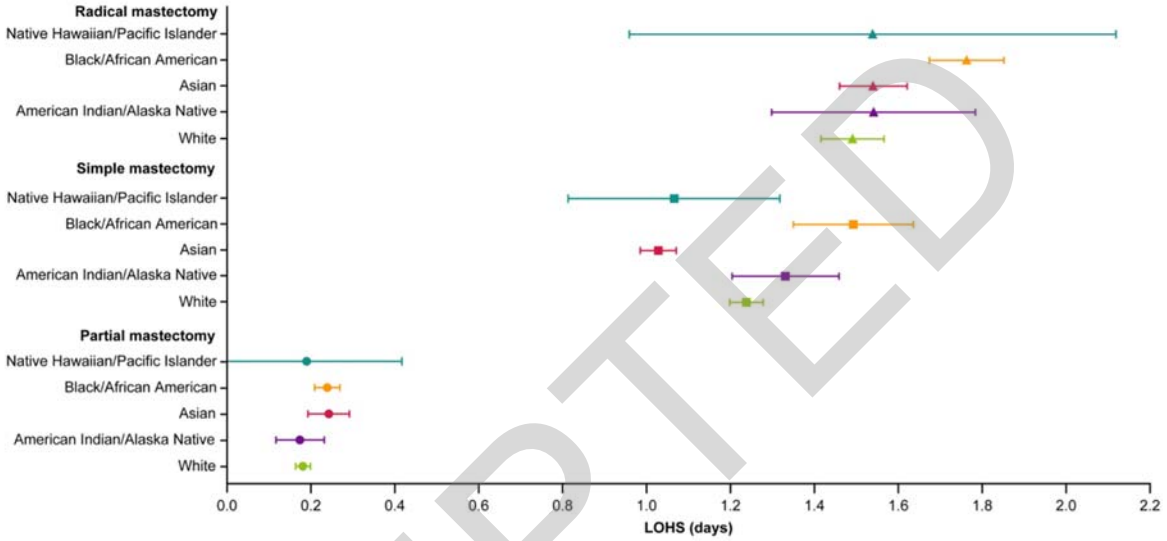

Figure 4. Graphical illustration of the results of the multivariable analyses. Table 5 shows the exact numbers

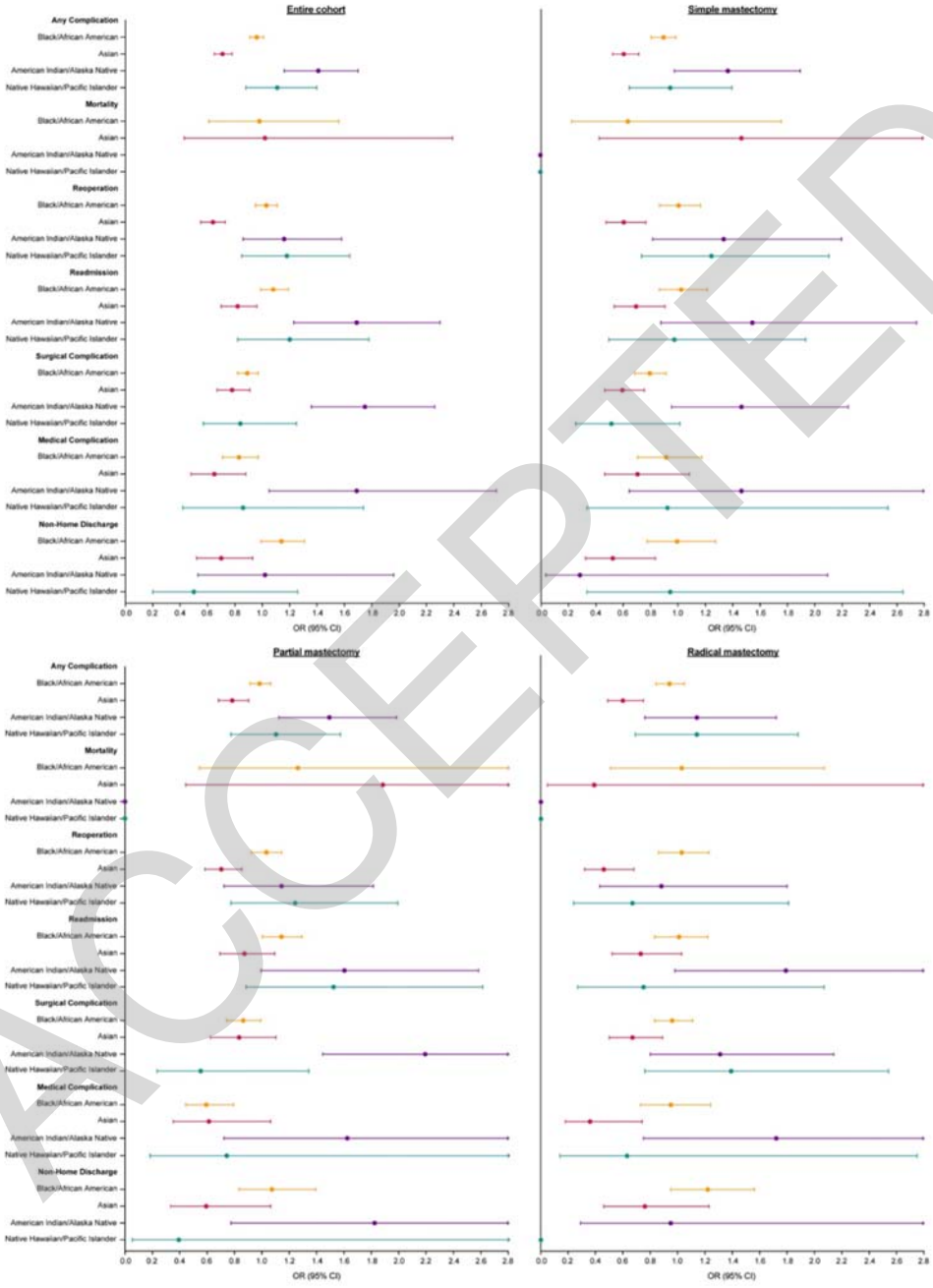

Table 1. Patient demographics and comorbidities stratified by the types of mastectomy and the racial groups. Reported as n (%), unless otherwise stated

Characteristic	Mastectomy (n=22	Partial Mastectomy	Simple Mastectomy	Radical Mastectomy	White (n=151,522)	Black/ African American	Asian (n=1	American Indi	Native Hawaiian
Demographics									
Age, mean ± SD	63 ± 13	63 ± 12	64 ± 13	61 ± 14	64 ± 12	61 ± 12	59 ± 12	59 ± 12	61 ± 12
BMI, mean ± SD	30 ±	30 ±	29 ±	30 ±	30 ±	32 ±	26 ±	32 ±	31 ±
Race									
American Indian or Alaskan Native	1,198 (0.5)	642 (0.5)	323 (0.6)	233 (0.7)					
Asian	11,21	5,487	3,875	1,855					
Native Hawaiian	1,018	531	320	167					
Black or African	23,98	14,09	5,703	4,188					
White	151,5	95,51	35,99	20,01					
Other/Unknown	34,00	20,42	8,276	5,307					
Preoperative health									
Diabetes	33,58	19,30	8,845	5,427	20,39	6,105	1,987	204	269
Insulin treated	9,763	5,343	2,688	1,732	6,142	1,988	383	73	76
COPD	7,655	4,281	2,116	1,258	5,863	826	67	43	27
Obesity	91,43	57,25	20,90	13,27	62,63	13,701	1,912	622	497
CHF	1,187 (0.5)	655 (0.5)	323 (0.6)	209 (0.7)	784 (0.5)	238 (1.0)	22 (0.2)	5 (0.4)	6 (0.6
Dialysis	667 (0.3)	311 (0.2)	223 (0.4)	133 (0.4)	254 (0.2)	286 (1.2)	34 (0.3)	3 (0.3)	11 (1.1
Renal	85	40	26	19	27	31	5	1	2
Hypertension	115,447	65,140 (48)	27,017 (50)	15,343 (48)	72,163 (48)	16,179 (67)	4,864 (43)	569 (48)	592 (58)
Ascites	71	30	22	19	55	0 (0.0)	2	0	3
Dyspnea	12,402 (5.6)	6,697 (4.9)	3,366 (6.2)	2,339 (7.3)	8,999 (5.9)	1,473 (6.1)	230 (2.0)	45 (3.8)	26 (2.6
Current smoker	25,856 (12)	14,703 (11)	6,553 (12)	4,600 (15)	17,701 (12)	3,791 (16)	357 (3.2)	319 (27)	131 (13)
Corticosteroid use	5,576 (2.5)	2,992 (2.2)	1,483 (2.7)	1,101 (3.5)	3851 (2.5)	723 (3.0)	182 (1.6)	52 (4.3)	23 (2.3
Weight loss >10%	925 (0.4)	327 (0.2)	284 (0.5)	314 (1.0)	683 (0.5)	118 (0.5)	28 (0.3)	7 (0.6)	5 (0.5
Disseminated cancer	4,591 (2.1)	1,540 (1.1)	1,281 (2.4)	1,770 (5.6)	2,808 (1.9)	537 (2.2)	145 (1.3)	18 (1.5)	19 (1.9
Wound infection	1,228 (0.6)	360 (0.3)	415 (0.8)	453 (1.4)	834 (0.6)	199 (0.8)	37 (0.3)	11 (1.0)	11 (1.1

History of Sepsis	675 (0.3)	266 (0.2)	189 (0.3)	210 (0.7)	442 (0.3)	119 (0.5)	29 (0.3)	1 (0.1)	4 (0.4
ASA class									
1 – No disturbance	9,318 (4.2)	6,658 (4.9)	1,729 (3.2)	931 (2.9)	5,045 (3.3)	427 (1.8)	789 (7.0)	22 (1.8)	35 (3.4
2 – Mild disturbance	119,804	77,198 (57)	27,379 (50)	15,227 (48)	82,034 (54)	10,442 (44)	7,458 (67)	499 (42)	541 (53)
3 – Severe disturbance	89,170 (40)	50,476 (37)	24,043 (44)	14,651 (46)	61,627 (41)	12,411 (52)	2,912 (26)	652 (54)	414 (41)
4 – Life-threatening	4,292 (1.9)	2,109 (1.5)	1,268 (2.3)	915 (2.9)	2,640 (1.7)	706 (2.9)	50 (0.4)	25 (2.1)	27 (2.7
5 – Moribund	7 (0.0)	3 (0.0)	2 (0.0)	2 (0.0)	2 (0.0)	3 (0.0)	0 (0.0)	0 (0.0)	0 (0.0
Wound class									
1 – Clean	197,811 (89)	120,228 (88)	48,401 (89)	29,182 (92)	135,632 (90)	21,296 (89)	9,826 (88)	1,043 (87)	875 (86)
2 – Clean/Contaminat	3,429 (1.5)	2,244 (1.6)	683 (1.3)	502 (1.6)	2,293 (1.5)	456 (1.9)	212 (1.9)	14 (1.2)	30 (3.0
3 – Contaminated	799 (0.4)	488 (0.4)	150 (0.3)	161 (0.5)	633 (0.4)	78 (0.4)	32 (0.3)	4 (0.3)	6 (0.6
4 – Dirty/Infected	316 (0.1)	67 (0.0)	113 (0.2)	136 (0.4)	204 (0.1)	66 (0.3)	10 (0.1)	4 (0.3)	3 (0.3
Unknown	20,592 (9.2)	13,663 (10)	5,143 (9.4)	1,786 (5.6)	12,760	2,091 (8.7)	1,137 (10)	133 (11)	104 (10)
Functional Status									
Independent	218,527 (99)	134,636 (99)	53,092 (98)	30,799 (97)	148,534 (99)	23,422 (98)	11,103 (99)	1,175 (98)	985 (98)
Partially or Totally Dependent	3,123 (1.4)	1,126 (0.8)	1,142 (2.1)	855 (2.7)	2,120 (1.4)	479 (2.0)	76 (0.7)	19 (1.6)	18 (1.8)

Table 2. Surgical characteristics classified by the three types of surgery and the five races. Reported as n (%).

Characteristic	Mastectomy (n=222,947)	Partial Mastectomy (n=136,690)	Simple Mastectomy (n=54,490)	Radical Mastectomy (n=31,767)	White (n=151,522)	Black/African American (n=23,987)	Asian (n=11,217)	American Indian and Alaska Native (n=1,198)	Native Hawaiian/ Pacific Islander (n=1,018)
Type of Surgery									
Partial Mastectomy	136,690 (61)				95,512 (63)	14,096 (59)	5,487 (49)	642 (54)	531 (52)
Simple Mastectomy	54,490 (24)				35,993 (24)	5,703 (24)	3,875 (35)	323 (27)	320 (31)
Radical Mastectomy	31,767 (14)				20,017 (13)	4,188 (17)	1,855 (17)	233 (19)	167 (16)
Type of anesthesia									
General	202,884 (91)	117,750 (86)	53,627 (98)	31,507 (99)	136,184 (90)	22,151 (92)	10,215 (91)	1,156 (96)	975 (96)
Monitored anesthesia care	18,239 (8.2)	17,539 (13)	565 (1.0)	135 (0.4)	14,082 (9.3)	1,648 (6.9)	926 (8.3)	37 (3.1)	36 (3.5)
Other/unknown	1,824 (0.8)	1,391 (1.0)	298 (0.5)	125 (0.4)	1,256 (0.8)	188 (0.8)	76 (0.7)	5 (0.4)	7 (0.7)
Setting									
Inpatient	45,152 (20)	7,580 (5.5)	21,791 (40)	15,781 (50)	25,401 (17)	5,250 (22)	3,052 (27)	362 (30)	202 (20)
Outpatient	177,795 (80)	129,110 (94)	32,699 (60)	15,986 (50)	126,121 (83)	18,737 (78)	8,165 (73)	836 (70)	816 (80)
Surgical Specialty									
General Surgery	221,456 (99)	135,854 (99)	54,055 (99)	31,547 (99)	150,549 (99)	23,833 (99)	11,119 (99)	1,194 (100)	998 (98)
Plastics	863 (0.4)	460 (0.3)	271 (0.5)	132 (0.4)	493 (0.3)	111 (0.5)	69 (0.6)	2 (0.2)	18 (1.8)
Other/unknown	628 (0.3)	376 (0.3)	164 (0.3)	88 (0.3)	480 (0.3)	43 (0.2)	29 (0.3)	2 (0.2)	2 (0.2)
Year of Surgery									
2008	9,399	4,515	2,565	2,319	7,098	1,101	306	60	12

	(4.2)	(3.3)	(4.7)	(7.3)	(4.7)	(4.6)	(2.7)	(5.0)	(1.2)
2009	11,547	5,764	3,144	2,629	8,702	1,368	415	76	76
	(5.2)	(4.2)	(5.8)	(8.3)	(5.7)	(5.7)	(3.7)	(6.3)	(7.5)
2010	11,225	5,906	2,905	2,414	8,252	1,290	459	71	69
	(5.0)	(4.3)	(5.3)	(7.6)	(5.4)	(5.4)	(4.1)	(5.9)	(6.8)
2011	4,561	2,520	1,130	911	3,352	565	195	53	18
	(2.0)	(1.8)	(2.1)	(2.9)	(2.2)	(2.4)	(1.7)	(4.4)	(1.8)
2012	12,786	7,107	3,318	2,361	9,058	1,437	695	68	83
	(5.7)	(5.2)	(6.1)	(7.4)	(6.0)	(6.0)	(6.2)	(5.7)	(8.2)
2013	15,000	8,677	3,751	2,572	10,738	1,704	797	94	76
	(6.7)	(6.3)	(6.9)	(8.1)	(7.1)	(7.1)	(7.1)	(7.8)	(7.5)
2014	16,138	9,669	3,889	2,580	11,672	1,878	761	86	76
	(7.2)	(7.1)	(7.1)	(8.1)	(7.7)	(7.8)	(6.8)	(7.2)	(7.5)
2015	18,006	11,191	4,298	2,517	12,656	1,874	868	101	64
	(8.1)	(8.2)	(7.9)	(7.9)	(8.4)	(7.8)	(7.7)	(8.4)	(6.3)
2016	20,226	13,077	4,566	2,583	13,644	2,181	908	89	78
	(9.1)	(9.6)	(8.4)	(8.1)	(9.0)	(9.1)	(8.1)	(7.4)	(7.7)
2017	20,834	13,578	4,786	2,470	13,968	2,194	1,074	61	105
	(9.3)	(9.9)	(8.8)	(7.8)	(9.2)	(9.1)	(9.6)	(5.1)	(10)
2018	20,740	13,609	4,858	2,273	13,661	2,139	1,132	89	93
	(9.3)	(10)	(8.9)	(7.2)	(9.0)	(8.9)	(10)	(7.4)	(9.1)
2019	21,685	14,231	5,169	2,285	13,698	1,987	1,262	125	72
	(9.7)	(10)	(9.5)	(7.2)	(9.0)	(8.3)	(11)	(10)	(7.1)
2020	20,218	13,183	4,968	2,067	12,263	2,178	1,208	92	92
	(9.1)	(9.6)	(9.1)	(6.5)	(8.1)	(9.1)	(11)	(7.7)	(9.0)
2021	20,592	13,663	5,143	1,786	12,760	2,091	1,137	133	104
	(9.2)	(10)	(9.4)	(5.6)	(8.4)	(8.7)	(10)	(11)	(10)

Table 3. Peri- and postoperative outcomes following partial, simple and radical mastectomy. Reported as n (%), unless otherwise stated.

Outcome	**Mastectomy (n=222,947)**	**Partial Mastectomy (n=136,690)**	**Simple Mastectomy (n=54,490)**	**Radical Mastectomy (n=31,767)**	**White (n=151,522)**	**Black/ African American (n=23,987)**	**Asian (n=11,217)**	**American Indian and Alaska Native (n=1,198)**	**Native Hawaiian / Pacific Islander (n=1,018)**
Length of Hospital Stay, Mean days ± SD	0.7 ± 3.4	0.2 ± 2.6	1.2 ± 4.1	1.5 ± 4.7	0.6 ± 5.3	0.8 ± 3.3	0.7 ± 1.8	0.8 ± 1.3	0.7 ± 2.8
Operative time, Mean minutes ± SD	90 ± 59	70 ± 41	117 ± 69	129 ± 66	90 ± 59	99 ± 63	101 ± 62	108 ± 61	105 ± 62
Any Complication	17,222 (7.7)	8,588 (6.3)	5,297 (9.7)	3,337 (11)	11,659 (7.7)	2,031 (8.5)	569 (5.1)	144 (12)	90 (8.8)
Mortality	221 (0.1)	70 (0.1)	83 (0.2)	68 (0.2)	156 (0.1)	31 (0.1)	6 (0.1)	1 (0.1)	1 (0.1)
Reoperation	6,972 (3.1)	3,773 (2.8)	2,059 (3.8)	1,140 (3.6)	4,931 (3.3)	844 (3.5)	246 (2.2)	52 (4.3)	37 (3.6)
Readmission	5,422 (2.4)	2,771 (2.0)	1,640 (3.0)	1,011 (3.2)	3,554 (2.3)	709 (3.0)	197 (1.8)	50 (4.2)	31 (0.3)
Unplanned Readmission	4,182 (1.9)	1,842 (1.3)	1,432 (2.6)	908 (2.9)	2,778 (1.8)	568 (2.4)	138 (1.2)	35 (2.9)	21 (0.2)
Surgical Complication	7,246 (3.3)	2,691 (2.0)	2,666 (4.9)	1,889 (5.9)	4,680 (3.1)	840 (3.5)	216 (1.9)	76 (6.3)	32 (3.1)
Superficial Incisional Infection	4,343 (1.9)	1,928 (1.4)	1,474 (2.7)	941 (3.0)	2,886 (1.9)	378 (1.6)	112 (1.0)	40 (3.3)	19 (1.9)
Deep Incisional Infection	779 (0.3)	284 (0.2)	272 (0.5)	223 (0.7)	537 (0.4)	85 (0.4)	15 (0.1)	14 (1.2)	0 (0.0)
Organ Space	712	277	266	169	489	57	27	10	6

Infection	(0.3)	(0.2)	(0.5)	(0.5)	(0.3)	(0.2)	(0.2)	(0.8)	(0.6)
Dehiscence	512 (0.2)	168 (0.1)	184 (0.3)	160 (0.5)	288 (0.2)	73 (0.3)	12 (0.1)	16 (1.3)	4 (0.4)
Bleeding	1,169 (0.5)	87 (0.1)	583 (1.1)	499 (1.6)	615 (0.4)	291 (1.2)	57 (0.5)	8 (0.7)	7 (0.7)
Medical Complication	2,124 (1.0)	837 (0.6)	739 (1.4)	548 (1.7)	1,515 (1.0)	237 (1.0)	56 (0.5)	22 (1.8)	10 (1.0)
Pneumonia	231 (0.1)	101 (0.1)	72 (0.1)	58 (0.2)	151 (0.1)	32 (0.1)	5 (0.0)	3 (0.3)	0 (0.0)
Reintubation	126 (0.1)	32 (0.0)	59 (0.1)	35 (0.1)	92 (0.1)	15 (0.1)	3 (0.0)	1 (0.1)	0 (0.0)
Pulmonary embolism	187 (0.1)	65 (0.0)	70 (0.1)	52 (0.2)	123 (0.1)	31 (0.1)	5 (0.0)	0 (0.0)	0 (0.0)
Ventilator > 48 Hours	46 (0.0)	11 (0.0)	25 (0.0)	10 (0.0)	36 (0.0)	4 (0.0)	1 (0.0)	0 (0.0)	1 (0.1)
Renal Insufficiency	48 (0.0)	12 (0.0)	19 (0.0)	17 (0.1)	26 (0.0)	11 (0.1)	1 (0.0)	0 (0.0)	1 (0.1)
Renal Failure	28 (0.0)	7 (0.0)	10 (0.0)	11 (0.0)	14 (0.0)	10 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Urinary Tract Infection	774 (0.3)	390 (0.3)	219 (0.4)	165 (0.5)	594 (0.4)	43 (0.2)	23 (0.2)	9 (0.8)	3 (0.3)
Cerebral Vascular Accident/Stroke	121 (0.1)	44 (0.0)	46 (0.1)	31 (0.1)	86 (0.1)	14 (0.1)	4 (0.0)	2 (0.2)	1 (0.1)
Cardiac Arrest	64 (0.0)	16 (0.0)	31 (0.1)	17 (0.1)	42 (0.0)	8 (0.0)	2 (0.0)	0 (0.0)	1 (0.1)
Myocardial Infarction	123 (0.1)	53 (0.0)	38 (0.1)	32 (0.1)	87 (0.1)	6 (0.0)	4 (0.0)	0 (0.0)	2 (0.2)
Deep Vein Thrombosis/Thrombophlebitis	250 (0.1)	86 (0.1)	101 (0.2)	63 (0.2)	183 (0.1)	31 (0.1)	4 (0.0)	0 (0.0)	0 (0.0)
Sepsis	448	117	175	156	309	69	8	11	5

	(0.2)	(0.1)	(0.3)	(0.5)	(0.2)	(0.3)	(0.1)	(0.9)	(0.5)
Septic Shock	81 (0.0)	17 (0.0)	38 (0.1)	26 (0.1)	68 (0.0)	11 (0.0)	1 (0.0)	0 (0.0)	0 (0.0)
Discharge destination									
Home	188,330 (84)	119,662 (88)	44,949 (82)	23,719 (75)	125,811 (83)	19,899 (83)	9,977 (89)	979 (82)	854 (84)
Non-Home	2,303 (1.0)	736 (0.5)	899 (1.6)	668 (2.1)	1,548 (1.0)	315 (1.3)	54 (0.5)	11 (1.0)	6 (0.6)
Unknown	32,314 (15)	16,292 (12)	8,642 (16)	7380 (23)	24,163 (16)	3,773 (16)	1,186 (11)	208 (17)	158 (16)

Table 4. Univariable analyses of the postoperative outcomes after partial, simple, and radical mastectomy. Statistically significant p values are highlighted in bold.

Outcome	Mastectomy Events	OR (95% CI)	P value	Partial Mastectomy Events	OR (95% CI)		Simple Mastectomy Events	OR (95% CI)		Radical Mastectomy Events	OR (95% C	
Any Complication												
White	11,659			5,887			3,601			2,171		
Black/African American	2,031	1.11 (1.06, 1.17)	**<0.001**	932	1.08 (1.00, 1.16)	**0.04**	607	1.07 (0.98, 1.17)	0.137	492	1.09 (0.99, 1.21)	0.09
Asian	569	0.64 (0.59, 0.70)	**<0.001**	258	0.75 (0.66, 0.85)	**<0.001**	203	0.50 (0.43, 0.58)	**<0.001**	108	0.51 (0.42, 0.62)	**<0.001**
American Indian/Alaska Native	144	1.64 (1.38, 1.95)	**<0.001**	66	1.74 (1.35, 2.25)	**<0.001**	45	1.46 (1.06, 2.00)	**0.02**	33	1.36 (0.94, 1.97)	0.107
Native Hawaiian/ Pacific Islander	90	1.16 (0.94, 1.45)	0.17	37	1.14 (0.82, 1.59)	0.44	31	0.96 (0.67, 1.40)	0.851	22	1.25 (0.79, 1.96)	0.334
Mortality												
White	156			47			63			46		

Black/African American	31	1.26 (0.85, 1.85)	0.25	9	1.3 (0.64, 2.65)	0.47	8	0.80 (0.38, 1.67)	0.56	14	1.46 (0.80, 2.65)	0.22
Asian	6	0.52 (0.23, 1.17)	0.12	2	0.74 (0.18, 3.05)	0.68	3	0.44 (0.14, 1.41)	0.17	1	0.23 (0.03, 1.70)	0.15
American Indian/Alaska Native	1	0.81 (0.11, 5.80)	0.83	1	3.17 (0.44, 230)	0.25	0	0.00 (0.00, Inf)	0.98	0	0.00 (0.00, Inf)	0.98
Native Hawaiian/ Pacific Islander	1	0.95 (0.13, 6.82)	0.96	0	0.00 (0.00, Inf)	0.98	0	0.00 (0.00, Inf)	0.98	1	2.62 (0.36, 19.08)	0.34
Reoperation												
White	4,931			2,742			1,419			770		
Black/African American	844	1.08 (1.01, 1.17)	**0.03**	417	1.03 (0.93, 1.15)	0.56	248	1.11 (0.97, 1.27)	0.15	179	1.12 (0.95, 1.32)	0.20
Asian	246	0.67 (0.59, 0.76)	**<0.001**	120	0.76 (0.63, 0.91)	**0.003**	94	0.61 (0.49, 0.75)	**<0.001**	32	0.44 (0.31, 0.65)	**<0.001**

American Indian/Alaska Native	52	1.35 (1.02, 1.78)	**0.04**	23	1.26 (0.83, 1.91)	0.28	17	1.35 (0.83, 2.21)	0.23	12	1.36 (0.76, 2.44)	0.31
Native Hawaiian/ Pacific Islander	37	1.12 (0.81, 1.56)	0.50	18	1.19 (0.74, 1.90)	0.48	15	1.20 (0.71, 2.02)	0.50	4	0.61 (0.23, 1.66)	0.34
Readmission												
White	3,554			1,818			1,084			652		
Black/African American	709	1.27 (1.17, 1.38)	**<0.001**	338	1.26 (1.12, 1.42)	**<0.001**	211	1.21 (1.04, 1.40)	**0.01**	160	1.18 (0.99, 1.41)	0.06
Asian	197	0.70 (0.60, 0.81)	**<0.001**	88	0.80 (0.64, 0.99)	**0.04**	68	0.53 (0.42, 0.68)	**<0.001**	41	0.57 (0.42, 0.79)	**0.001**
American Indian/Alaska Native	50	1.92 (1.44, 2.56)	**<0.001**	21	1.76 (1.14, 2.73)	**0.01**	15	1.73 (1.02, 2.93)	**0.04**	14	2.07 (1.19, 3.60)	**0.01**
Native Hawaiian/ Pacific Islander	31	1.32 (0.92, 1.89)	0.13	16	1.62 (0.98, 2.68)	0.06	9	0.91 (0.47, 1.78)	0.79	6	1.07 (0.47, 2.44)	0.87

Unplanned Readmission												
White	2,778			1,250			943			585		
Black/African American	568	1.02 (0.85, 1.24)	0.80	227	0.87 (0.69, 1.11)	0.265	192	1.45 (0.91, 2.33)	0.12	149	1.01 (0.60, 1.70)	0.98
Asian	138	0.65 (0.48, 0.88)	**0.005**	49	0.57 (0.37, 0.87)	**0.009**	57	0.73 (0.39, 1.36)	0.32	32	0.43 (0.20, 0.91)	**0.03**
American Indian/Alaska Native	35	0.72 (0.39, 1.33)	0.30	14	1.0 (0.40, 2.49)	~0.99	11	0.46 (0.14, 1.46)	0.19	10	0.34 (0.10, 1.10)	0.07
Native Hawaiian/ Pacific Islander	21	0.65 (0.31, 1.39)	0.27	10	0.83 (0.30, 2.31)	0.73	6	0.33 (0.08, 1.35)	0.12	5	0.68 (0.08, 5.85)	0.72
Surgical Complication												
White	4680			1,700			1,798			1,182		
Black/African American	840	1.14 (1.06, 1.23)	**0.001**	272	1.09 (0.95, 1.24)	0.21	284	1.0 (0.88, 1.13)	0.96	284	1.16 (1.01, 1.33)	**0.03**
Asian	216	0.62	**<0.**	69	0.70 (0.55,	**0.0**	87	0.44	**<0.**	60	0.53	**<0.**

		(0.54, 0.71)	**0.001**		0.90)	**0.04**		(0.35, 0.54)	**0.001**		(0.41, 0.69)	**0.001**
American Indian/Alaska Native	76	2.13 (1.68, 2.69)	**<0.001**	32	2.89 (2.02, 4.14)	**<0.001**	25	1.60 (1.06, 2.41)	**0.03**	19	1.41 (0.88, 2.27)	0.15
Native Hawaiian/ Pacific Islander	32	1.02 (0.72, 1.45)	0.92	8	0.84 (0.42, 1.70)	0.64	10	0.61 (0.33, 1.15)	0.13	14	1.46 (0.84, 2.53)	0.18
Medical Complication												
White	1515			635			513			367		
Black/African American	237	0.99 (0.86, 1.13)	0.86	64	0.68 (0.53, 0.88)	**0.004**	92	1.13 (0.91, 1.42)	0.27	81	1.06 (0.83, 1.35)	0.66
Asian	56	0.50 (0.38, 0.65)	**<0.001**	17	0.46 (0.29, 0.75)	**0.002**	27	0.49 (0.33, 0.72)	**<0.001**	12	0.35 (0.20, 0.62)	**<0.001**
American Indian/Alaska Native	22	1.85 (1.21, 2.83)	**0.004**	9	2.12 (1.10, 4.12)	**0.03**	7	1.53 (0.72, 3.26)	0.27	6	1.42 (0.63, 3.20)	0.41
Native	10	0.	0.	3	0.85	0.	4	0.8	0.	3	0.9	0.

Hawaiian/ Pacific Islander		98 (0.53, 1.83)	96		(0.27, 2.65)	78		8 (0.33, 2.36)	79		8 (0.31, 3.08)	97
Non-Home Discharge												
White	1,548			493			620			435		
Black/African American	315	1.29 (1.14, 1.45)	**<0.001**	87	1.19 (0.95, 1.50)	0.14	109	1.08 (0.88, 1.33)	0.44	119	1.32 (1.07, 1.62)	**0.009**
Asian	54	0.44 (0.34, 0.58)	**<0.001**	12	0.40 (0.23, 0.71)	**0.002**	22	0.30 (0.20, 0.46)	**<0.001**	20	0.42 (0.27, 0.66)	**<0.001**
American Indian/Alaska Native	11	0.91 (0.50, 1.66)	0.77	7	2.09 (0.99, 4.42)	0.06	1	0.19 (0.03, 1.33)	0.09	3	0.59 (0.19, 1.86)	0.37
Native Hawaiian/ Pacific Islander	6	0.57 (0.26, 1.28)	0.17	1	0.36 (0.05, 2.59)	0.31	4	0.70 (0.26, 1.90)	0.49	1	0.26 (0.04, 1.84)	0.18

Table 5. Multivariable analyses of the postoperative outcomes after partial, simple, and radical mastectomy. Statistically significant p values are highlighted in bold

Outcome	Mastectomy OR (95% CI)	P Val	Partial Mastectomy OR (95% CI)	P Val	Simple Mastectomy OR (95% CI)	P Val	Radical Mastectomy OR (95% CI)	P Val
Any Complication								
White								
Black/African American	0.96 (0.91, 1.01)	0.14	0.98 (0.91, 1.06)	0.69	0.90 (0.81, 0.99)	**0.039**	0.94 (0.84, 1.05)	0.27
Asian	0.71 (0.65, 0.78)	**<0.001**	0.78 (0.68, 0.90)	**<0.001**	0.61 (0.53, 0.72)	**<0.001**	0.60 (0.49, 0.75)	**<0.001**
American Indian/Alaska Native	1.41 (1.16, 1.70)	**<0.001**	1.49 (1.12, 1.98)	**0.007**	1.37 (0.9ssss8, 1.90)	0.07	1.14 (0.76, 1.72)	0.51
Native Hawaiian/ Pacific Islander	1.11 (0.88, 1.40)	0.38	1.10 (0.77, 1.57)	0.59	0.95 (0.65, 1.40)	0.81	1.14 (0.69, 1.88)	0.62
Mortality								
White								
Black/African American	0.98 (0.61, 1.56)	0.93	1.26 (0.54, 2.93)	0.60	0.64 (0.23, 1.76)	0.39	1.03 (0.51, 2.07)	0.94
Asian	1.02 (0.43, 2.39)	0.97	1.88 (0.44, 8.11)	0.40	1.47 (0.43, 5.00)	0.53	0.39 (0.05, 2.96)	0.37
American Indian/Alaska Native	0.00 (0.00, Inf)	~0.99	0.00 (0.00, Inf)	~0.99	0.00 (0.00, Inf)	~0.99	0.00 (0.00, Inf)	~0.99
Native Hawaiian/ Pacific Islander	0.00 (0.00, Inf)	~0.99	0.00 (0.00, Inf)	~0.99	0.00 (0.00, Inf)	~0.99	0.00 (0.00, Inf)	~0.99
Reoperation								
White								
Black/African American	1.03 (0.95, 1.11)	0.53	1.03 (0.92, 1.14)	0.66	1.01 (0.87, 1.17)	0.92	1.03 (0.86, 1.23)	0.76
Asian	0.64 (0.55, 0.73)	**<0.001**	0.70 (0.58, 0.85)	**<0.001**	0.61 (0.48, 0.77)	**<0.001**	0.46 (0.32, 0.68)	**<0.001**
American Indian/Alaska Native	1.16 (0.86, 1.58)	0.33	1.14 (0.72, 1.81)	0.58	1.34 (0.82, 2.20)	0.25	0.88 (0.43, 1.80)	0.73
Native Hawaiian/ Pacific	1.18 (0.85, 1.64)	0.33	1.24 (0.77, 1.99)	0.37	1.25 (0.74, 2.11)	0.41	0.67 (0.24, 1.81)	0.43

Islander								
Readmission								
White								
Black/African American	1.08 (0.99, 1.19)	0.08	1.14 (1.00, 1.29)	**0.045**	1.03 (0.87, 1.22)	0.76	1.01 (0.83, 1.22)	0.95
Asian	0.82 (0.70, 0.96)	**0.01**	0.87 (0.69, 1.09)	0.22	0.70 (0.54, 0.91)	**<0.001**	0.73 (0.52, 1.03)	0.08
American Indian/Alaska Native	1.69 (1.23, 2.30)	**0.001**	1.60 (0.99, 2.58)	0.06	1.55 (0.88, 2.75)	0.13	1.79 (0.98, 3.28)	0.06
Native Hawaiian/ Pacific Islander	1.20 (0.82, 1.78)	0.35	1.52 (0.88, 2.61)	0.13	0.98 (0.50, 1.94)	0.97	0.75 (0.27, 2.07)	0.58
Surgical Complication								
White								
Black/African American	0.89 (0.82, 0.97)	**0.007**	0.86 (0.74, 0.99)	0.036	0.80 (0.69, 0.92)	**0.002**	0.96 (0.83, 1.11)	0.58
Asian	0.78 (0.67, 0.91)	**0.002**	0.83 (0.62, 1.10)	0.188	0.60 (0.47, 0.76)	**<0.001**	0.67 (0.50, 0.89)	**0.006**
American Indian/Alaska Native	1.75 (1.36, 2.26)	**<0.001**	2.19 (1.44, 3.32)	**<0.001**	1.47 (0.96, 2.25)	0.08	1.31 (0.80, 2.14)	0.29
Native Hawaiian/ Pacific Islander	0.84 (0.57, 1.25)	0.40	0.55 (0.23, 1.34)	0.19	0.52 (0.26, 1.02)	0.06	1.39 (0.76, 2.54)	0.29
Medical Complication								
White								
Black/African American	0.83 (0.71, 0.97)	**0.017**	0.59 (0.44, 0.79)	**<0.001**	0.92 (0.71, 1.18)	0.50	0.95 (0.73, 1.24)	0.72
Asian	0.65 (0.48, 0.88)	**0.005**	0.61 (0.35, 1.06)	0.082	0.71 (0.47, 1.09)	0.12	0.36 (0.18, 0.74)	**0.005**
American Indian/Alaska Native	1.69 (1.05, 2.71)	**0.029**	1.62 (0.72, 3.66)	0.25	1.47 (0.65, 3.33)	0.36	1.72 (0.75, 3.94)	0.20
Native Hawaiian/ Pacific Islander	0.86 (0.42, 1.74)	0.67	0.74 (0.18, 2.98)	0.67	0.93 (0.34, 2.54)	0.89	0.63 (0.14, 2.75)	0.54
Non-Home Discharge								

White								
Black/African American	1.14 (0.99, 1.31)	0.08	1.07 (0.83, 1.39)	0.60	1.00 (0.78, 1.28)	1.00	1.22 (0.95, 1.56)	0.11
Asian	0.70 (0.52, 0.93)	**0.01**	0.59 (0.33, 1.06)	0.08	0.53 (0.33, 0.84)	**<0.001**	0.76 (0.46, 1.23)	0.26
American Indian/Alaska Native	1.02 (0.53, 1.96)	0.95	1.82 (0.77, 4.31)	0.17	0.29 (0.04, 2.10)	0.22	0.95 (0.29, 3.04)	0.93
Native Hawaiian/ Pacific Islander	0.50 (0.20, 1.26)	0.14	0.39 (0.05, 3.02)	0.37	0.95 (0.34, 2.65)	0.92	0.00 (0.00, Inf)	~0.99