Omar Jean-Baptiste
MSCR Graduation Thesis: Overall Survival in Breast Reconstruction: An Analysis of the National Cancer Database

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Date

Overall Survival in Breast Reconstruction: An Analysis of the National Cancer Database

By

Omar Jean-Baptiste

Master of Science

Clinical Research

Yuan Liu, Ph.D

Advisor

Jordan Kempker, MD MSCR

Advisor

Heather R. Faulkner, MD MPH

Committee Member

Amita Manatunga, Ph.D MSCR

Committee Member

Accepted:

Kimberly Jacob Arriola, Ph.D, MPH
Dean of the James T. Laney School of Graduate Studies

4/25/2025
Date

Overall Survival in Breast Reconstruction: An Analysis of the
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By

Omar Jean-Baptiste
BS, University of South Florida, 2019

Advisor: Yuan Liu, PhD

An abstract of
A thesis submitted to the Faculty of the James T. Laney School of Graduate Studies of Emory University
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Introduction
Breast cancer is the most diagnosed cancer in women and a leading cause of cancer-related mortality. Surgical treatment remains a cornerstone of care, with many patients undergoing mastectomy, some of whom opt for reconstruction using implant-based or autologous techniques. While reconstruction is primarily pursued for cosmetic and psychological reasons, its potential association with overall survival remains uncertain, with conflicting findings in the literature. This study aimed to assess the association between breast reconstruction and overall survival in a large, nationally representative cohort.

Methods
We conducted a retrospective cohort analysis using the National Cancer Database (NCDB), including women with stage 0–III breast cancer who underwent mastectomy with or without reconstruction. The primary exposure was surgical type (mastectomy only vs. reconstruction), and the primary outcome was overall survival. Reconstruction included both autologous and implant-based approaches. Age was stratified into five groups (18–30, 31–40, 41–50, 51–65, 66–80). Descriptive and univariable analyses were performed, followed by multivariable Cox proportional hazards modeling. A directed acyclic graph (DAG) was used to select covariates, and time-dependent variables were adjusted accordingly.

Results
Of 176,310 patients included, 122,208 underwent mastectomy only and 54,102 underwent mastectomy with reconstruction. Reconstruction was more common among patients treated at academic centers and among those with higher income, education, and private insurance. In univariable analysis, reconstruction was associated with improved survival (HR 0.32, 95% CI 0.31–0.33). In the multivariable Cox model adjusting for age, stage, comorbidities, insurance, income, and race, reconstruction remained associated with improved survival (HR 0.45, 95% CI 0.42–0.48, $p < 0.001$).

Discussion
Breast reconstruction after mastectomy was associated with improved overall survival, even after adjusting for demographic and clinical covariates. While this observational study cannot establish causality, it highlights potential survival differences that warrant further investigation. Limitations include missing data, risk of residual confounding, and lack of information on timing of reconstruction. Future prospective studies are needed to clarify mediating factors such as follow-up intensity, quality of life, and treatment adherence.

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Introduction

General Overview of Breast Cancer

Breast cancer is the most frequently diagnosed cancer among women worldwide and remains a leading cause of cancer-related mortality, accounting for approximately 30% of all new cancer cases and 670,000 deaths annually. [1] In the United States, breast cancer incidence has been rising at an annual rate of 0.6% since the mid-2000s, despite advancements in screening and treatment [2]. Additionally, breast cancer is the most diagnosed cancer in women in the United States, accounting for 31.8% of all cancer cases leading to approximately 310,000 new cases annually and second in most cancer related deaths. [2, 3] While early detection and therapeutic improvements have significantly reduced mortality—leading to an overall decline of 42% since 2021—survival rates remain highly variable across populations. [4]

Breast cancer is a heterogeneous disease influenced by multiple factors, including genetic predisposition, hormonal exposure, and lifestyle-related risks. [5] While advances in treatment have led to improved five-year survival rates for localized disease (>99%), the prognosis for metastatic breast cancer remains poor, with five-year survival rates below 32%. [2] Additionally, racial and socioeconomic disparities persist, with Black women experiencing a disproportionately higher mortality rate compared to White women, despite a lower overall incidence of the disease. [6] These differences have been attributed to a combination of factors, including tumor biology, disparities in access to care, and treatment differences. [7]

Why Surgical Choice is an Important Issue

Surgery remains a cornerstone of breast cancer treatment, with mastectomy and breast-conserving surgery (BCS), commonly known as lumpectomy, being the primary options for patients with

early-stage disease. [8] While BCS followed by radiation therapy is often preferred for its breast-preserving benefits and comparable oncologic outcomes, mastectomy is recommended for patients with larger tumors, multicentric disease, or genetic predispositions, such as BRCA1/2 mutations. [9] In recent decades, an increasing number of patients undergoing mastectomy have elected to pursue breast reconstruction to restore breast contour and improve psychosocial well-being. [10]

Breast reconstruction can be performed using either implant-based or autologous (flap) tissue techniques, each with distinct advantages and complications. [11] Implant-based reconstruction is the most performed method due to its shorter operative time and recovery period, whereas autologous reconstruction offers a more natural aesthetic result but requires longer surgical procedures and recovery time. [11] While the primary motivation for reconstruction is typically restoration of appearance and psychological, some studies suggest that surgical choice may also impact long-term survival outcomes. [12-18]

Uncertainty in Survival Outcomes and Disparities

The potential relationship between breast reconstruction and survival remains controversial. Some retrospective analyses have suggested that patients who undergo immediate breast reconstruction may experience improved overall survival compared to those who undergo mastectomy alone. [12-18] Hypothesized reasons for this association include increased postoperative surveillance, better health status of reconstruction candidates, and potential biological effects of implants or reconstructive techniques. [12-16, 18] However, other studies have found no significant survival differences between reconstructive and non-reconstructive cohorts after adjusting for confounding variables such as age, tumor stage, and comorbidities. [18-21]

Disparities in access to breast reconstruction further complicate this issue. Despite federal mandates such as the Women's Health and Cancer Rights Act (WHCRA) which requires insurance coverage for post-mastectomy reconstruction, socioeconomic and racial disparities persist. [22] Studies have shown that non-Hispanic Black women, uninsured patients, and those from lower-income backgrounds are significantly less likely to receive reconstruction compared to their White, privately insured counterparts. [22] These disparities raise critical questions regarding the impact of surgical choice not only on cosmetic and psychological outcomes but also on its impact on mortality.

Research Question and Study Justification

Given the conflicting evidence on the relationship between breast reconstruction and survival, further investigation is needed to determine whether reconstructive surgery influences long-term oncologic outcomes. Additionally, disparities in surgical decision-making warrant examination to better understand the factors contributing to differential access to reconstruction.

This study aims to assess the impact of breast reconstruction on overall survival using data from the National Cancer Database (NCDB), a comprehensive dataset capturing a large proportion of U.S. cancer cases. By leveraging a nationally representative cohort, this study will evaluate whether surgical choice is associated with survival differences while controlling for demographic and clinical confounders. Furthermore, it will examine how race, socioeconomic status, and insurance type influence access to breast reconstruction.

The following sections will provide a detailed review of prior research, outlining the current evidence on surgical choice, survival outcomes, and disparities in breast cancer treatment.

Background

Introduction to Breast Cancer

Breast cancer is the most commonly diagnosed cancer among women worldwide and represents a significant public health concern. [1] It accounts for approximately 30% of all newly diagnosed cancers and remains a leading cause of cancer-related mortality in women, with an estimated 670,000 deaths annually. [1] In the United States, breast cancer incidence has been steadily increasing at an annual rate of approximately 0.6% since the mid-2000s, making it the second most diagnosed cancer overall. [2] The rising incidence is attributed to multiple factors, including reproductive trends, increased obesity rates, and enhanced detection through widespread screening programs. [23]

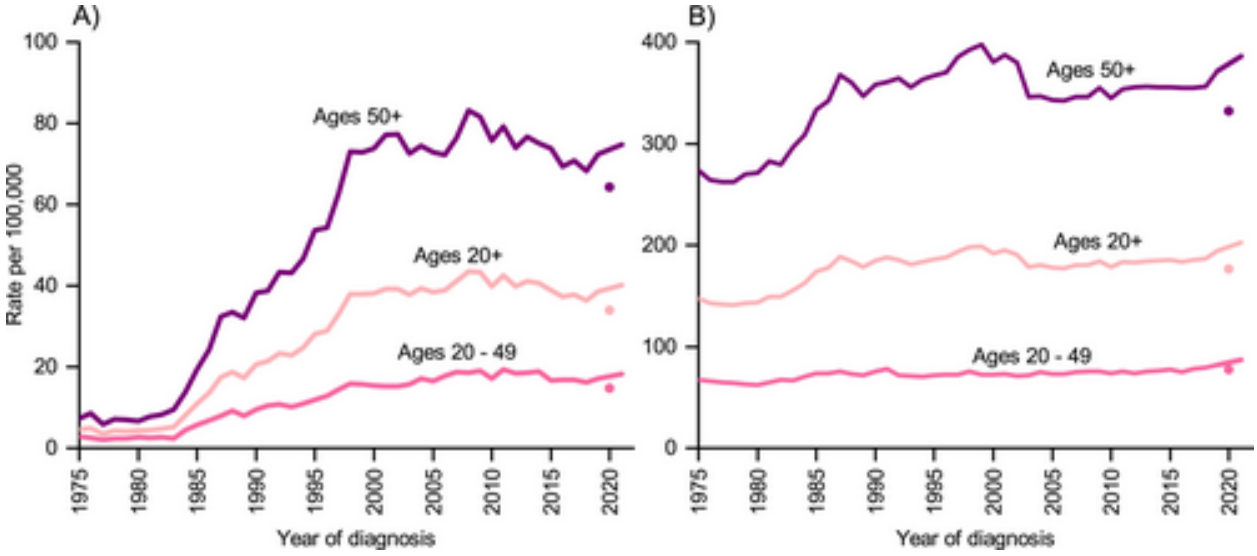

Figure 1: Age-adjusted trends in incidence rates for (A) ductal carcinoma in situ and (B) invasive breast cancer among females in the United States from 1975 to 2021. The incidence rates are standardized to the 2000 U.S. population, with adjustments made for delays in reporting invasive cases. The y-axis scales differ between the two graphs. Data for the year 2020 is displayed separately from the trend line. *(Adapted from Giaquinoto et al., 2024, licensed under CC BY-NC-ND 4.0.)*

Despite this increasing incidence, mortality rates have declined substantially due to advancements in early detection and treatment. Since 1989, breast cancer mortality in the U.S. has

decreased by approximately 44%, reflecting the impact of mammography screening, targeted therapies, and improvements in systemic treatment. [24] However, these survival gains have not been equally distributed across all populations. Black women, for instance, have a disproportionately higher mortality rate compared to White women, despite a similar or slightly lower incidence rate. [25] This disparity is influenced by multiple factors, including differences in tumor biology, stage at diagnosis, healthcare access, and treatment adherence. [26]

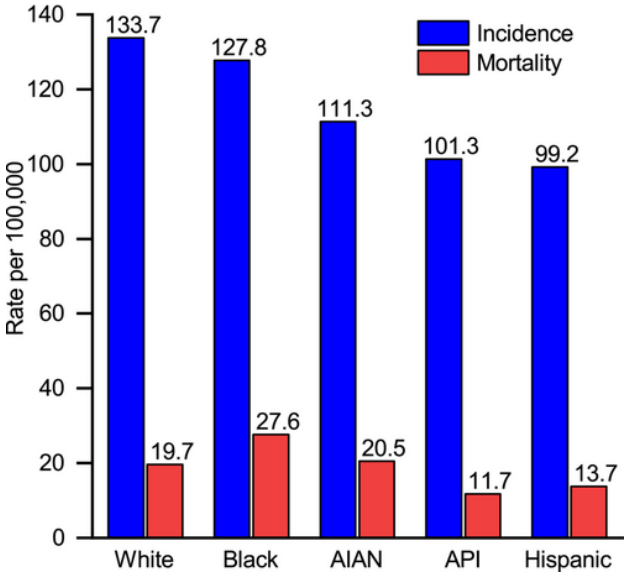

Figure 2: Comparison of breast cancer incidence and mortality rates across racial groups in the United States. While Black women have a lower diagnosis rate than White women, they experience a higher mortality rate per 100,000 individuals. *(Adapted from Giaquinoto et al., Year, licensed under CC BY-NC-ND 4.0.)*

Risk Factors for Breast Cancer

Breast cancer risk is influenced by a combination of non-modifiable biological factors and modifiable lifestyle and environmental exposures. While some individuals have an inherited predisposition due to genetic mutations, others develop the disease due to hormonal, metabolic, or environmental influences that can accumulate over a lifetime. Understanding these risk factors is important for early detection, prevention strategies, and personalized treatment approaches.

Non-Modifiable Risk Factors

Several biological and genetic factors contribute to an individual's lifetime risk of developing breast cancer. Age is one of the most significant risk factors, with incidence rising steadily as women grow older. The majority of breast cancer cases are diagnosed in women over the age of 50 years, reflecting the cumulative effect of genetic mutations and hormonal exposure over time. [27]

Family history and genetic predisposition also play a critical role in breast cancer risk. Women with a first-degree relative (mother, sister, or daughter) diagnosed with breast cancer have a significantly higher risk of developing the disease themselves, with the 10-year absolute risk of developing breast cancer reaching 14.1%. [28] Inherited mutations in the BRCA1 and BRCA2 genes dramatically increase lifetime breast cancer risk, with BRCA1 mutation carriers facing a 55-72% risk and BRCA2 mutation carriers face a 45-69% risk, compared to the general population risk of 12%. [29] Other less common genetic mutations, including those in TP53, PALB2, CHEK2, and ATM genes, also contribute to inherited susceptibility, although their impact on lifetime risk varies. [30]

Racial and ethnic differences further influence breast cancer risk and outcomes. While White women have the highest overall incidence of breast cancer, Black women are more likely to be diagnosed at younger ages and with more aggressive subtypes, such as triple-negative breast cancer (TNBC). TNBC lacks expression of estrogen receptor (ER), progesterone receptor (PR), and HER2, making it more resistant to standard hormone therapies and associated with poorer survival outcomes. [26]

In addition to genetics, hormonal and reproductive factors significantly shape breast cancer risk. Early menarche (before age 12), late menopause (after age 55), and nulliparity (never having children)

have all been associated with increased risk, likely due to prolonged lifetime exposure to endogenous estrogen and progesterone. These hormones promote cell proliferation in breast tissue, which can contribute to the development of hormone receptor-positive tumors. [31]

Modifiable Risk Factors

While genetic predisposition and biological factors are beyond an individual's control, several modifiable risk factors contribute to breast cancer development. These include obesity, hormone exposure, alcohol consumption, physical activity, and environmental exposures, all of which can be targeted through prevention efforts.

Obesity and metabolic health play a particularly important role in postmenopausal breast cancer. In overweight and obese women, adipose tissue becomes the primary source of estrogen production, increasing hormone receptor-positive breast cancer risk. [32] Additionally, obesity is linked to insulin resistance, chronic inflammation, and metabolic syndrome, all of which have been associated with tumor progression and poorer survival outcomes. [33]

Hormone replacement therapy (HRT), commonly prescribed for menopausal symptom management, has been linked to increased breast cancer risk, particularly when combined estrogen-progestin therapy is used for more than 5 years. [34, 35] However, the risk varies depending on dose, duration, and individual patient characteristics, making it a key consideration in postmenopausal healthcare decisions.

Alcohol consumption is another well-established risk factor, with a dose-dependent relationship between alcohol intake and breast cancer risk. Women who consume more than 1 – 2 alcoholic drinks

per week have an estimated 30 – 50% higher risk of developing breast cancer compared to non-drinkers. [36-39] Alcohol is thought to increase risk by raising circulating estrogen levels and generating DNA-damaging reactive oxygen species, both of which can contribute to carcinogenesis. [40]

Physical inactivity and poor diet also contribute to increased risk, with sedentary lifestyles and diets high in processed foods and saturated fats being linked to higher breast cancer incidence. [41] Conversely, regular physical activity and a diet rich in fruits, vegetables, and fiber have been associated with a reduced risk, likely due to their effects on hormone regulation, insulin sensitivity, and systemic inflammation. [42]

Finally, environmental exposures have been implicated in breast cancer risk, though evidence remains inconclusive. Endocrine-disrupting chemicals (EDCs), such as bisphenol A (BPA) and certain pesticides, have been hypothesized to interfere with hormonal regulation, potentially increasing breast cancer risk. [43] While more research is needed, concerns about chemical exposure and long-term environmental influences continue to be explored in epidemiological studies.

Pathophysiology and Molecular Subtypes of Breast Cancer

Breast cancer is a heterogeneous disease composed of unique molecular subtypes, each with biological characteristics, prognostic implications, and treatment responses. Classification of these subtypes is primarily based on the expression of hormone receptors (estrogen receptor [ER] and progesterone receptor [PR]) and human epidermal growth factor receptor 2 (HER2) status, which guide therapeutic decision-making.

The most common subtype is hormone receptor-positive (HR+) breast cancer, which is characterized by the presence of ER and/or PR expression and accounts for approximately 65-75% of all breast cancer cases. [44] These tumors tend to be less aggressive, exhibit slower progression, and respond favorably to endocrine therapy, such as tamoxifen or aromatase inhibitors, which block estrogen signaling and inhibit tumor growth. [45] Due to its typically favorable prognosis, HR+ breast cancer is often treated with a combination of endocrine therapy, chemotherapy (when indicated), and targeted agents such as CDK4/6 inhibitors in advanced disease. [46]

Another clinically significant subtype is HER2-positive (HER2+) breast cancer, which is defined by the overexpression of the HER2 protein. This subtype accounts for approximately 15-25% of breast cancer cases and was historically associated with a more aggressive clinical course and poorer prognosis. [47] However, the development of HER2-targeted therapies, including trastuzumab (Herceptin) and pertuzumab (Perjeta), has dramatically improved survival outcomes for patients with HER2+ disease. [48] These therapies work by blocking HER2-mediated signaling pathways and enhancing immune system recognition of tumor cells, leading to significant reductions in recurrence and mortality rates. [49]

Triple-negative breast cancer (TNBC) represents the most aggressive subtype, characterized by the absence of ER, PR, and HER2 expression. Accounting for approximately 15% of all breast cancer cases, TNBC is associated with high proliferation rates, early recurrence, and a lack of targeted therapies. [50] This subtype is more common in younger women and Black women and has traditionally been treated with chemotherapy alone due to the lack of hormone or HER2-directed treatment options. [51] However, recent advances in immunotherapy, particularly immune checkpoint inhibitors such as

pembrolizumab (Keytruda), have shown promise in improving outcomes for TNBC patients, especially those with PD-L1-positive tumors. [52] Despite these advancements, TNBC continues to have worse overall survival compared to other subtypes. [53]

Survival Outcomes by Stage and Subtype

Breast cancer survival is heavily dependent on **tumor stage at diagnosis** and **molecular subtype**.

• **Stage 0 (Ductal Carcinoma In Situ - DCIS):** Nearly 100% five-year survival rate due to early detection and localized disease. [24]

• **Stage I-III (Localized/Regional Disease):** Five-year survival rates range from 99% for stage I to 87% for stage III, with survival decreasing as tumor size and nodal involvement increase. [24]

• **Stage IV (Metastatic Breast Cancer - MBC):** Five-year survival remains low at approximately 32%, although advancements in systemic therapies have improved median survival times in recent years. [24]

While survival outcomes have improved dramatically over the past few decades, treatment disparities, tumor biology, and access to early detection remain critical factors affecting prognosis. Addressing these disparities and understanding the role of different surgical interventions in long-term survival are essential for improving breast cancer outcomes across all populations.

Current Treatment Approaches

Breast cancer treatment has evolved significantly over the past several decades, with a multimodal approach now serving as the standard of care. Treatment strategies are tailored based on tumor stage, molecular subtype, and patient-specific factors, incorporating combinations of surgery, systemic therapy (chemotherapy, endocrine therapy, targeted therapy), and radiation therapy. [54]

These advancements have contributed to improved survival rates, with early-stage breast cancer now having a five-year survival rate exceeding 99%. However, treatment decisions remain complex, requiring a multidisciplinary approach guided by recommendations from leading oncology organizations such as the National Comprehensive Cancer Network (NCCN), American Society of Clinical Oncology (ASCO), and the European Society for Medical Oncology (ESMO).

Overview of Breast Cancer Treatment Paradigms

Surgery

Surgical intervention remains a cornerstone of breast cancer management with an estimated 90% of women undergoing some form of surgical treatment, particularly for early-stage disease, where complete tumor removal is a critical step in achieving long-term disease control. [55] The two primary surgical approaches include breast-conserving surgery (BCS) and mastectomy, with the choice between them depending on tumor characteristics, patient preferences, and contraindications to radiation therapy. [56]

Breast-conserving surgery (BCS), also known as lumpectomy or partial mastectomy, involves the removal of the tumor while preserving as much of the breast tissue as possible. This procedure is typically followed by radiation therapy to minimize the risk of local recurrence and is preferred for patients with small, localized tumors who do not have contraindications to radiation therapy. [56] Studies have shown that BCS combined with radiation therapy provides survival outcomes comparable to mastectomy, reinforcing its role as an effective treatment option for appropriately selected patients. [57]

Mastectomy, the complete removal of one or both breasts, remains a key surgical option, particularly for patients with large tumors, multicentric disease, genetic predispositions (such as BRCA1/2 mutations), or contraindications to radiation therapy. [56] There are several variations of mastectomy, each designed to balance oncologic safety with potential reconstructive outcomes. A total (simple) mastectomy involves the removal of the entire breast without lymph node dissection, whereas a modified radical mastectomy includes axillary lymph node dissection to assess the extent of disease spread. [58] More recently, skin-sparing and nipple-sparing mastectomies have been developed, allowing for the preservation of the breast skin and/or nipple-areola complex, which facilitates improved cosmetic outcomes in patients undergoing immediate breast reconstruction. [59]

For patients electing to undergo mastectomy, breast reconstruction is an option to restore breast contour, offering both cosmetic and psychological benefits. Reconstruction can be performed using implant-based techniques or autologous tissue transfer, depending on patient preferences, anatomy, and prior treatments.

Chemotherapy

Chemotherapy plays a role in the management of early-stage, locally advanced, and metastatic breast cancer, either as a neoadjuvant (pre-surgical) or adjuvant (post-surgical) therapy. Neoadjuvant chemotherapy (NAC) is administered before surgery to downstage tumors, making previously inoperable cases resectable and increasing the likelihood of breast-conserving surgery. [60] This approach is particularly beneficial for HER2-positive and triple-negative breast cancer (TNBC), as these subtypes tend to be highly responsive to chemotherapy. [61]

Following surgical resection, adjuvant chemotherapy is used to eliminate microscopic residual disease, reducing the risk of recurrence and improving long-term survival. [62] It is typically recommended for node-positive disease, high-grade tumors, or patients identified as high-risk through genomic profiling tests, such as Oncotype DX and MammaPrint [63].

Commonly used chemotherapy regimens include anthracyclines (doxorubicin, epirubicin) and taxanes (paclitaxel, docetaxel), which are frequently combined for enhanced efficacy. Additionally, the GeparSixto clinical trial showed platinum-based chemotherapy, such as carboplatin, to be of particular effectiveness in BRCA-mutated and TNBC patients, offering increased response rates in these aggressive subtypes compared to no added carboplatin chemotherapy. [64]

Radiation Therapy and Endocrine Therapy in Breast Cancer Treatment

Radiation therapy is a key component of breast cancer treatment, particularly for patients undergoing breast-conserving surgery (BCS), where it plays a key role in eliminating residual microscopic disease and reducing local recurrence. It is also recommended in select patients after mastectomy (post-mastectomy radiation therapy, PMRT), particularly for those with tumors ≥5 cm, positive lymph nodes, or close/positive surgical margins based on the Danish Breast Cancer Cooperative Group 82b trial. [65] Additionally, regional nodal irradiation (RNI) is used for patients with ≥4 positive lymph nodes or other high-risk features, further reducing the likelihood of recurrence. [66] Recent advancements in radiation techniques, including intensity-modulated radiation therapy (IMRT) and hypofractionated regimens, have helped reduce toxicity while maintaining therapeutic outcomes. [67]

For patients with hormone receptor-positive (HR+) breast cancer, endocrine therapy is the standard of care, accounting for approximately 65 – 75% of all breast cancer cases. [44] By blocking estrogen signaling or reducing estrogen levels, endocrine therapy significantly lowers recurrence risk in both early-stage and metastatic disease. Selective estrogen receptor modulators (SERMs) such as tamoxifen are commonly prescribed for premenopausal women, preventing estrogen from binding to its receptor and stimulating tumor growth. In postmenopausal women, aromatase inhibitors (AIs), including letrozole, anastrozole, and exemestane, inhibit estrogen production by blocking the aromatase enzyme, further suppressing tumor progression. A Cochrane review has shown in high-risk premenopausal patients, ovarian suppression (OFS) with GnRH agonists (e.g., leuprolide) combined with an aromatase inhibitor improved survival outcomes. [68] The duration of endocrine therapy typically ranges from 5 to 10 years, depending on recurrence risk and patient tolerance, though a recent publican in the NEJM extending hormone therapy by 5 years provided no benefit over a 2-year extension (HR, 0.99; 95% CI, 0.85 - 1.15; P = 0.90) but was associated with a greater risk of bone fracture (HR, 1.35; 95% CI, 1.00 - 1.84). [69]

Targeted Therapies (HER2-Targeted Agents, CDK4/6 Inhibitors, PARP Inhibitors)

Targeted therapies have transformed breast cancer management by selectively inhibiting oncogenic pathways, improving survival outcomes while reducing the systemic toxicity associated with traditional chemotherapy. Among the most significant advancements is HER2-targeted therapy, which has dramatically improved prognosis for patients with HER2-positive breast cancer, a subtype that accounts for approximately 20% of cases. [70] Monoclonal antibodies such as trastuzumab (Herceptin) and pertuzumab (Perjeta) block HER2 signaling and enhance immune-mediated tumor destruction,

leading to significantly improved survival in both early-stage and metastatic disease. Additionally, HER2-targeted tyrosine kinase inhibitors (TKIs), including tucatinib, neratinib, and lapatinib, are used in metastatic settings to overcome resistance mechanisms and extend progression-free survival. [71]

How Treatment Decisions Are Made

Breast cancer treatment is personalized based on tumor stage, molecular subtype, and patient-specific factors, following guidelines established by the National Comprehensive Cancer Network (NCCN), the American Society of Clinical Oncology (ASCO), and the European Society for Medical Oncology (ESMO). The 8th edition of the American Joint Committee on Cancer (AJCC) Staging System integrates traditional anatomic staging—tumor size (T), nodal involvement (N), and distant metastasis (M)—with biological markers such as estrogen receptor (ER), progesterone receptor (PR), and HER2 status to refine prognosis and guide treatment selection. [72] Additionally, molecular profiling tools such as Oncotype DX and MammaPrint help determine the need for chemotherapy in patients with hormone receptor-positive (HR+) breast cancer, reducing unnecessary exposure to cytotoxic agents in those with a low risk of recurrence. [63]

Another important factor in treatment planning is the choice between neoadjuvant and adjuvant therapy, both of which play a role in surgical decision-making. Neoadjuvant therapy, which is administered before surgery, is frequently recommended for HER2-positive and triple-negative breast cancer (TNBC) patients, as it helps shrink tumors, facilitates breast-conserving surgery, and provides an early assessment of treatment response. Conversely, adjuvant therapy, given after surgical resection, is aimed at eliminating residual microscopic disease and reducing the risk of recurrence. The decision

between neoadjuvant and adjuvant therapy depends on a combination of tumor size, nodal involvement, response to systemic treatments, and shared decision making between the provider and patient. [73]

Surgical Approaches to Breast Cancer Treatment

The surgical management of breast cancer has undergone significant transformation over the past century, evolving from highly invasive procedures to more conservative, patient-centered approaches. Historically, surgical treatment was based on the assumption that more extensive tissue removal led to better outcomes, but advancements in cancer biology and clinical trials have demonstrated that less radical procedures can achieve equivalent survival rates while preserving function and aesthetics. [74] Today, the choice between mastectomy and breast-conserving surgery (BCS)—as well as the option of breast reconstruction—depends on a combination of tumor characteristics, genetic predisposition, and patient preferences. The following section explores the historical evolution of breast cancer surgery, outlining the shift toward more personalized, evidence-based surgical approaches.

Historical Evolution of Breast Cancer Surgery

The approach to breast cancer surgery has transitioned from highly invasive procedures aimed at removing as much tissue as possible to more refined, oncologically safe techniques that prioritize patient outcomes and quality of life.

The radical mastectomy, introduced by William Halsted in the late 19th century, represented the first standardized surgical treatment for breast cancer. This procedure involved the complete

removal of the breast, underlying pectoralis major and minor muscles, and axillary lymph nodes, following the centrifugal theory of cancer spread, which suggested that aggressive local control would prevent distant metastasis. [75, 76] While radical mastectomy effectively reduced local recurrence rates, it also resulted in severe physical disfigurement, functional impairment, and psychological distress, leading to a decline in its use as less aggressive alternatives emerged. [77, 78]

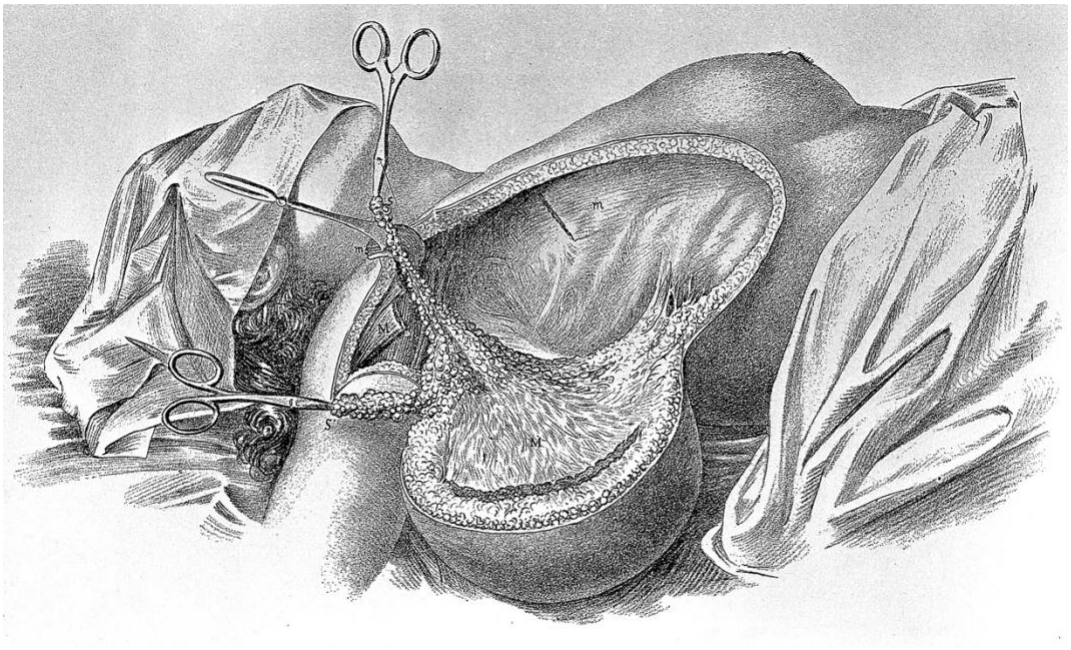

Figure 3: Depiction of Halsted mastectomy (*licensed under CC BY-NC-ND 4.0)*

By the mid-20th century, growing evidence suggested that removing the chest wall muscles was unnecessary for most patients, leading to the development of the modified radical mastectomy (MRM). This procedure preserved the pectoralis muscles while still including axillary lymph node dissection, reducing the morbidity associated with radical mastectomy while maintaining effective oncologic

control. [79] The MRM became the standard of care for several decades, offering patients a less debilitating surgical option without compromising survival outcomes.

Further advancements in clinical research eventually led to the introduction of breast-conserving surgery (BCS) as an alternative to mastectomy. The landmark National Surgical Adjuvant Breast and Bowel Project (NSABP) B-06 trial provided compelling evidence that lumpectomy followed by radiation therapy offered survival outcomes equivalent to mastectomy in early-stage breast cancer when looking at patients over a 25 year period (HR 1.05, 95% 0.90 to 1.23). [74] This finding marked a shift in breast cancer treatment, increasing the adoption of BCS, particularly for patients with small, localized tumors and no contraindications to radiation therapy.

Current Surgical Options

Mastectomy vs. Breast-Conserving Surgery (Lumpectomy + Radiation)

Mastectomy and breast-conserving surgery (BCS) remain the two primary surgical options for breast cancer treatment, with the decision between them influenced by tumor characteristics, patient preferences, and eligibility for radiation therapy. Mastectomy involves the complete removal of the breast and is typically performed when the tumor is too large relative to breast size to allow for a cosmetically acceptable BCS outcome. It is also recommended in cases of multicentric disease, where tumors are present in multiple quadrants of the breast, or when radiation therapy is contraindicated due to prior irradiation or specific comorbidities. [56]

In contrast, BCS, also known as lumpectomy, is preferred for patients with small, localized tumors who can undergo post-operative radiation therapy to minimize the risk of recurrence. Extensive

research has demonstrated that BCS followed by radiation therapy provides survival rates equivalent to mastectomy, reinforcing its oncologic safety as an alternative to total breast removal. Additionally, some studies suggest that patients undergoing BCS experience superior psychological and quality-of-life outcomes, including lower distress levels and improved body image, compared to those who undergo mastectomy. [80-83]

For patients opting for mastectomy, breast reconstruction may be considered to restore breast contour, using either implant-based or autologous techniques.

Breast Reconstruction Options

Breast reconstruction can be performed immediately at the time of mastectomy or delayed until after adjuvant therapy, depending on patient preference, tumor characteristics, prior treatments, and the availability of reconstructive expertise. The two primary approaches to reconstruction are implant-based reconstruction and autologous (flap-based) reconstruction, each with distinct advantages and considerations.

Implant-Based Reconstruction

Implant-based reconstruction is the most commonly performed method, involving the placement of a silicone or saline implant to recreate the breast mound. [84] In patients with good skin preservation, such as those undergoing nipple-sparing or skin-sparing mastectomy, a direct-to-implant approach allows for immediate placement of the implant at the time of mastectomy, minimizing the need for additional surgeries. [85] However, in cases where more gradual expansion of the skin is needed, a two-stage expander reconstruction is performed, in which a temporary tissue expander is placed first and later replaced with an implant. [86]

While implant-based reconstruction is less invasive and requires shorter operative times compared to autologous reconstruction, it carries risks related to implants such as capsular contracture, implant rupture, infection, and the potential need for revision surgeries over time, especially because implants are not lifetime devices. [11] Capsular contracture, affecting up to 13% of patients within three years of prosthetic reconstruction is influenced by risk factors such as radiation, smoking, hematoma, infection, and silicone rupture. [87]

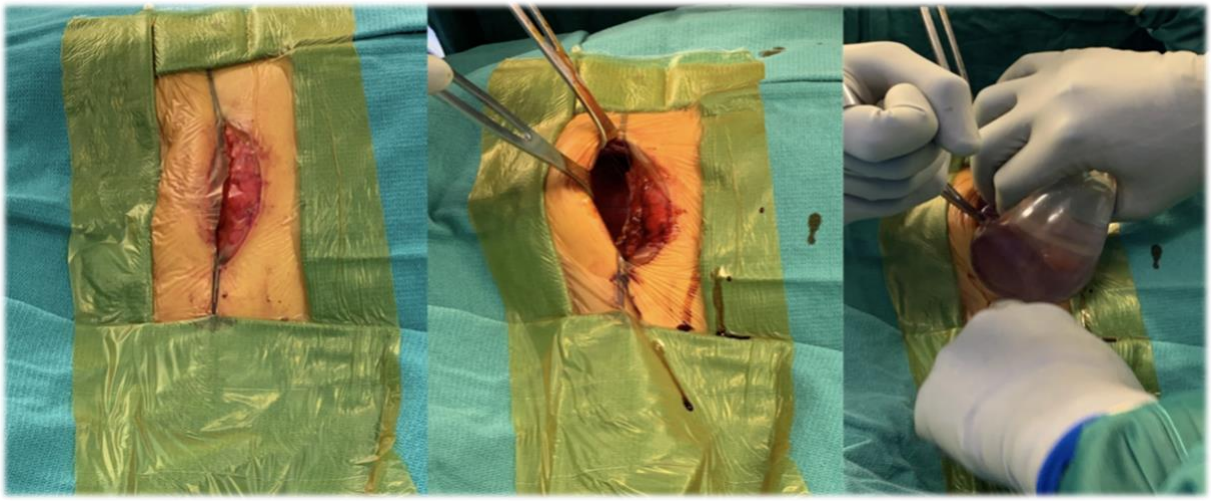

Figure 4: Implant based breast reconstruction, with a prosthesis being placed in the breast pocket (*Adapted from Brown et al., 2023, with permission*)

Autologous (Flap-Based) Reconstruction

Autologous reconstruction uses the patient's own tissue from another part of the body to reconstruct the breast mound, often preferred by patients seeking a more natural appearance or those who wish to avoid implants. This method usually involves microsurgical transfer of tissue, with several commonly used techniques:

• The transverse rectus abdominis myocutaneous (TRAM) flap harvests skin, fat, and muscle from the lower abdomen, providing a robust volume of tissue for reconstruction but carrying a risk of abdominal wall weakness and hernia formation. [88]

• The deep inferior epigastric perforator (DIEP) flap is similar to the TRAM flap but spares the abdominal muscle, reducing complications such as hernia and muscle weakness while maintaining the benefits of using autologous abdominal tissue. [89, 90]

• The latissimus dorsi flap involves transferring muscle and skin from the back, often combined with an implant to achieve the desired breast volume. This technique is frequently used when abdominal tissue is unavailable or in patients requiring additional soft-tissue coverage. [91]

Although autologous reconstruction provided superior aesthetic outcomes and long-term durability in a systematic review (45% of studies), it requires longer operative times, extended recovery periods, and access to microsurgical expertise, making it a more complex procedure compared to implant-based approaches. [92]

Survival Outcomes & Surgical Choice

Surgical choice plays a critical role in long-term survival outcomes for patients with breast cancer, with ongoing debate regarding the relative benefits of mastectomy, breast-conserving therapy (BCT), and breast reconstruction. While BCT with radiation therapy has been shown to offer survival rates comparable to mastectomy in appropriately selected patients, the question of whether breast reconstruction following mastectomy impacts oncologic outcomes remains unresolved. Some studies suggest a survival advantage with reconstruction, potentially due to factors such as better post-treatment surveillance and improved psychosocial well-being, while others find no significant difference

when adjusting for confounders. This section reviews comparative survival outcomes associated with different surgical approaches and explores the conflicting evidence regarding reconstruction's impact on survival.

Comparative Survival Outcomes of Different Surgical Procedures

Mastectomy vs. Breast-Conserving Therapy (BCT)

Breast-conserving therapy (BCT), which consists of lumpectomy followed by radiation therapy, is an established alternative to mastectomy for patients with early-stage breast cancer. The landmark NSABP B-06 trial was among the first to show no significant difference in long-term survival between BCT and mastectomy, leading to widespread adoption of breast-conserving approaches. [74]

Subsequent population-based studies have reinforced these findings, with some suggesting that BCT may even offer a survival advantage over mastectomy. [93-96] Additionally, in the 02-98 clinical trial by the Breast International Group, patients undergoing mastectomy without radiation may experience higher locoregional recurrence rates, particularly in node-positive disease, which could contribute to worse long-term outcomes. [97]

Despite these findings, BCT is not suitable for all patients. Tumor size, multifocality, contraindications to radiation, and patient preference play key roles in determining the appropriate surgical approach. Some patients, particularly those with BRCA mutations or high-risk features, may opt for mastectomy as a risk-reducing strategy with one study showing no primary BCs occurred after a prophylactic mastectomy (PM) (median follow-up 4.5 years). [98]

Mastectomy Alone vs. Mastectomy with Reconstruction

For patients undergoing mastectomy, the decision to pursue immediate or delayed breast reconstruction has traditionally been viewed as a cosmetic and psychological consideration rather than one affecting survival outcomes. However, emerging evidence suggests that reconstruction may confer a survival benefit, potentially due to improved postoperative care, enhanced surveillance, and better patient selection.

A 2021 retrospective cohort study from the University of California San Diego, involving 474 breast cancer patients, found a significant survival advantage for those who underwent breast reconstruction (both autologous and implant-based) compared to those who had mastectomy alone. The adjusted hazard ratio (aHR) for overall survival in the reconstructive cohort was 0.47 (95% CI, 0.25 to 0.88), indicating a nearly 53% reduction in mortality risk. [13] Similarly, a 2009 SEER database study by Bezuhly et al., which included over 50,000 patients, reported a breast cancer-specific survival (BCSS) benefit in those undergoing immediate breast reconstruction, with an aHR ranging from 0.66 to 0.75 across different age groups, suggesting a consistent protective effect. [14]

A 2012 study from the University of Utah, analyzing another 50,000 SEER database patients, found that patients undergoing mastectomy with reconstruction had a significantly lower adjusted hazard of death (HR 0.73, 95% CI 0.66-0.81) compared to those who had mastectomy alone. [15] Additionally, a Swedish study of 983 patients demonstrated a survival advantage specifically for autologous tissue reconstruction, reporting an aHR of 0.44 (95% CI, 0.28 to 0.69) for overall survival and 0.55 (95% CI, 0.34-0.92) for breast cancer-specific survival in patients receiving DIEP flap reconstruction. [16] A separate study assessing TRAM flap reconstruction similarly found a significant reduction in

mortality risk, with a reported relative risk (RR) of 0.54 (P = 0.03), although inconsistencies in reporting (e.g., use of RR instead of HR) warrant careful interpretation of results. [17]

Further supporting these findings, a 2023 study by Wu et al., analyzing 27,893 SEER database patients, found a significant survival benefit for autologous breast reconstruction (ABR) following mastectomy, with an adjusted hazard ratio (aHR) of 0.83 (95% CI, 0.74 to 0.94) for overall survival. [18] These results suggest that patients who undergo autologous reconstruction may experience improved survival compared to those undergoing mastectomy alone, although the underlying mechanisms remain unclear.

Conflicting Evidence on Reconstruction and Survival

Despite multiple studies suggesting a survival advantage associated with breast reconstruction, others have found no significant difference in outcomes when controlling for confounders such as age, tumor stage, and comorbidities.

The same 2023 study by Wu et al., which reported a survival benefit for autologous reconstruction, also found no significant difference in breast cancer-specific survival (BCSS) after adjusting for confounders (aHR 0.93, 95% CI, 0.82 to 1.07). [18] Similarly, a 2022 study by Xiong et al., analyzing 6,002 SEER patients, initially found improved unadjusted survival in the reconstruction group but later failed to detect a significant difference after adjusting for key covariates (BCSS P = 0.143, OS P = 0.272). [19]

A 2013 study from Fudan University, using a 35,126-patient SEER cohort, suggested that the survival benefit of reconstruction may be driven by socioeconomic factors rather than surgical intervention itself. While their initial multivariate analysis showed improved BCSS (HR = 0.87, 95% CI 0.80–0.95, P = 0.001) and OS (HR = 0.70, 95% CI 0.65–0.75, P < 0.001) in reconstructed patients, further stratification by income level revealed that the survival benefit was primarily observed in higher-income groups (BCSS HR = 0.85, 95% CI 0.73–0.99, P = 0.034). [21] These findings suggest that healthcare access, insurance status, and socioeconomic disparities may play a significant role in determining both surgical choice and survival outcomes.

Additional evidence from a 2018 SEER-based study by Wu et al., which analyzed 1,732 matched pairs of locally advanced breast cancer patients, found no overall survival benefit associated with immediate breast reconstruction. [20] However, they did identify a potential age-dependent effect, where patients under 50 experienced a survival benefit (HR = 0.750 for BCSS, HR = 0.779 for OS), whereas older patients did not. This suggests that age and treatment tolerance may influence the impact of reconstruction on survival.

Taken together, these studies indicate that while some observational data suggest a survival benefit with reconstruction, others fail to confirm a consistent oncologic advantage after adjusting for confounders. The variability in study methodologies, patient selection criteria, and statistical adjustments highlights the need for prospective, randomized trials to definitively determine whether breast reconstruction influences survival or whether observed differences are due to selection bias and healthcare disparities.

Disparities in Breast Cancer Surgery & Reconstruction

Despite advancements in breast cancer treatment and reconstruction, significant disparities persist in access to surgical care, particularly among racial and ethnic minorities, lower-income patients, and those with limited healthcare access. Research has consistently demonstrated that Black, Hispanic, and uninsured women are less likely to undergo breast reconstruction after mastectomy, even when adjusting for clinical factors such as tumor stage and treatment eligibility. [99] These disparities are influenced by a complex interplay of socioeconomic status, insurance coverage, institutional differences, and patient-level barriers, all of which contribute to inequities in breast cancer surgical outcomes. It is crucial to understand how the interplay of social factors impact access to care for developing targeted interventions to improve equitable access to reconstruction and ensuring that all patients receive optimal oncologic and quality-of-life outcomes.

Racial and Ethnic Disparities in Breast Reconstruction

Numerous studies have documented racial and ethnic disparities in breast reconstruction rates. A 2019 study by Restrepo et al., using National Cancer Database (NCDB) data, found that White patients and those with private insurance were significantly more likely to receive breast reconstruction compared to Black patients and those with government insurance. The odds ratio (OR) for reconstruction was 0.94 for Black patients and 0.46 for those with government-sponsored insurance, highlighting a substantial disparity in surgical access. [100]

Similarly, a 2022 study by Danko et al., also leveraging NCDB data, confirmed these findings, showing that younger patients, those diagnosed at earlier tumor stages, and individuals residing in

urban areas were more likely to undergo immediate breast reconstruction. [101] These findings suggest that geographic location and stage at diagnosis may further compound racial disparities, as Black and Hispanic patients are more likely to present with later-stage disease, which can limit reconstruction options. [102]

Further supporting these trends, a large SEER database study by Sergesketter et al., which included 346,418 breast cancer patients from 1998 to 2014, found that non-Hispanic Black and Hispanic women were significantly less likely to undergo immediate reconstruction following mastectomy compared to non-Hispanic White women ($OR < 1$, $p < 0.05$). [102] Interestingly, when comparing autologous versus implant-based reconstruction, non-Hispanic White patients underwent autologous reconstruction at lower rates than Black and Hispanic women, suggesting potential differences in reconstructive preferences, access to microsurgical expertise, or institutional recommendations.

Despite these disparities, the study by Sergesketter et al. also noted that reconstruction rates have increased over time among all racial groups, with Black and Hispanic women showing a higher per-year increase in reconstruction rates compared to non-Hispanic White women. [102] This trend indicates that while racial gaps in access persist, efforts to improve reconstruction equity may be gradually reducing disparities.

Interestingly, a 2016 single-institution study by Sharma et al. reported that non-Hispanic Black women were more likely than non-Hispanic White women to receive autologous reconstruction, with an odds ratio of 2.23. [103] While this finding appears to contradict broader national trends, it suggests

that individual institutional factors, patient preferences, and availability of microsurgical expertise may influence reconstructive choices.

Socioeconomic Disparities in Breast Reconstruction

Beyond racial and ethnic differences, socioeconomic status (SES) plays a major role in determining access to breast reconstruction. Several studies have demonstrated that lower-income patients, those with lower educational attainment, and those living in rural areas are significantly less likely to receive reconstruction.

The 2019 NCDB study by Restrepo et al. found that patients residing in higher-income zip codes (OR = 1.87) or with higher educational levels had increased odds of undergoing reconstruction. [100] Similarly, the 2013 Fudan University study, using a SEER-based cohort of 35,126 patients, found that while immediate reconstruction was associated with improved survival, this benefit was largely observed in higher-income patients (HR = 0.85, 95% CI 0.73–0.99, P = 0.034). [21] This suggests that financial and systemic barriers may prevent lower-income patients from accessing reconstructive options.

Insurance status is one of the strongest predictors of reconstruction access. Patients with private insurance are significantly more likely to undergo immediate or delayed reconstruction compared to those on Medicaid or uninsured patients. [104] Although the Women's Health and Cancer Rights Act (WHCRA) was enacted to mandate insurance coverage for post-mastectomy reconstruction,

disparities remain in implementation and accessibility, particularly among lower-income and minority patients.

Summary of Knowledge Gaps & Study Justification

Despite significant advancements in breast cancer treatment, the impact of surgical choice on overall survival remains uncertain. While mastectomy and breast-conserving therapy (BCT) have been shown to have comparable survival outcomes in early-stage disease, the role of breast reconstruction in modifying survival after mastectomy is less clear. Some studies suggest that reconstruction is associated with improved survival, while others find no significant difference after adjusting for confounders.

To address these knowledge gaps, this study will evaluate whether breast reconstruction following mastectomy impacts overall survival and whether differences persist after controlling for tumor stage, comorbidities, and socioeconomic factors.

Thesis Specific Aim & Hypotheses

Specific Aim: To compare the overall survival among a reconstructed vs. non-reconstructed cohort when adjusting for age, stage at diagnosis, and other potential confounders and effect modifiers.

Hypothesis: There will be a difference in overall survival between the two cohorts when relevant confounders and effect modifiers are considered.

To investigate these research questions, this study will use a retrospective cohort design with data from the National Cancer Database (NCDB). The following section outlines the study design, patient selection criteria, and statistical methodologies used to evaluate the impact of surgical choice on survival outcomes.

Methods:

Study Design and Data Source

This study is a retrospective cohort analysis utilizing data from the National Cancer Database (NCDB), a hospital-based registry jointly maintained by the American College of Surgeons (ACS) and the American Cancer Society (ACS). The NCDB captures approximately 70% of all newly diagnosed cancer cases in the United States through over 1,500 Commission on Cancer (CoC)-accredited facilities. Data are extracted from medical records, pathology reports, and physician follow-ups by Certified Tumor Registrars (CTRs) following standardized protocols. Before inclusion in the dataset, hospitals perform internal quality checks, and the NCDB applies automated validation techniques to detect missing values, errors, and inconsistencies. [105, 106] Additionally, the NCDB tracks overall survival (OS) through annual hospital follow-ups, physician reports, and cross-referencing with the Social Security Death Index (SSDI) and National Death Index (NDI). [107]

Study Population and Patient Selection

The study cohort included women aged 18-80 years diagnosed with stage 0 to stage 3 breast cancer who underwent mastectomy with or without breast reconstruction between 2010 and 2017. These inclusion criteria were selected to reflect a representative patient population undergoing curative-intent treatment, while patients outside this age range were excluded to eliminate outliers with non-representative clinical courses.

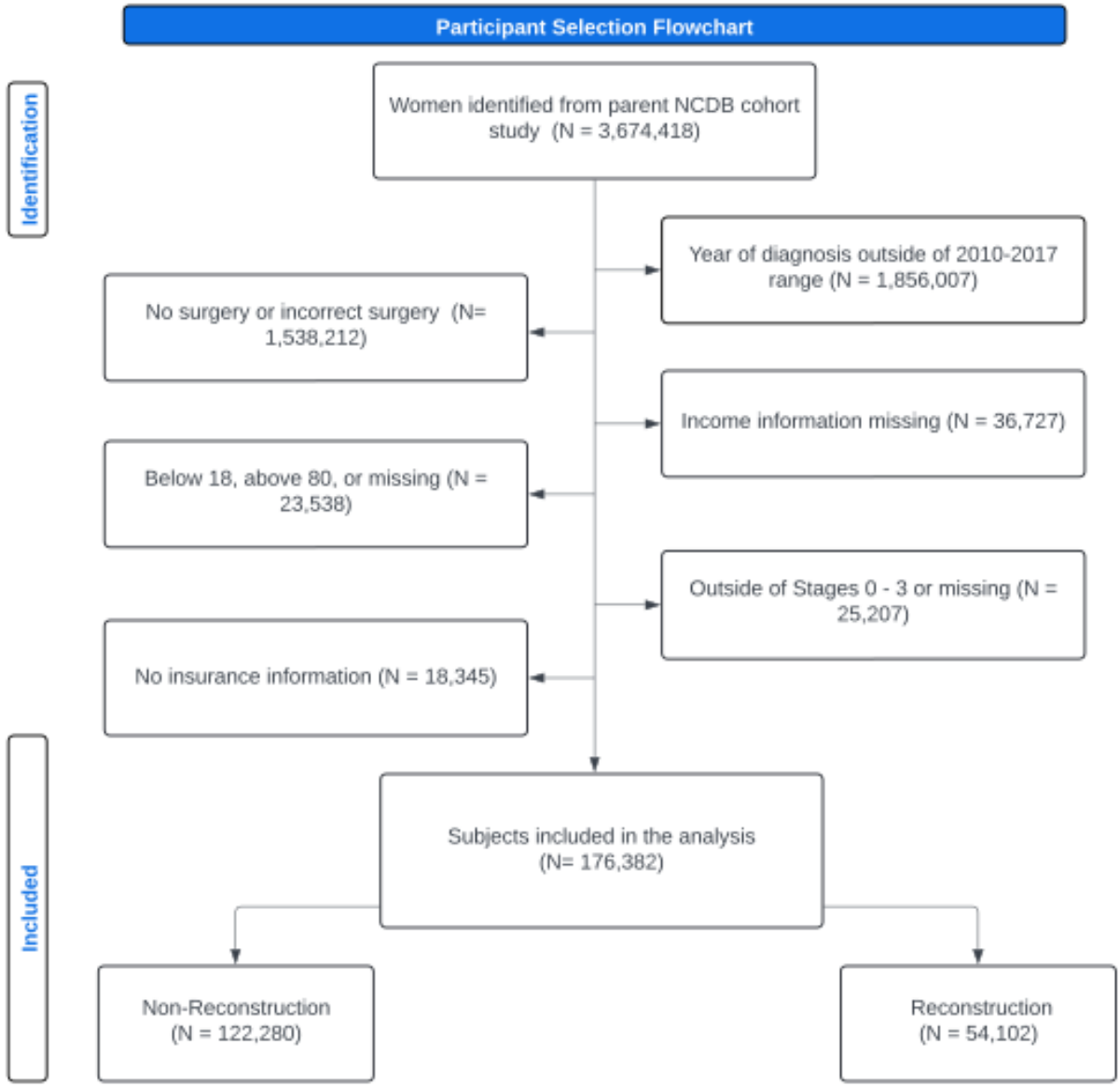

Figure 5: *The selection process for the study cohort from the National Cancer Database (NCDB). Of 3,674,418 women, exclusions were made for diagnosis outside 2010–2017, missing income or insurance data, age outside 18–80, stage IV or missing stage, and incorrect surgical coding. The final cohort included 176,382 women, with 122,280 (69.3%) undergoing mastectomy alone and 54,102 (30.7%) receiving reconstruction.*

Exclusion criteria included male patients, pregnant patients, and individuals diagnosed with stage 4 (metastatic) breast cancer, as metastatic disease represents a distinct clinical entity with different treatment objectives. Additionally, patients with missing insurance or income data were excluded to maintain consistency in socioeconomic analyses. Patients with missing vital status data were also removed to ensure accuracy in survival estimates. The final study cohort was derived after applying these criteria, as illustrated in Figure 5 (Patient Selection Flowchart).

Exposure and Outcome Definition

The primary exposure variable was surgical choice, categorized as:

1) Mastectomy without reconstruction (reference group)
2) Mastectomy with reconstruction, consisting of implant-based and autologous reconstruction.

Surgical categories were defined using the National Cancer Database's standardized codes from the 2020 Participant User File (PUF) Data Dictionary. All cases were classified under the malignant breast cancer codes C50.0–C50.9. Individual procedures were designated using appended surgical codes. Mastectomy without reconstruction included Code 41 (C50.41), Code 51 (C50.51), and Code 61 (C50.61), representing total, modified radical, and radical mastectomies, respectively—each performed without removal of the uninvolved contralateral breast.

Mastectomy with reconstruction was further subclassified into:

- Implant-based reconstruction: Code 45 (C50.45), Code 55 (C50.55), and Code 66 (C50.66)
- Autologous (tissue-based) reconstruction: Code 44 (C50.44), Code 54 (C50.54), and Code 65 (C50.65).

However, the NCDB does not specify whether the reconstruction was immediate or delayed. Thus, all patients who underwent reconstruction were analyzed together, without distinction by timing. Patients with missing or ambiguous surgical codes were excluded.

The primary outcome was overall survival (OS), defined as the time from surgery to death or last follow-up. Patients who were alive at last follow-up were right-censored.

Variables

To facilitate statistical analysis, several variables were recoded and categorized:

Age at diagnosis was grouped into five strata: 18–30, 31–40, 41–50, 51–65, and 66–80 years to assess age-related trends in surgical choice and survival. Age strata were selected to align with commonly used groupings in breast cancer statistics reports while maintaining a distribution that allows for proper statistical power and meaningful comparisons. Stage classification followed the AJCC 7th edition, with stages harmonized into stage 0, stage 1 (1A, 1B), stage 2 (2A, 2B), and stage 3 (3A, 3B, 3C). This study adhered to AJCC 7th edition staging to ensure consistency across the study period, as the 8th edition—implemented after 2017—incorporates hormone receptor status into staging. Since breast cancer stage was defined differently in the 8th edition, including data beyond 2017 would introduce inconsistencies in stage classification, making direct comparisons unreliable. By restricting the study window to 2010–2017, we ensured that all cases were staged using the same criteria, preventing misclassification due to changes in staging definitions.

Race and ethnicity were categorized into four mutually exclusive groups for analysis: Non-Hispanic White, Black, Hispanic, and Asian. Non-Hispanic White patients were defined as those

identified as White with no indication of Hispanic ethnicity. Black patients included all individuals identified as Black, regardless of Hispanic background, to capture both non-Hispanic and Afro-Latino populations. Hispanic patients included individuals identified as Hispanic, regardless of whether they were also identified as White or had an unclassified race. Asian patients included individuals identified with Asian or Pacific Islander backgrounds. To maintain consistency and avoid misclassification, individuals with missing or unknown race and Hispanic ethnicity were excluded from the analytic sample. Insurance status was collapsed into three categories: Uninsured/Medicaid, Private Insurance, and Medicare/Other Government Insurance. Radiation therapy was classified as no radiation or received radiation.

The Charlson-Deyo Comorbidity Index (CCI) is a validated tool used to quantify a patient's comorbidity burden and predict mortality risk. Originally developed by Charlson et al. in 1987 to estimate 1-year mortality based on 19 weighted comorbid conditions, the index was later adapted for use with administrative data by Deyo and Romano through the incorporation of ICD-9-CM and CPT-4 codes. A cancer-specific adaptation, known as the NCI Comorbidity Index, was developed using SEER-Medicare data, excluding cancer-related diagnoses from the score to avoid overlap with the primary disease. In 2014, the index underwent further refinement to improve diagnostic coding accuracy, including updates to ICD codes and evaluation of CPT-4 contributions. The version used in this study—Charlson-Deyo—applies standardized weights (1, 2, 3, or 6) to 17 comorbid conditions, with higher scores reflecting greater comorbidity burden and worse prognosis. [108] A time-to-event variable was created, representing survival time in months.

Directed Acyclic Graph (DAG) and Confounder Selection

A Directed Acyclic Graph (DAG) was constructed to identify potential confounders in the relationship between surgical choice and survival outcomes. Confounders identified through DAG analysis, including age, stage at diagnosis, race/ethnicity, insurance status, and comorbidities (Charlson Comorbidity Index), were adjusted for in the multivariable models. The DAG is presented in Figure 6.

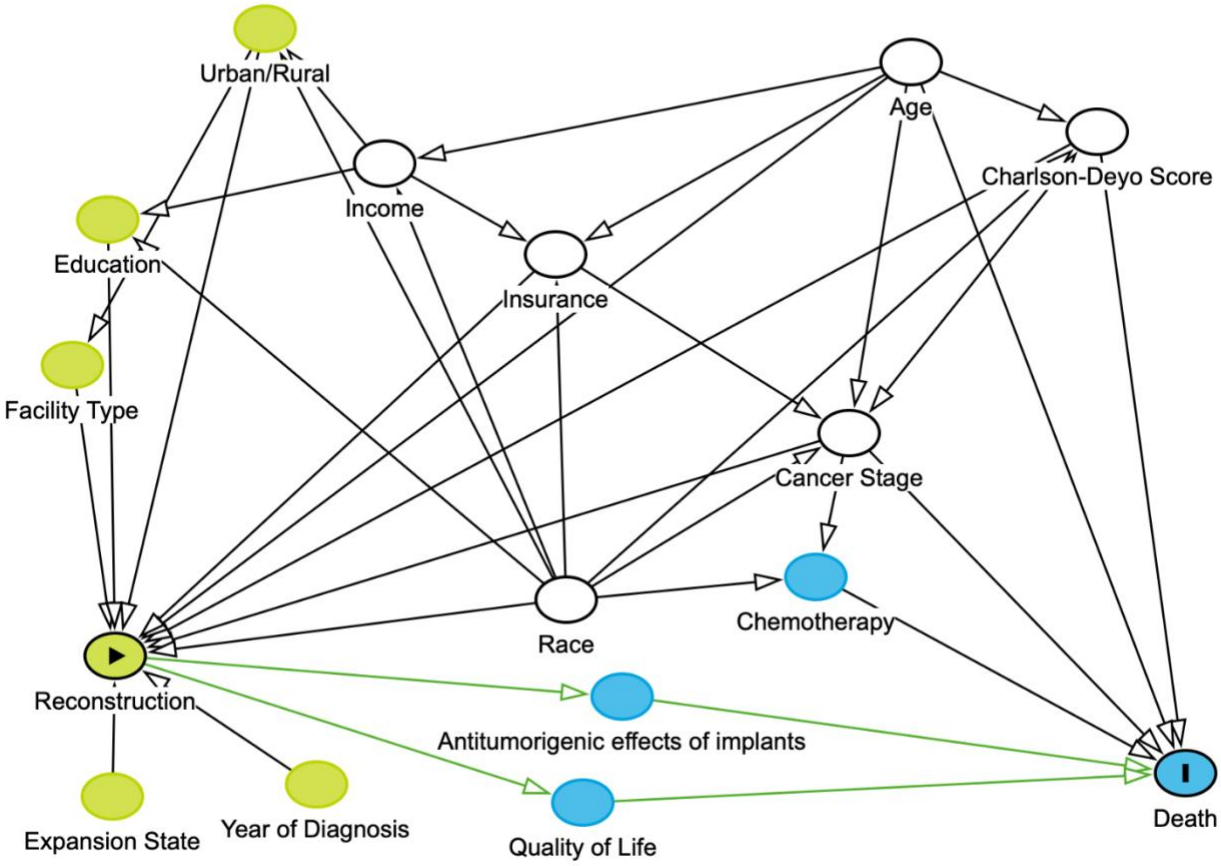

Figure 6: *Proposed Directed Acyclic Graph (DAG) for the Cox proportional hazards model, outlining the relationships between breast reconstruction (exposure) and overall survival (outcome). White nodes represent confounders adjusted in the model (e.g., age, comorbidities, cancer stage, race, and insurance). Blue nodes indicate mediators (e.g., chemotherapy, quality of life, and potential antitumorigenic effects of implants), which lie on the causal pathway. Green nodes are pre-exposure*

(ancestor) variables (e.g., facility type, education, and geographic factors) that influence reconstruction likelihood but do not directly affect survival. This DAG guides confounder selection with the goal of an unbiased estimation of surgical choice on survival.

Statistical Analysis

Baseline patient characteristics were summarized using means, medians, and proportions. Differences in categorical variables were assessed using chi-square tests, and continuous variables were compared using t-tests. Survival curves were generated using Kaplan-Meier estimates, with differences between groups evaluated via the log-rank test.

Survival curves were generated using Kaplan-Meier estimates, with differences assessed using the log-rank test. The association between surgical choice and overall survival was first examined in a univariable Cox proportional hazards model, followed by a multivariable Cox model adjusting for confounders.

The **Cox proportional hazards model** was defined as follows:

$$h(t)=h0(t)\exp(\beta_1\cdot\text{Recon}+\beta_2\cdot\text{Recon}\cdot\text{Time}+\beta_3\cdot\text{Age}\cdot\text{Time}+\beta_4\cdot\text{AgeStrata}_1+\beta_5\cdot\text{AgeStrata}_2+\beta_6\cdot\text{AgeStrata}_3+\beta_7\cdot\text{AgeStrata}_4+\beta_8\cdot\text{Stage}\cdot\text{Time}+\beta_9\cdot\text{Stage}_1+\beta_{10}\cdot\text{Stage}_2+\beta_{12}\cdot\text{Stage}_3+\beta_{13}\cdot\text{Race}_1+\beta_{14}\cdot\text{Race}_2+\beta_{15}\cdot\text{Race}_3+\beta_{16}\cdot\text{Comobid}_1+\beta_{17}\cdot\text{Comorbid}_2+\beta_{18}\cdot\text{Comorbid}_3+\beta_{19}\cdot\text{Insure}_1+\beta_{20}\cdot\text{Insure}_2+\beta_{21}\cdot\text{Income}_1+\beta_{22}\cdot\text{Income}_2+\beta_{23}\cdot\text{Income}_3)$$

Figure 7: *Equation of the Cox-Proportional Hazards model.*

where h(t) represents the hazard at time t, $h0(t)$ is the baseline hazard, X_n are covariates, and β_n are the corresponding regression coefficients.

The proportional hazards assumption was assessed using Schoenfeld residuals for all variables included in the model. Variables that violated the assumption were modeled using time-dependent covariates in an extended Cox model.

To evaluate effect modification and explore subgroup-specific trends, stratified analyses were performed by cancer stage (0–III), age, race/ethnicity, and Charlson-Deyo Comorbidity Index. These variables were chosen a priori due to their clinical significance and established associations with treatment access and survival. Proportionality was tested within each stratum, and time covariates were incorporated where appropriate.

Overall survival (OS) was defined as the time in months from surgery to death or last follow-up, with patients still alive at last contact considered right-censored.

Software and Ethical Considerations

Statistical analysis was conducted using SAS statistical software (version 9.4; SAS Institute Inc, Cary, NC) and SAS macros developed by the Biostatistics and Bioinformatics Shared Resources at Winship Cancer Institute at Emory University in Atlanta, Georgia. [109] Figures we also created using R 4.3.2 (R Core Team, 2025). Since the NCDB consists of de-identified patient data, informed consent was not required.

Results:

Table 1: Baseline Characteristics of the Study Population

Variable	Level	N (%) = 176,382
Facility Type	Community Cancer Program	12011 (7.1)
	Comprehensive Community Cancer Program	72137 (42.7)
	Academic/Research Program	51558 (30.5)
	Integrated Network Cancer Program	33233 (19.7)
	Missing	7443
Facility Location	New England	7961 (4.7)
	Middle Atlantic	24504 (14.5)
	South Atlantic	39305 (23.3)
	East North Central	28548 (16.9)
	East South Central	11181 (6.6)
	West North Central	13578 (8.0)
	West South Central	14837 (8.8)
	Mountain	6342 (3.8)
	Pacific	22683 (13.4)
	Missing	7443
Race	White	128057 (72.6)
	Black	22022 (12.5)
	Hispanic	9307 (5.3)
	Asian	16996 (9.6)

Table 1: Baseline Characteristics of the Study Population

Variable	Level	N (%) = 176,382
Insurance Status	Not Insured	4978 (2.8)
	Government Insurance	75373 (42.7)
	Private Insurance	96031 (54.4)
Charlson-Deyo Score	0	139977 (79.4)
	1	27794 (15.8)
	2	6065 (3.4)
	>= 3	2546 (1.4)
AJCC 7th Edition Cancer Stage	Stage 0	33630 (19.1)
	Stage I	65830 (37.3)
	Stage II	57868 (32.8)
	Stage III	19054 (10.8)
Vital Status	Dead	32505 (18.4)
	Alive	143877 (81.6)
Median Income Quartiles 2016-2020	< $46,277	27828 (15.8)
	$46,227-$57,856	36935 (20.9)
	$57,857-$74,062	41347 (23.4)
	>= $74,063	70272 (39.8)
Percent No High School Degree Quartiles 2016-2020	>= 15.3%	34915 (19.8)
	9.1%-15.2%	48270 (27.4)
	5.0%-9.0%	51335 (29.1)
	< 5.0%	41862 (23.7)

Table 1: Baseline Characteristics of the Study Population

Variable	Level	N (%) = 176,382
Age by Strata	18 - 30	1041 (0.6)
	31 - 40	8205 (4.7)
	41 - 50	28259 (16.0)
	51 - 65	69069 (39.2)
	66 - 80	69808 (39.6)

The study cohort consisted of 176,382 patients who underwent mastectomy with or without reconstruction (Table 1). The majority were treated at Comprehensive Community Cancer Programs (42.7%), followed by Academic/Research Programs (30.5%) and Integrated Network Cancer Programs (19.7%). A smaller proportion received treatment at Community Cancer Programs (7.1%). Geographic distribution varied, with the highest proportion of patients located in the South Atlantic region (23.3%), followed by the East North Central (16.9%) and Middle Atlantic (14.5%) regions.

The racial composition of the cohort was predominantly White (72.6%), while Black (12.5%), Asian (9.6%), and Hispanic (5.3%) patients represented smaller proportions (Table 1). Regarding insurance coverage, 54.4% of patients had private insurance, while 42.7% were covered by government insurance, and 2.8% were uninsured.

In terms of clinical characteristics, most patients (79.4%) had no recorded comorbidities (Charlson-Deyo Score = 0), while 15.8% had a score of 1, and a smaller proportion (1.4%) had a score of 3 or greater. Breast cancer staging was classified using the AJCC 7th Edition, with the largest proportion of patients diagnosed at Stage I (37.3%), followed by Stage II (32.8%), Stage 0 (19.1%), and Stage III

(10.8%). At the time of data collection, 18.4% of patients were deceased, while 81.6% remained alive (Table 1).

Socioeconomic characteristics varied across the cohort. Income distribution was relatively balanced, with the largest proportion of patients (39.8%) falling into the highest income quartile (≥$74,063), while the lowest proportion (15.8%) belonged to the <$46,277 category. Similarly, education levels were stratified by the percentage of residents without a high school diploma, with 19.8% of patients residing in areas where at least 15.3% of residents had not completed high school, while 23.7% lived in areas where fewer than 5.0% had not completed high school.

Age distribution was skewed toward older patients, with the majority falling within the 51–65 (39.2%) and 66–80 (39.6%) age groups. Younger patients were less represented, with only 0.6% of the cohort aged 18–30 and 4.7% aged 31–40 (Table 1). These baseline characteristics provide a comprehensive overview of the study population and establish the foundation for further analysis of surgical choice and survival outcomes.

Table 2: Baseline Characteristics of the Study Population Stratified by Surgery

Variable	Level	Surgery Type			Parametric P-value*
		Mastectomy only N (%) = 122,280	Implant N (%) = 29,496	Autologous N (%) = 24,604	
Facility Type	Community Cancer Program	10212 (8.6)	937 (3.4)	862 (3.8)	**<.001**
	Comprehensive Community Cancer Program	53423 (45.1)	10723 (39.0)	7991 (34.9)	
	Academic/Research Program	32473 (27.4)	9768 (35.5)	9317 (40.7)	
	Integrated Network Cancer Program	22426 (18.9)	6064 (22.1)	4743 (20.7)	
	Missing	3746	2004	1693	
Facility Location	New England	4807 (4.1)	1794 (6.5)	1360 (5.9)	**<.001**
	Middle Atlantic	14114 (11.9)	5198 (18.9)	5192 (22.7)	
	South Atlantic	27483 (23.2)	5850 (21.3)	5972 (26.1)	
	East North Central	20262 (17.1)	4974 (18.1)	3312 (14.5)	
	East South Central	9077 (7.7)	948 (3.4)	1156 (5.0)	
	West North Central	10146 (8.6)	2419 (8.8)	1013 (4.4)	
	West South Central	11305 (9.5)	1503 (5.5)	2029 (8.9)	
	Mountain	4579 (3.9)	1011 (3.7)	752 (3.3)	
	Pacific	16761 (14.1)	3795 (13.8)	2127 (9.3)	
	Missing	3746	2004	1693	
Race	White	87526 (71.6)	22676 (76.9)	17855 (72.6)	**<.001**
	Black	16076 (13.1)	2654 (9.0)	3292 (13.4)	
	Hispanic	6539 (5.3)	1530 (5.2)	1238 (5.0)	
	Asian	12139 (9.9)	2636 (8.9)	2221 (9.0)	

Table 2: Baseline Characteristics of the Study Population Stratified by Surgery

Variable	Level	Surgery Type			Parametric P-value*
		Mastectomy only N (%) = 122,280	Implant N (%) = 29,496	Autologous N (%) = 24,604	
Insurance Status	Not Insured	4149 (3.4)	432 (1.5)	397 (1.6)	**<.001**
	Government Insurance	63789 (52.2)	6691 (22.7)	4893 (19.9)	
	Private Insurance	54342 (44.4)	22373 (75.9)	19316 (78.5)	
Charlson-Deyo Score	0	93037 (76.1)	25583 (86.7)	21357 (86.8)	**<.001**
	1	21699 (17.7)	3324 (11.3)	2771 (11.3)	
	2	5227 (4.3)	452 (1.5)	386 (1.6)	
	>= 3	2317 (1.9)	137 (0.5)	92 (0.4)	
AJCC 7th Edition Cancer Stage	Stage 0	18750 (15.3)	8182 (27.7)	6698 (27.2)	**<.001**
	Stage I	44494 (36.4)	11822 (40.1)	9514 (38.7)	
	Stage II	43016 (35.2)	8015 (27.2)	6837 (27.8)	
	Stage III	16020 (13.1)	1477 (5.0)	1557 (6.3)	
Vital Status	Dead	28183 (23.0)	2254 (7.6)	2068 (8.4)	**<.001**
	Alive	94097 (77.0)	27242 (92.4)	22538 (91.6)	
Median Income Quartiles 2016-2020	< $46,277	22503 (18.4)	2703 (9.2)	2622 (10.7)	**<.001**
	$46,227-$57,856	28655 (23.4)	4484 (15.2)	3796 (15.4)	
	$57,857-$74,062	29444 (24.1)	6494 (22.0)	5409 (22.0)	
	>= $74,063	41678 (34.1)	15815 (53.6)	12779 (51.9)	
Percent No High School Degree Quartiles 2016-2020	>= 15.3%	26851 (22.0)	4265 (14.5)	3799 (15.4)	**<.001**
	9.1%-15.2%	35321 (28.9)	6743 (22.9)	6206 (25.2)	
	5.0%-9.0%	35044 (28.7)	8953 (30.4)	7338 (29.8)	
	< 5.0%	25064 (20.5)	9535 (32.3)	7263 (29.5)	

Table 2: Baseline Characteristics of the Study Population Stratified by Surgery

Variable	Level	Surgery Type			Parametric P-value*
		Mastectomy only N (%) = 122,280	Implant N (%) = 29,496	Autologous N (%) = 24,604	
Age by Strata	18 - 30	539 (0.4)	277 (0.9)	225 (0.9)	**<.001**
	31 - 40	3988 (3.3)	2272 (7.7)	1945 (7.9)	
	41 - 50	13400 (11.0)	7998 (27.1)	6861 (27.9)	
	51 - 65	44210 (36.2)	13277 (45.0)	11582 (47.1)	
	66 - 80	60143 (49.2)	5672 (19.2)	3993 (16.2)	

* The parametric p-value is calculated by chi-square test.

Table 3: Baseline Characteristics of Mastectomy only vs Reconstruction

Covariate	Level	Surgery Type: Mastectomy only N=122,280 (%)	Surgery Type: Reconstruction N (%) = 54,102 (%)	Parametric P-value*
Facility Type	Community Cancer Program	10212 (8.62)	1799 (3.57)	**<.001**
	Comprehensive Community Cancer Program	53423 (45.07)	18714 (37.13)	
	Academic/Research Program	32473 (27.4)	19085 (37.86)	
	Integrated Network Cancer Program	22426 (18.92)	10807 (21.44)	
Facility Location	New England	4807 (4.06)	3154 (6.26)	**<.001**
	Middle Atlantic	14114 (11.91)	10390 (20.61)	
	South Atlantic	27483 (23.19)	11822 (23.45)	
	East North Central	20262 (17.09)	8286 (16.44)	
	East South Central	9077 (7.66)	2104 (4.17)	
	West North Central	10146 (8.56)	3432 (6.81)	
	West South Central	11305 (9.54)	3532 (7.01)	
	Mountain	4579 (3.86)	1763 (3.5)	
	Pacific	16761 (14.14)	5922 (11.75)	
Race	White	87526 (71.58)	40531 (74.92)	**<.001**
	Black	16076 (13.15)	5946 (10.99)	
	Hispanic	6539 (5.35)	2768 (5.12)	
	Asian	12139 (9.93)	4857 (8.98)	
Insurance Status	Not Insured	4149 (3.39)	829 (1.53)	**<.001**
	Government Insurance	63789 (52.17)	11584 (21.41)	
	Private Insurance	54342 (44.44)	41689 (77.06)	

Table 3: Baseline Characteristics of Mastectomy only vs Reconstruction

Covariate	Level	Surgery Type: Mastectomy only N=122,280 (%)	Surgery Type: Reconstruction N (%) = 54,102 (%)	Parametric P-value*
Charlson-Deyo Score	0	93037 (76.09)	46940 (86.76)	**<.001**
	1	21699 (17.75)	6095 (11.27)	
	2	5227 (4.27)	838 (1.55)	
	>= 3	2317 (1.89)	229 (0.42)	
AJCC 7th Edition Cancer Stage	Stage 0	18750 (15.33)	14880 (27.5)	**<.001**
	Stage I	44494 (36.39)	21336 (39.44)	
	Stage II	43016 (35.18)	14852 (27.45)	
	Stage III	16020 (13.1)	3034 (5.61)	
Vital Status	Dead	28183 (23.05)	4322 (7.99)	**<.001**
	Alive	94097 (76.95)	49780 (92.01)	
Median Income Quartiles 2016-2020	< $46,277	22503 (18.4)	5325 (9.84)	**<.001**
	$46,227-$57,856	28655 (23.43)	8280 (15.3)	
	$57,857-$74,062	29444 (24.08)	11903 (22)	
	>= $74,063	41678 (34.08)	28594 (52.85)	
Percent No High School Degree Quartiles 2016-2020	>= 15.3%	26851 (21.96)	8064 (14.91)	**<.001**
	9.1%-15.2%	35321 (28.89)	12949 (23.93)	
	5.0%-9.0%	35044 (28.66)	16291 (30.11)	
	< 5.0%	25064 (20.5)	16798 (31.05)	
Age by Strata	18 - 30	539 (0.44)	502 (0.93)	**<.001**
	31 - 40	3988 (3.26)	4217 (7.79)	
	41 - 50	13400 (10.96)	14859 (27.46)	
	51 - 65	44210 (36.15)	24859 (45.95)	
	66 - 80	60143 (49.18)	9665 (17.86)	

Table 3: Baseline Characteristics of Mastectomy only vs Reconstruction

Covariate	Level	Surgery Type: Mastectomy only N=122,280 (%)	Surgery Type: Reconstruction N (%) = 54,102 (%)	Parametric P-value*

* The parametric p-value is calculated by chi-square test.

Tables 2 and 3 present the distribution of patient characteristics stratified by surgical type, with Table 2 differentiating between implant-based and autologous reconstruction, while Table 3 consolidates both reconstructive methods into a single "reconstruction" category. Among the 176,382 patients, 122,280 (69.3%) underwent mastectomy alone, while 54,102 (30.7%) received some form of reconstruction. Across both tables, surgical choice varied by facility type, with patients treated at Academic/Research Programs most likely to undergo reconstruction (37.9%), particularly autologous reconstruction (40.7%) (Tables 3 and 2). Conversely, Comprehensive Community Cancer Programs had the highest proportion of mastectomy-only (45.1%) patients, with fewer patients receiving reconstruction (Table 3).

Geographic differences in surgical choice were evident, as the South Atlantic and East North Central regions had the highest volume of overall surgeries and no significance in their type of surgery, yet a significant different in the proportion of reconstruction were observed in the New England and Middle Atlantic regions (Table 3). Racial differences were also observed, with White patients more likely to receive reconstruction (74.9% vs 71.6%), while Black patients had a higher mastectomy-only proportion (13.2% vs 11.0%). Hispanic (5.3%) and Asian (9.6%) patients had lower proportions

undergoing autologous reconstruction compared to Black patients (13.4%), though all were still at lower proportions than White patients (Table 2).

Insurance status significantly influenced surgical choice. Privately insured patients had the highest proportion of reconstruction (77.1%), while government-insured patients had a higher mastectomy-only proportion (52.1%). Uninsured patients predominantly underwent mastectomy alone (3.4%). Comorbidity burden, measured by the Charlson-Deyo Score, showed that patients with higher scores (≥3, 1.4%) were more likely to undergo mastectomy alone (1.9%), while those with lower scores (0, 79.4%) had the highest proportion of reconstruction (86.7%).

Cancer stage was a key factor in surgical decisions. Stage 0 patients had a higher proportion of reconstruction (27.5%) compared to mastectomy only (15.3%), while Stage III patients were most likely to receive mastectomy alone (13.1%) compared to reconstruction (6.5%) (Table 3). Across both tables, patients who had died at follow-up (18.4%) were more likely to have undergone mastectomy alone (23.1%), while those who were alive (81.6%) were more likely to have undergone reconstruction (97.0%) (Table 3). Socioeconomic disparities were evident, as patients in the highest income quartile (≥$74,063, 39.8%) had the highest proportion of reconstruction (52.8%), while those in the lowest income quartile (<$46,277, 15.8%) had higher mastectomy-only proportions (83.1%). Additionally, patients from areas with lower educational attainment (≥15.3% without a high school degree) had higher mastectomy-only proportions (21.9%).

Age was significantly associated with surgical choice. Older patients were more likely to undergo mastectomy alone, while younger patients (18–30 and 31–40 years) had higher proportions of reconstruction. Among patients aged 18–30 years, 20.9% received implant-based reconstruction, whereas only 0.4% of those aged 66–80 years underwent implant-based reconstruction. In Table 3,

which consolidates all reconstruction procedures into one category, 17.9% of patients aged 66–80 years still underwent reconstruction, but mastectomy-only remained the dominant choice (79.9%). The combined results from Tables 2 and 3 highlight distinct differences in surgical treatment patterns across demographic, clinical, and socioeconomic factors, emphasizing variability in access and utilization of reconstructive surgery.

Table 4: Crude Overall Survival for the Key Demographic Variables

			Months (OS)	
Covariate	**Level**	**N**	**Hazard Ratio (95% CI)**	**HR P-value**
Surgery	Reconstruction	53608	0.32 (0.31-0.33)	**<.001**
	Mastectomy only	121336	REF	REF
Age by Strata	18 - 30	1034	0.65 (0.56-0.75)	**<.001**
	31 - 40	8146	0.43 (0.40-0.45)	**<.001**
	41 - 50	27997	0.32 (0.31-0.33)	**<.001**
	51 - 65	68525	0.51(0.49-0.52)	**<.001**
	66 - 80	69242	REF	REF
AJCC 7th Edition Cancer Stage	Stage 0	33284	0.19 (0.18-0.19)	**<.001**
	Stage I	65314	0.31 (0.30-0.32)	**<.001**
	Stage II	57414	0.52 (0.51-0.54)	**<.001**
	Stage III	18932	REF	REF
Race	Black	21869	1.35 (1.31-1.40)	**<.001**
	Hispanic	9141	0.77 (0.73-0.82)	**<.001**
	Asian	16753	0.70 (0.67-0.73)	**<.001**
	White	127181	REF	REF
Charlson-Deyo Score	0	138786	0.23 (0.21-0.24)	**<.001**
	1	27589	0.39 (0.36-0.41)	**<.001**
	2	6035	0.63 (0.59-0.68)	**<.001**
	>= 3	2534	REF	REF
Insurance Status	Not Insured	4954	1.82 (1.70-1.94)	**<.001**
	Government Insurance	74794	2.45 (2.39-2.50)	**<.001**
	Private Insurance	95196	REF	REF

Table 4: Crude Overall Survival for the Key Demographic Variables

			Months (OS)	
Covariate	**Level**	**N**	**Hazard Ratio (95% CI)**	**HR P-value**
Median Income Quartiles 2016-2020	< $46,277	27684	1.74 (1.68-1.79)	**<.001**
	$46,227-$57,856	36703	1.57 (1.52-1.61)	**<.001**
	$57,857-$74,062	41066	1.31 (1.27-1.35)	**<.001**
	>= $74,063	69491	REF	REF

* Number of observations in the original data set = 176382. Number of observations used = 174944.

Table 4 presents crude hazard ratios (HRs) for overall survival (OS) across various demographic, clinical, and socioeconomic factors. The primary exposure of surgical type indicates that patients who underwent reconstruction (n = 53,608) had a lower hazard of mortality (HR = 0.32, 95% CI: 0.31–0.33) compared to those who underwent mastectomy alone (n = 121,336, reference group). Age stratification shows differences in hazard ratios, with patients aged 18–30 years (HR = 0.65, 95% CI: 0.56–0.75) and 31–40 years (HR = 0.43, 95% CI: 0.40–0.45) having lower hazards of mortality compared to those aged 66–80 years (reference group). The hazard ratio increased with advancing age, with patients aged 41–50 and 51–65 years having HRs of 0.32 (95% CI: 0.31–0.33) and 0.51 (95% CI: 0.49–0.52), respectively.

Cancer stage was strongly associated with survival outcomes, with patients diagnosed at Stage 0 having the lowest hazard ratio (HR = 0.19, 95% CI: 0.18–0.19), followed by Stage I (HR = 0.31, 95% CI: 0.30–0.32) and Stage II (HR = 0.52, 95% CI: 0.51–0.54), while Stage III served as the reference group. Racial differences in hazard ratios were observed, with Black patients (HR = 1.35, 95% CI: 1.31–1.40) experiencing a higher hazard of mortality compared to White patients (reference group), while Hispanic (HR = 0.77, 95% CI: 0.73–0.82) and Asian (HR = 0.70, 95% CI: 0.67–0.73) patients had lower hazard ratios.

Charlson-Deyo comorbidity scores were also associated with mortality, with patients having no comorbidities (score = 0) demonstrating the lowest hazard ratio (HR = 0.23, 95% CI: 0.21–0.24), while those with increasing comorbidity burden had progressively higher hazards, with those having a score ≥3 serving as the reference group. Similarly, insurance status showed differences in crude hazard ratios, with uninsured patients (HR = 1.82, 95% CI: 1.70–1.94) and those with government insurance (HR = 2.45, 95% CI: 2.39–2.50) exhibiting higher hazards of mortality compared to privately insured patients (reference group).

Income stratification revealed that patients in the lowest median income quartile (<$46,277) had the highest hazard ratio (HR = 1.74, 95% CI: 1.68–1.79), followed by those in the $46,227–$57,856 (HR = 1.57, 95% CI: 1.52–1.61) and $57,857–$74,062 (HR = 1.31, 95% CI: 1.27–1.35) quartiles, while the highest-income quartile (≥$74,063) served as the reference group.

Figure 8: Kaplan-Meier curves of Mastectomy Only versus Reconstruction

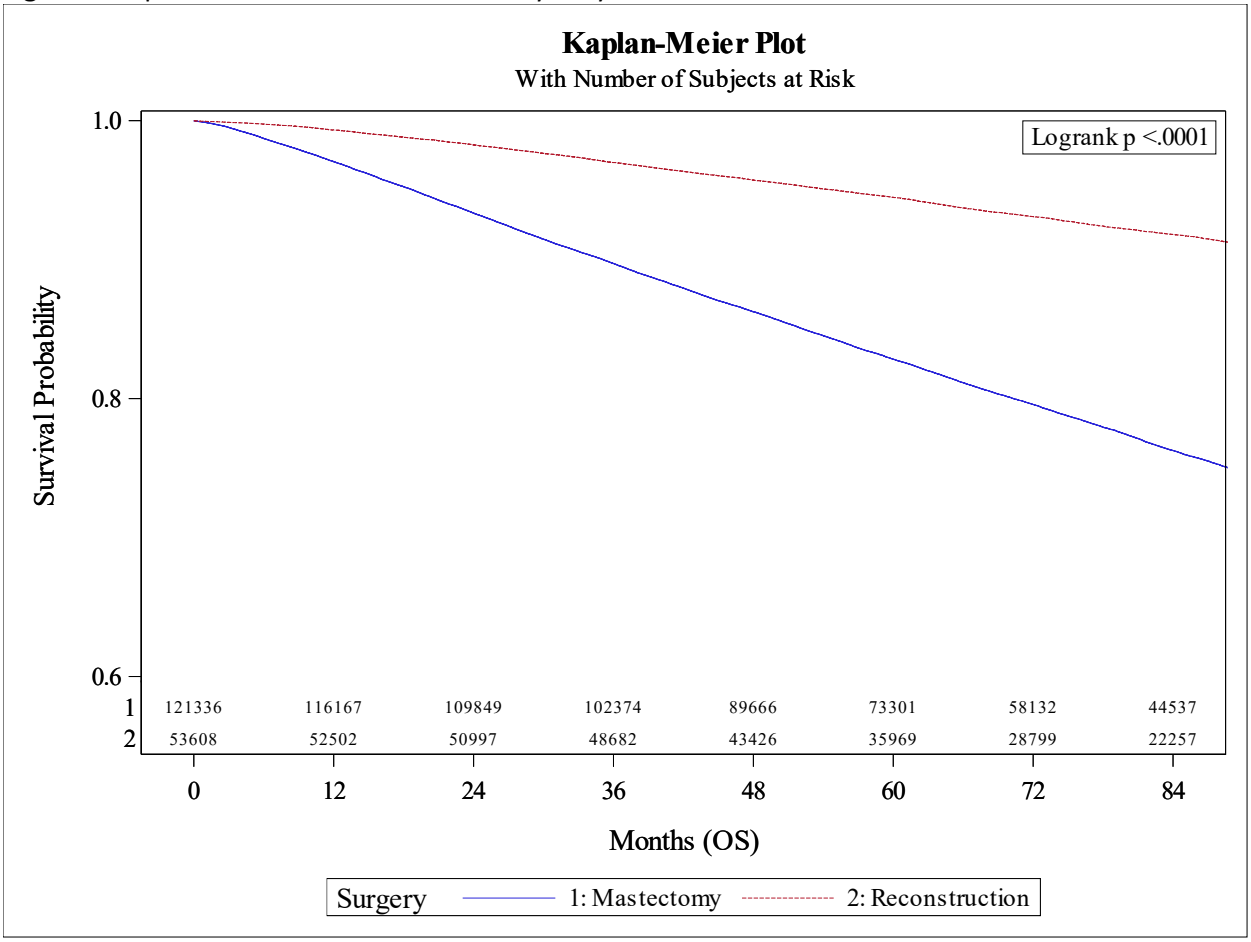

Figure 8 presents the Kaplan-Meier survival curves comparing overall survival (OS) between patients who underwent mastectomy alone and those who received reconstruction following mastectomy. The x-axis represents months since surgery, while the y-axis denotes survival probability. The blue curve represents patients who had mastectomy only, while the red dashed curve represents those who underwent reconstruction. The number of subjects at risk is displayed below the x-axis at various time points. A log-rank test indicates a statistically significant difference between the two groups ($p < 0.0001$), with the reconstruction group demonstrating a higher probability of survival over time.

Table 5: Kaplan-Meier Estimated Overall Survival Rates at 12 and 60 Months by Surgery Type

Surgery	Months (OS)	Survival Rate (95% CI)
Mastectomy Only	12	97.0% (97.0%, 97.1%)
	60	82.8% (82.6%, 83.1%)
Reconstruction	12	99.3% (99.2%, 99.4%)
	60	94.5% (94.3%, 94.7%)

Table 5 summarizes the Kaplan-Meier estimated overall survival rates at 12 and 60 months for both surgical groups. At 12 months, the survival rate for mastectomy-only patients was 97.0% (95% CI: 97.0%–97.1%), while for those who underwent reconstruction, the survival rate was higher at 99.3% (95% CI: 99.2%–99.4%). At 60 months, survival remained lower in the mastectomy-only group (82.8%, 95% CI: 82.6%–83.1%) compared to the reconstruction group (94.5%, 95% CI: 94.3%–94.7%). These findings illustrate a divergence in survival probabilities over time between the two surgical groups.

Figure 9: Kaplan-Meier Survival Curves by Race

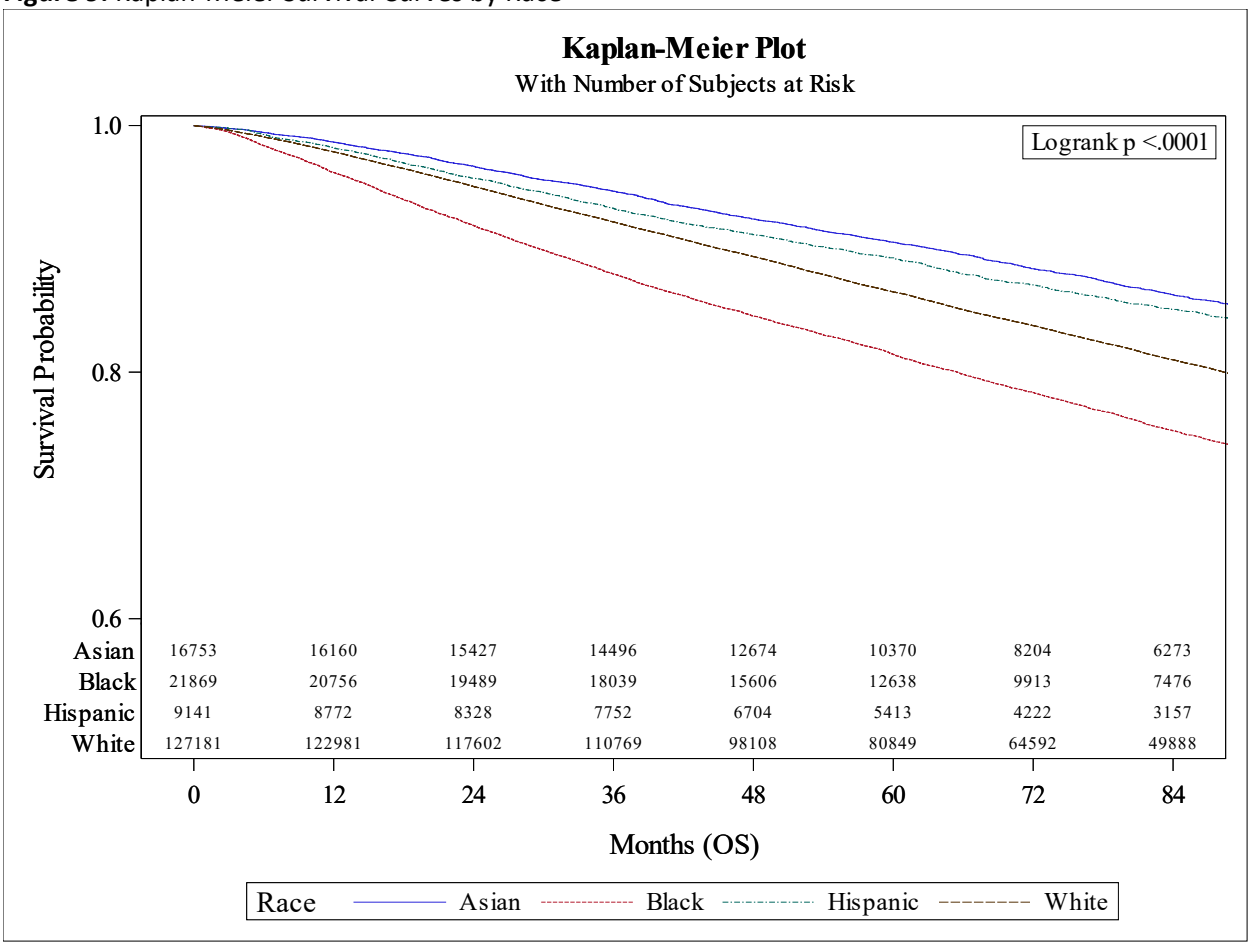

Figure 9 displays Kaplan-Meier survival curves stratified by race, comparing overall survival (OS) among Asian, Black, Hispanic, and White patients. The x-axis represents months since surgery, and the y-axis denotes survival probability. The survival curves indicate variation in OS across racial groups, with Black patients showing the steepest decline in survival probability over time, while Asian patients exhibit the highest survival probabilities. The log-rank test ($p < 0.0001$) suggests a statistically significant difference in survival across racial groups. The number of subjects at risk at each time point is displayed beneath the x-axis.

Table 6: Kaplan-Meier Estimated Overall Survival Rates at 12 and 60 Months by Race

Race	Months (OS)	Survival Rate (95% CI)
Asian	12	98.7% (98.5%, 98.8%)
	60	90.5% (90.1%, 91.0%)
Black	12	96.2% (95.9%, 96.4%)
	60	81.4% (80.9%, 82.0%)
Hispanic	12	98.2% (97.9%, 98.4%)
	60	89.3% (88.6%, 89.9%)
White	12	97.9% (97.8%, 97.9%)
	60	86.5% (86.3%, 86.7%)

Table 6 presents the Kaplan-Meier estimated survival rates at 12 and 60 months for each racial group. At 12 months, survival rates were highest among Asian (98.7%, 95% CI: 98.5%–98.8%) and Hispanic (98.2%, 95% CI: 97.9%–98.4%) patients, followed closely by White patients (97.9%, 95% CI: 97.8%–97.9%) and Black patients (96.2%, 95% CI: 95.9%–96.4%). By 60 months, survival remained highest for Asian patients (90.5%, 95% CI: 90.1%–91.0%), while Hispanic (89.3%, 95% CI: 88.6%–89.9%) and White (86.5%, 95% CI: 86.3%–86.7%) patients also had relatively high survival. Black patients had the lowest survival probability at 60 months (81.4%, 95% CI: 80.9%–82.0%). These findings highlight differences in long-term survival outcomes across racial groups.

Figure 10: Kaplan-Meier curve of survival by Stage

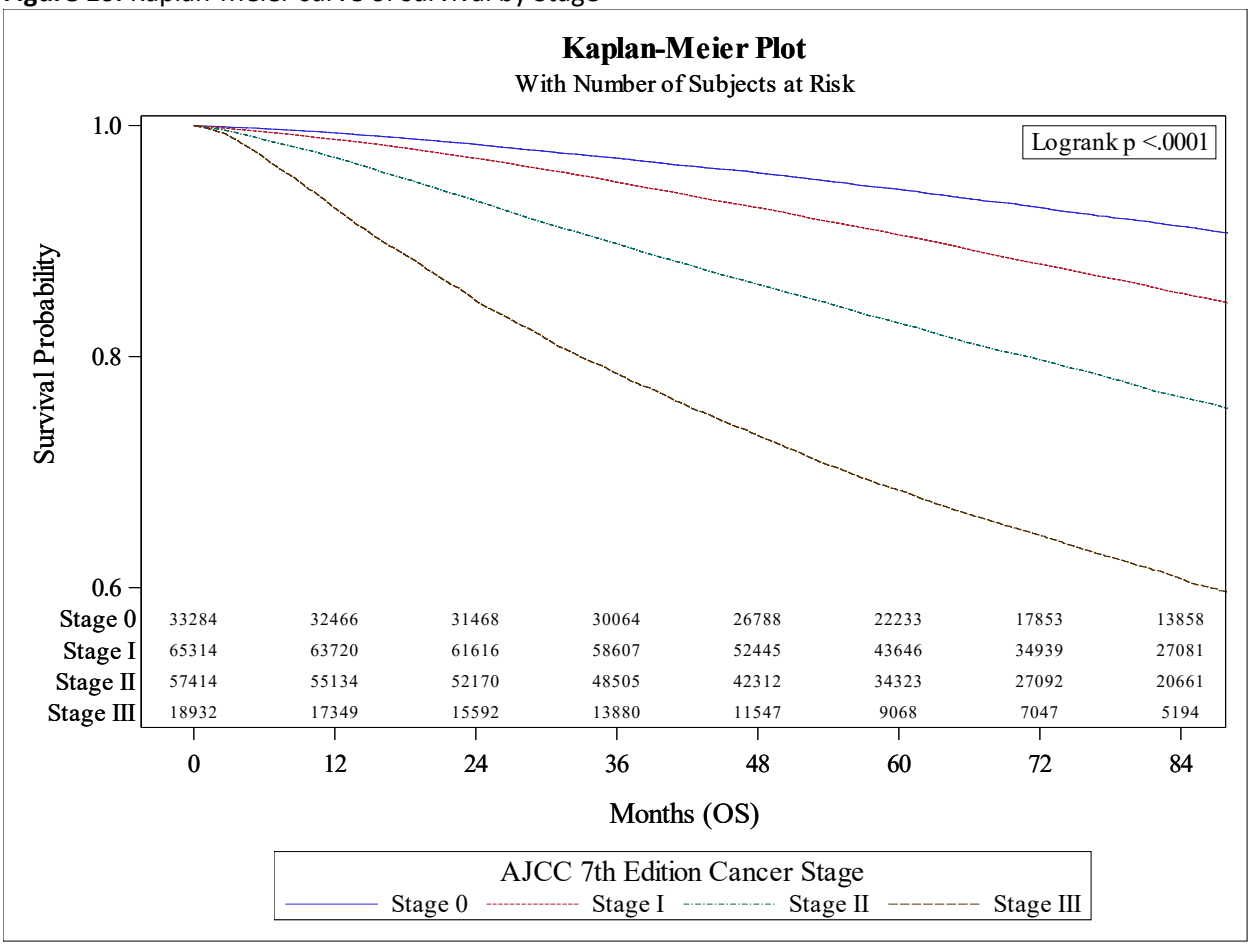

Figure 10 presents the Kaplan-Meier survival curves stratified by AJCC 7th Edition cancer stage, illustrating differences in overall survival (OS) among patients with stage 0, stage I, stage II, and stage III breast cancer. The x-axis represents months since surgery, while the y-axis indicates survival probability. The survival curves demonstrate a clear separation based on cancer stage, with stage 0 and stage I patients having the highest survival probabilities, while stage III patients show a markedly steeper decline in survival over time. The log-rank test ($p < 0.0001$) suggests significant differences in survival across stages. The number of subjects at risk at various time points is shown below the x-axis.

Table 7: Kaplan-Meier Estimated Overall Survival Rates at 12 and 60 Months by Cancer Stage

AJCC 7th Edition Cancer Stage	Months (OS)	Survival Rate (95% CI)
Stage 0	12	99.4% (99.3%, 99.4%)
	60	94.5% (94.2%, 94.7%)
Stage I	12	98.8% (98.7%, 98.9%)
	60	90.5% (90.3%, 90.8%)
Stage II	12	97.2% (97.1%, 97.4%)
	60	82.9% (82.6%, 83.2%)
Stage III	12	92.8% (92.5%, 93.2%)
	60	68.4% (67.7%, 69.1%)

Table 7 provides the estimated survival rates at 12 and 60 months for each cancer stage. At 12 months, survival rates were highest among stage 0 (99.4%, 95% CI: 99.3%–99.4%) and stage I (98.8%, 95% CI: 98.7%–98.9%) patients, followed by stage II (97.2%, 95% CI: 97.1%–97.4%). Stage III patients had the lowest 12-month survival rate (92.8%, 95% CI: 92.5%–93.2%). By 60 months, survival declined across all groups, with stage 0 patients maintaining the highest survival probability (94.5%, 95% CI: 94.2%–94.7%), while stage III patients had the lowest survival rate at 60 months (68.4%, 95% CI: 67.7%–69.1%). These results highlight the strong association between cancer stage and long-term survival outcomes.

Figure 11: Kaplan-Meier curves of survival by Charlson-Deyo Score

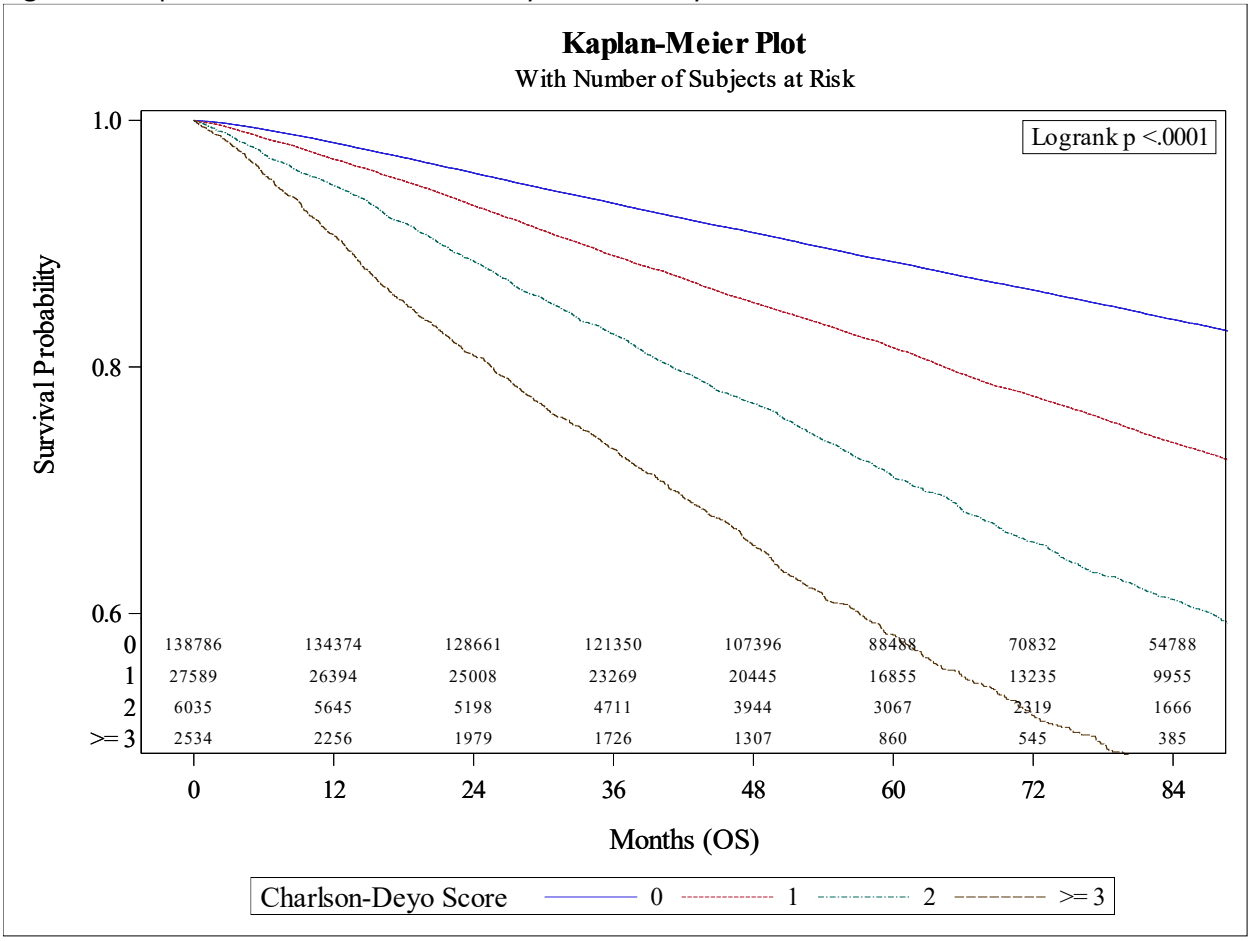

Figure 11 presents Kaplan-Meier survival curves stratified by Charlson-Deyo comorbidity score, illustrating overall survival (OS) among patients with different levels of comorbidity burden. The x-axis represents months since surgery, while the y-axis indicates survival probability. Patients with a Charlson-Deyo score of 0 exhibited the highest survival probabilities throughout the follow-up period, whereas those with a score ≥3 had the steepest decline in survival. The log-rank test ($p < 0.0001$) confirms significant differences in survival among the groups. The number of subjects at risk at each time point is displayed beneath the x-axis.

Table 8: Kaplan-Meier Estimated Overall Survival Rates at 12 and 60 Months by Charlson-Deyo Score

Charlson-Deyo Score	Months (OS)	Survival Rate (95% CI)
0	12	98.2% (98.1%, 98.3%)
	60	88.5% (88.3%, 88.7%)
1	12	96.8% (96.6%, 97.0%)
	60	81.6% (81.1%, 82.0%)
2	12	94.7% (94.1%, 95.2%)
	60	71.1% (69.9%, 72.3%)
>= 3	12	90.7% (89.5%, 91.7%)
	60	58.3% (56.1%, 60.3%)

Table 8 provides estimated survival rates at 12 and 60 months by comorbidity score. At 12 months, survival was highest among patients with a Charlson-Deyo score of 0 (98.2%, 95% CI: 98.1%–98.3%) and progressively decreased with higher scores. Patients with a score of 1 had a 12-month survival rate of 96.8% (95% CI: 96.6%–97.0%), while those with a score of 2 had a rate of 94.7% (95% CI: 94.1%–95.2%). The lowest 12-month survival rate was observed among patients with a score ≥3 (90.7%, 95% CI: 89.5%–91.7%). By 60 months, survival rates declined across all groups, with patients in the lowest comorbidity category (score = 0) maintaining the highest survival probability (88.5%, 95% CI: 88.3%–88.7%) and those with a score ≥3 exhibiting the lowest survival rate (58.3%, 95% CI: 56.1%–60.3%). These findings highlight the strong association between comorbidity burden and long-term survival outcomes.

Figure 12: Kaplan-Meier curves of survival by Insurance status

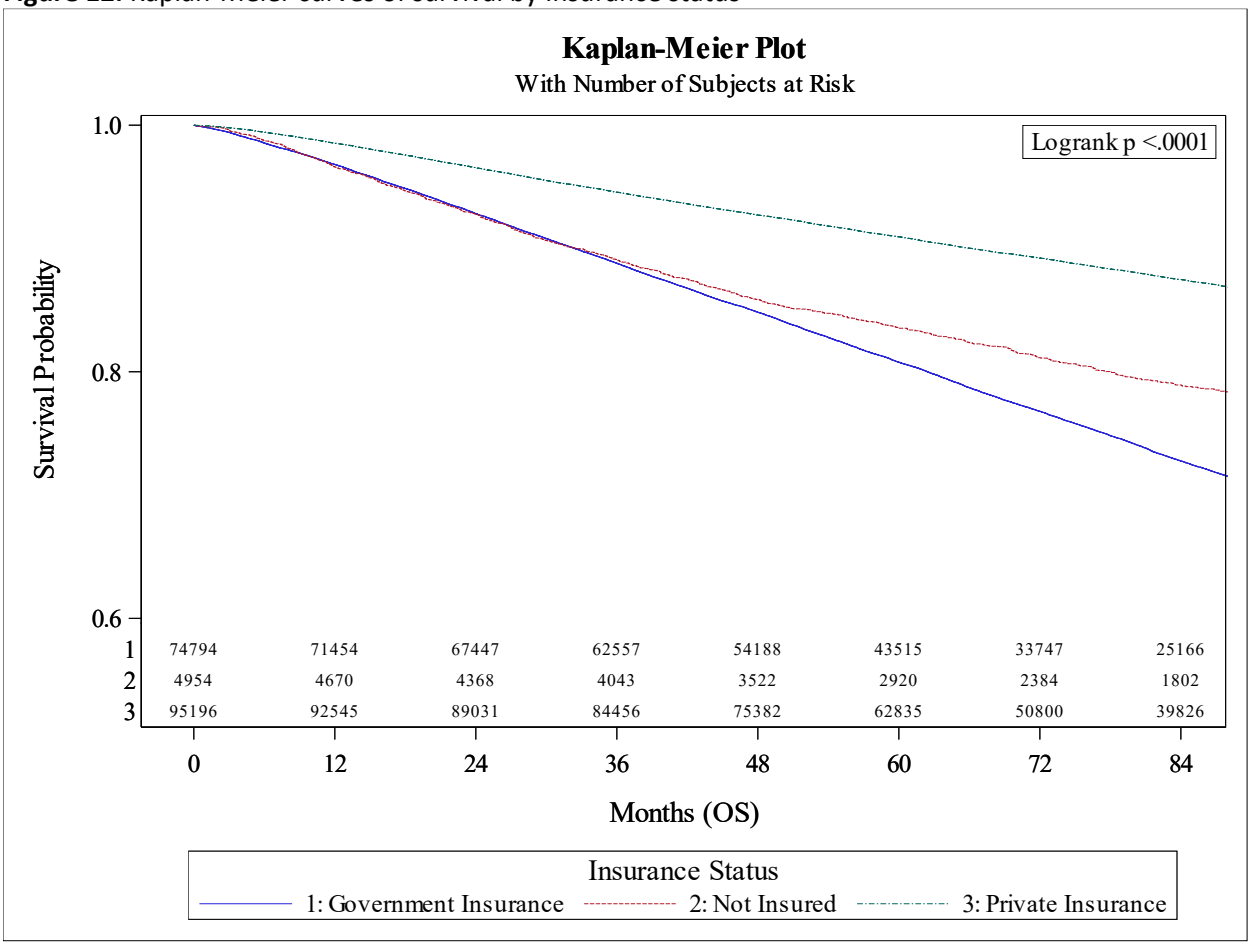

Figure 12 presents Kaplan-Meier survival curves stratified by insurance status, illustrating overall survival (OS) differences among patients with private insurance, government insurance, and no insurance. The x-axis represents months since surgery, while the y-axis indicates survival probability. Patients with private insurance demonstrated the highest survival probability over time, while those with government insurance had the lowest. The survival curve for uninsured patients fell between these two groups. The log-rank test ($p < 0.0001$) confirms significant survival differences by insurance status. The number of subjects at risk at each time point is displayed beneath the x-axis.

Table 9: Kaplan-Meier Estimated Overall Survival Rates at 12 and 60 Months by Insurance Status

Insurance Status	Months (OS)	Survival Rate (95% CI)
Government Insurance	12	96.8% (96.7%, 96.9%)
	60	80.8% (80.5%, 81.1%)
Not Insured	12	96.6% (96.1%, 97.1%)
	60	83.5% (82.4%, 84.6%)
Private Insurance	12	98.5% (98.5%, 98.6%)
	60	90.9% (90.7%, 91.1%)

Table 9 provides estimated survival rates at 12 and 60 months by insurance status. At 12 months, survival rates were highest among privately insured patients (98.5%, 95% CI: 98.5%–98.6%), followed by those with government insurance (96.8%, 95% CI: 96.7%–96.9%) and uninsured patients (96.6%, 95% CI: 96.1%–97.1%). By 60 months, survival rates had declined in all groups, with private insurance holders maintaining the highest survival probability (90.9%, 95% CI: 90.7%–91.1%), followed by uninsured patients (83.5%, 95% CI: 82.4%–84.6%), and government-insured patients exhibiting the lowest survival rate (80.8%, 95% CI: 80.5%–81.1%). These results highlight notable differences in survival outcomes based on insurance coverage.

Figure 13: Kaplan-Meier Curves for Overall Survival Stratified by Income Quartile (2016–2020)

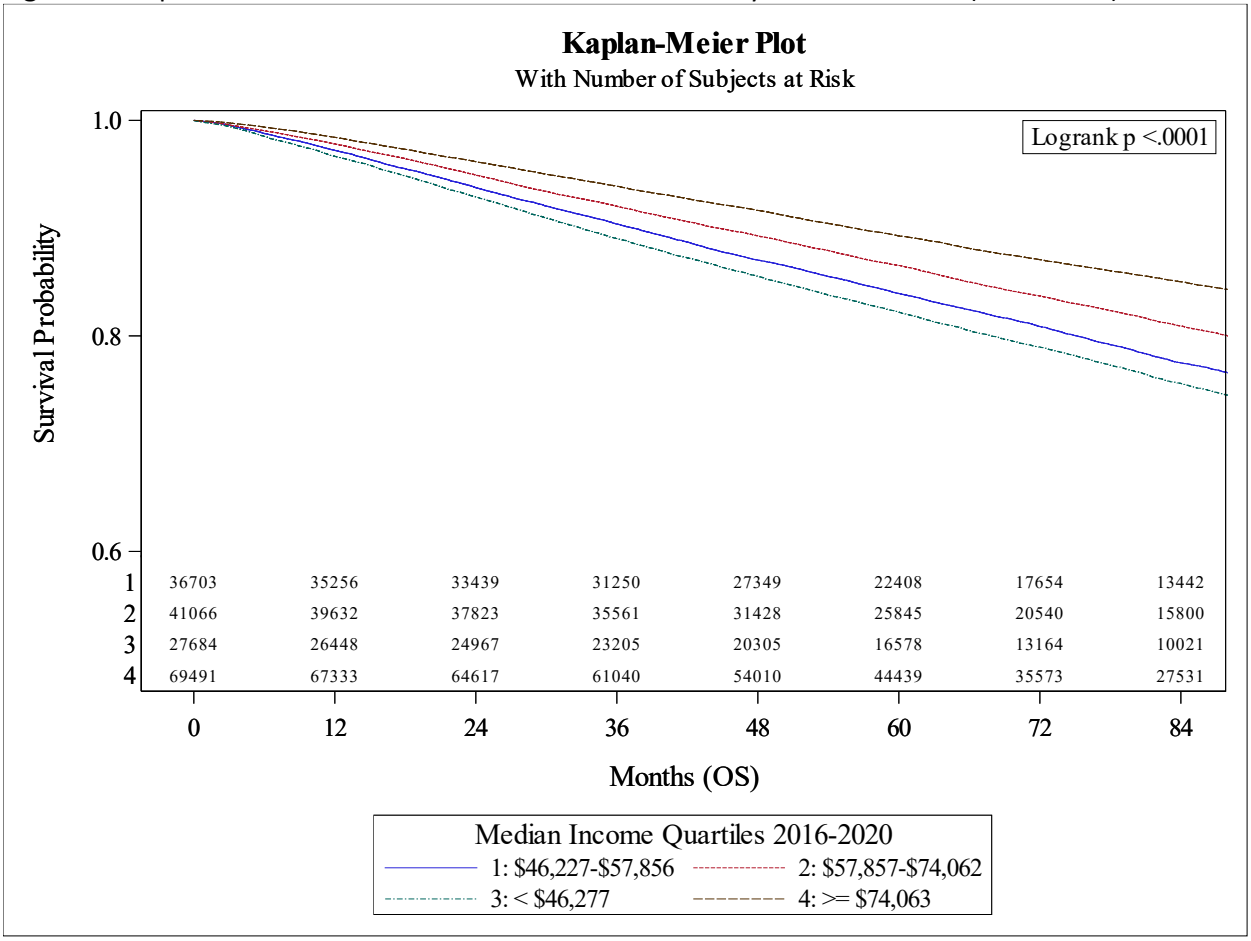

Figure 13 presents Kaplan-Meier survival curves stratified by median income quartiles for the years 2016–2020. The x-axis represents overall survival (OS) in months, ranging from 0 to 84 months, while the y-axis represents survival probability. The four income quartiles are distinguished by different line styles: <$46,277, $46,227–$57,856, $57,857–$74,062, and ≥$74,063. The survival probability appears to decline over time across all income quartiles, with a significant separation between the curves. The number of subjects at risk at various time points is displayed beneath the x-axis for each income group. The log-rank test p-value is reported as <0.0001.

Table 10: Kaplan-Meier Estimated Overall Survival Rates at 12 and 60 Months by Median Income Quartile

Median Income Quartiles 2016-2020	Months (OS)	Survival Rate (95% CI)
$46,227-$57,856	12	97.2% (97.0%, 97.4%)
	60	83.9% (83.5%, 84.3%)
$57,857-$74,062	12	97.8% (97.7%, 97.9%)
	60	86.5% (86.2%, 86.9%)
< $46,277	12	96.7% (96.4%, 96.9%)
	60	82.2% (81.7%, 82.7%)
>= $74,063	12	98.4% (98.3%, 98.5%)
	60	89.3% (89.0%, 89.5%)

Table 10 provides Kaplan-Meier estimated overall survival rates at 12 and 60 months, stratified by median income quartiles. At 12 months, survival rates are above 96% across all income quartiles, with the highest survival rate observed in the highest income group (≥$74,063) at 98.4% (95% CI: 98.3%, 98.5%). At 60 months, survival rates decrease across all quartiles, with the highest income quartile maintaining the highest survival probability at 89.3% (95% CI: 89.0%, 89.5%), while the lowest quartile (<$46,277) has the lowest survival probability at 82.2% (95% CI: 81.7%, 82.7%). The intermediate income quartiles show survival probabilities between these extremes.

Figure 14: Forest Plot of Univariate Hazard Ratios for Predictors of Overall Survival

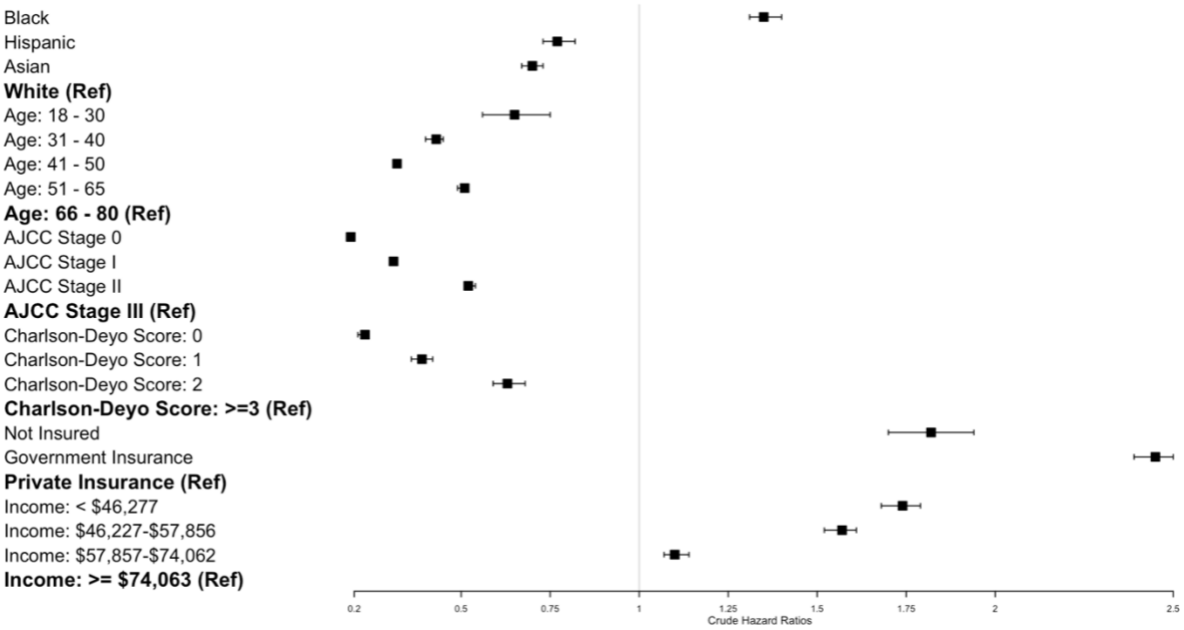

Figure 14 presents a forest plot displaying crude hazard ratios (HRs) for individual variables related to overall survival. Each variable is plotted with its corresponding HR and 95% confidence interval (CI), with reference groups indicated in bold. The plot shows that younger age groups, earlier cancer stages, lower Charlson-Deyo scores, and higher income levels are associated with lower hazards of mortality, as their HRs fall below 1. In contrast, Black race, lack of insurance, lower income, and advanced cancer stages are associated with higher hazards, with HRs exceeding 1. The reference groups, such as White race, age 66–80, stage III cancer, Charlson-Deyo score ≥3, private insurance, and the highest income quartile (≥$74,063), serve as comparison points for each category. The clear separation of HRs and confidence intervals highlights significant differences in survival risk across demographic, clinical, and socioeconomic factors.

Table 11: Cox-Proportional Hazards Model With the Time-Dependent Covariates in the Model

			Months (OS)	
Covariate	**Level**	**N**	**Hazard Ratio (95% CI)**	**HR P-value**
Surgery	Reconstruction	53608	0.45 (0.42-0.48)	**<.001**
	Mastectomy only	121336	REF	REF
Age by Strata	18 - 30	1034	1.80 (1.53-2.12)	**<.001**
	31 - 40	8146	1.18 (1.08-1.29)	**<.001**
	41 - 50	27997	0.83 (0.78-0.89)	**<.001**
	51 - 65	68525	0.88 (0.85-0.91)	**<.001**
	66 - 80	69242	REF	REF
AJCC 7th Edition Cancer Stage	Stage 0	33284	0.09 (0.09-0.10)	**<.001**
	Stage I	65314	0.18 (0.18-0.19)	**<.001**
	Stage II	57414	0.42 (0.40-0.43)	**<.001**
	Stage III	18932	REF	REF
Race	Black	21869	1.17 (1.13-1.21)	**<.001**
	Hispanic	9141	0.74 (0.70-0.79)	**<.001**
	Asian	16753	0.77 (0.73-0.80)	**<.001**
	White	127181	REF	REF
Charlson-Deyo Score	0	138786	0.33 (0.31-0.35)	**<.001**
	1	27589	0.47 (0.44-0.50)	**<.001**
	2	6035	0.70 (0.65-0.75)	**<.001**
	>= 3	2534	REF	REF
Insurance Status	Not Insured	4954	1.33 (1.25-1.42)	**<.001**
	Government Insurance	74794	1.48 (1.43-1.53)	**<.001**
	Private Insurance	95196	REF	REF

			Months (OS)	
Covariate	**Level**	**N**	**Hazard Ratio (95% CI)**	**HR P-value**
Median Income Quartiles 2016-2020	< $46,277	27684	1.24 (1.20-1.28)	**<.001**
	$46,227-$57,856	36703	1.20 (1.17-1.24)	**<.001**
	$57,857-$74,062	41066	1.10 (1.07-1.14)	**<.001**
	>= $74,063	69491	REF	REF

* Number of observations in the original data set = 176382. Number of observations used = 174944.

Table 11 presents the results of the Cox proportional hazards model, which evaluates the association between surgical type and overall survival while adjusting for covariates. The hazard ratio (HR) for patients who underwent breast reconstruction compared to those who underwent mastectomy alone is 0.45 (95% CI: 0.42–0.48, $p < 0.001$). This indicates a lower hazard of mortality in the reconstruction group relative to the mastectomy-only group after adjusting for other factors included in the model.

Figure 15: Forest Plot of Hazard Ratios Comparing Breast Reconstruction to Mastectomy (Unadjusted and Adjusted Models)

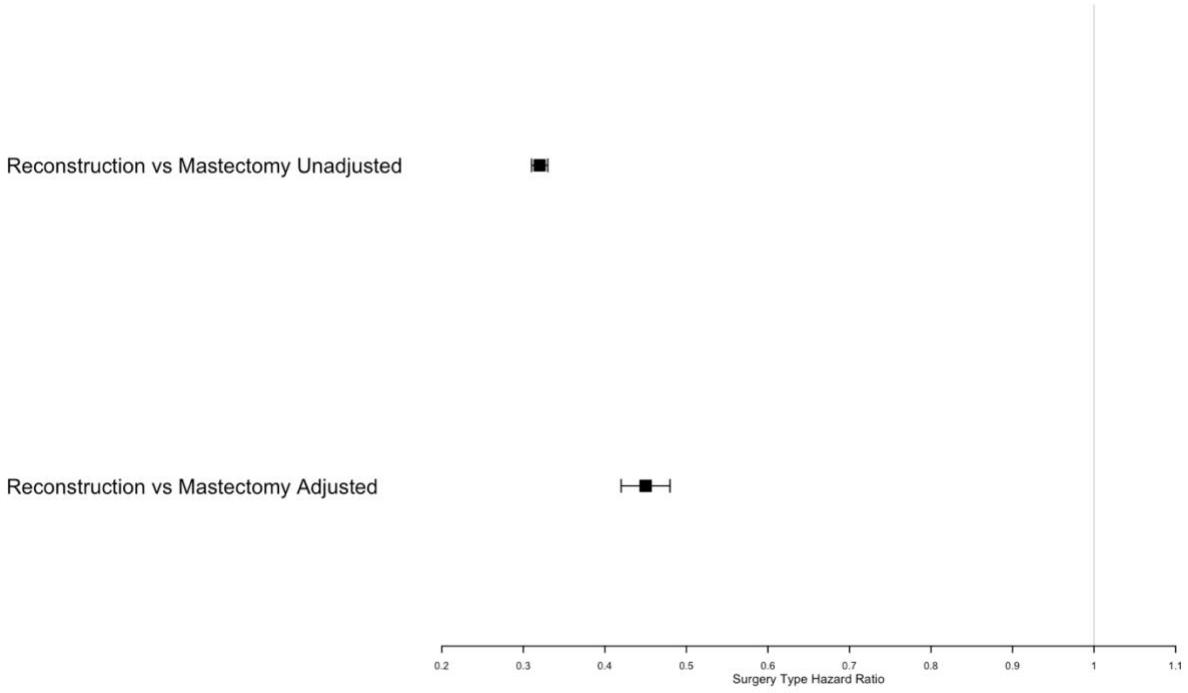

Figure 15 presents a forest plot comparing the hazard ratios (HRs) for overall survival between patients undergoing breast reconstruction and those receiving mastectomy alone. The unadjusted (crude) HR is displayed in the upper portion of the plot, with an HR of 0.32 and a confidence interval (CI) ranging from 0.31 to 0.33, indicating a lower hazard of mortality for the reconstruction group before adjusting for covariates. The adjusted HR, shown in the lower portion of the plot, is slightly higher than the unadjusted HR but remains below 1.0. The x-axis represents the hazard ratio scale, ranging from approximately 0.2 to just above 1.0. Both estimates indicate a difference in survival between the two surgical groups, with the adjusted HR accounting for potential confounders.

Sensitivity Analysis

Stage Strata

Table 12: Descriptive Statistics for Overall Survival in Stage 0 Breast Cancer

		Surgery Type		
Covariate	**Level**	**Mastectomy only N (%) = 18,750**	**Implant Based Reconstruction N (%) = 14,880**	**Parametric P-value***
Facility Type	Community Cancer Program	1335 (7.25)	539 (3.81)	**<.001**
	Comprehensive Community Cancer Program	8173 (44.38)	5186 (36.62)	
	Academic/Research Program	5293 (28.74)	5354 (37.8)	
	Integrated Network Cancer Program	3615 (19.63)	3084 (21.78)	
Facility Location	New England	755 (4.1)	946 (6.68)	**<.001**
	Middle Atlantic	2300 (12.49)	2844 (20.08)	
	South Atlantic	4138 (22.47)	3429 (24.21)	
	East North Central	3149 (17.1)	2333 (16.47)	
	East South Central	1331 (7.23)	579 (4.09)	
	West North Central	1473 (8)	899 (6.35)	
	West South Central	1671 (9.07)	952 (6.72)	
	Mountain	671 (3.64)	475 (3.35)	
	Pacific	2928 (15.9)	1706 (12.05)	

Table 12: Descriptive Statistics for Overall Survival in Stage 0 Breast Cancer

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 18,750	Implant Based Reconstruction N (%) = 14,880	
Race	White	12637 (67.4)	10888 (73.17)	**<.001**
	Black	2873 (15.32)	1860 (12.5)	
	Hispanic	959 (5.11)	719 (4.83)	
	Asian	2281 (12.17)	1413 (9.5)	
Insurance Status	Not Insured	482 (2.57)	190 (1.28)	**<.001**
	Government Insurance	9694 (51.7)	3003 (20.18)	
	Private Insurance	8574 (45.73)	11687 (78.54)	
Charlson-Deyo Score	0	14341 (76.49)	12824 (86.18)	**<.001**
	1	3290 (17.55)	1760 (11.83)	
	2	811 (4.33)	236 (1.59)	
	>= 3	308 (1.64)	60 (0.4)	
Vital Status	Dead	2366 (12.62)	553 (3.72)	**<.001**
	Alive	16384 (87.38)	14327 (96.28)	
Median Income Quartiles 2016-2020	< $46,277	3330 (17.76)	1412 (9.49)	**<.001**
	$46,227-$57,856	4145 (22.11)	2260 (15.19)	
	$57,857-$74,062	4406 (23.5)	3230 (21.71)	
	>= $74,063	6869 (36.63)	7978 (53.62)	
Age by Strata	18 - 30	29 (0.15)	90 (0.6)	**<.001**
	31 - 40	435 (2.32)	956 (6.42)	
	41 - 50	1966 (10.49)	4451 (29.91)	
	51 - 65	7033 (37.51)	6976 (46.88)	
	66 - 80	9287 (49.53)	2407 (16.18)	

* The parametric p-value is calculated by chi-square test.

Table 13: Descriptive Statistics for Overall Survival in Stage 1 Breast Cancer

		Surgery Type		
Covariate	**Level**	**Mastectomy only N (%) = 44,494**	**Implant Based Reconstruction N (%) = 21,336**	**Parametric P-value***
Facility Type	Community Cancer Program	4062 (9.27)	730 (3.6)	**<.001**
	Comprehensive Community Cancer Program	20250 (46.19)	7694 (37.94)	
	Academic/Research Program	11063 (25.23)	7486 (36.91)	
	Integrated Network Cancer Program	8467 (19.31)	4372 (21.56)	
Facility Location	New England	1905 (4.35)	1347 (6.64)	**<.001**
	Middle Atlantic	5254 (11.98)	4162 (20.52)	
	South Atlantic	9861 (22.49)	4688 (23.11)	
	East North Central	7408 (16.9)	3365 (16.59)	
	East South Central	3648 (8.32)	868 (4.28)	
	West North Central	4127 (9.41)	1430 (7.05)	
	West South Central	3864 (8.81)	1374 (6.77)	
	Mountain	1672 (3.81)	726 (3.58)	
	Pacific	6103 (13.92)	2322 (11.45)	
Race	White	33820 (76.01)	16650 (78.04)	**<.001**
	Black	4640 (10.43)	1948 (9.13)	
	Hispanic	1872 (4.21)	988 (4.63)	
	Asian	4162 (9.35)	1750 (8.2)	
Insurance Status	Not Insured	904 (2.03)	275 (1.29)	**<.001**
	Government Insurance	26086 (58.63)	5233 (24.53)	
	Private Insurance	17504 (39.34)	15828 (74.18)	

Table 13: Descriptive Statistics for Overall Survival in Stage 1 Breast Cancer

		Surgery Type		
Covariate	**Level**	**Mastectomy only N (%) = 44,494**	**Implant Based Reconstruction N (%) = 21,336**	**Parametric P-value***
Charlson-Deyo Score	0	33415 (75.1)	18552 (86.95)	**<.001**
	1	8238 (18.51)	2354 (11.03)	
	2	2001 (4.5)	351 (1.65)	
	>= 3	840 (1.89)	79 (0.37)	
Vital Status	Dead	8241 (18.52)	1330 (6.23)	**<.001**
	Alive	36253 (81.48)	20006 (93.77)	
Median Income Quartiles 2016-2020	< $46,277	7949 (17.87)	2004 (9.39)	**<.001**
	$46,227-$57,856	10593 (23.81)	3203 (15.01)	
	$57,857-$74,062	10839 (24.36)	4743 (22.23)	
	>= $74,063	15113 (33.97)	11386 (53.37)	
Age by Strata	18 - 30	87 (0.2)	120 (0.56)	**<.001**
	31 - 40	730 (1.64)	1249 (5.85)	
	41 - 50	3573 (8.03)	5327 (24.97)	
	51 - 65	14827 (33.32)	10070 (47.2)	
	66 - 80	25277 (56.81)	4570 (21.42)	

* The parametric p-value is calculated by chi-square test.

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 43,016	Implant Based Reconstruction N (%) = 14,852	
Facility Type	Community Cancer Program	3557 (8.62)	449 (3.36)	**<.001**
	Comprehensive Community Cancer Program	18692 (45.3)	4936 (36.95)	
	Academic/Research Program	11425 (27.69)	5180 (38.78)	
	Integrated Network Cancer Program	7592 (18.4)	2792 (20.9)	
Facility Location	New England	1542 (3.74)	718 (5.38)	**<.001**
	Middle Atlantic	4695 (11.38)	2734 (20.47)	
	South Atlantic	9724 (23.56)	3093 (23.16)	
	East North Central	7129 (17.28)	2224 (16.65)	
	East South Central	3092 (7.49)	556 (4.16)	
	West North Central	3489 (8.45)	953 (7.13)	
	West South Central	4098 (9.93)	1025 (7.67)	
	Mountain	1617 (3.92)	465 (3.48)	
	Pacific	5880 (14.25)	1589 (11.9)	
Race	White	30380 (70.62)	10938 (73.65)	**<.001**
	Black	5759 (13.39)	1636 (11.02)	
	Hispanic	2594 (6.03)	883 (5.95)	
	Asian	4283 (9.96)	1395 (9.39)	
Insurance Status	Not Insured	1716 (3.99)	279 (1.88)	**<.001**
	Government Insurance	21431 (49.82)	2854 (19.22)	
	Private Insurance	19869 (46.19)	11719 (78.91)	

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 43,016	Implant Based Reconstruction N (%) = 14,852	
Charlson-Deyo Score	0	32498 (75.55)	12882 (86.74)	**<.001**
	1	7711 (17.93)	1684 (11.34)	
	2	1923 (4.47)	208 (1.4)	
	>= 3	884 (2.06)	78 (0.53)	
Vital Status	Dead	11340 (26.36)	1681 (11.32)	**<.001**
	Alive	31676 (73.64)	13171 (88.68)	
Median Income Quartiles 2016-2020	< $46,277	8077 (18.78)	1588 (10.69)	**<.001**
	$46,227-$57,856	10097 (23.47)	2374 (15.98)	
	$57,857-$74,062	10450 (24.29)	3257 (21.93)	
	>= $74,063	14392 (33.46)	7633 (51.39)	
Age by Strata	18 - 30	263 (0.61)	224 (1.51)	**<.001**
	31 - 40	1792 (4.17)	1578 (10.62)	
	41 - 50	5349 (12.43)	4221 (28.42)	
	51 - 65	15714 (36.53)	6506 (43.81)	
	66 - 80	19898 (46.26)	2323 (15.64)	

* The parametric p-value is calculated by chi-square test.

Table 14: Descriptive Statistics for Overall Survival in Stage 2 Breast Cancer

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 16,020	Implant Based Reconstruction N (%) = 3,034	
Facility Type	Community Cancer Program	1258 (8.38)	81 (3.11)	**<.001**
	Comprehensive Community Cancer Program	6308 (42.03)	898 (34.5)	
	Academic/Research Program	4692 (31.26)	1065 (40.91)	
	Integrated Network Cancer Program	2752 (18.33)	559 (21.48)	
Facility Location	New England	605 (4.03)	143 (5.49)	**<.001**
	Middle Atlantic	1865 (12.43)	650 (24.97)	
	South Atlantic	3760 (25.05)	612 (23.51)	
	East North Central	2576 (17.16)	364 (13.98)	
	East South Central	1006 (6.7)	101 (3.88)	
	West North Central	1057 (7.04)	150 (5.76)	
	West South Central	1672 (11.14)	181 (6.95)	
	Mountain	619 (4.12)	97 (3.73)	
	Pacific	1850 (12.33)	305 (11.72)	
Race	White	10689 (66.72)	2055 (67.73)	**<.001**
	Black	2804 (17.5)	502 (16.55)	
	Hispanic	1114 (6.95)	178 (5.87)	
	Asian	1413 (8.82)	299 (9.85)	
Insurance Status	Not Insured	1047 (6.54)	85 (2.8)	**<.001**
	Government Insurance	6578 (41.06)	494 (16.28)	
	Private Insurance	8395 (52.4)	2455 (80.92)	

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 16,020	Implant Based Reconstruction N (%) = 3,034	
Charlson-Deyo Score	0	12783 (79.79)	2682 (88.4)	**<.001**
	1	2460 (15.36)	297 (9.79)	
	2	492 (3.07)	43 (1.42)	
	>= 3	285 (1.78)	12 (0.4)	
Vital Status	Dead	6236 (38.93)	758 (24.98)	**<.001**
	Alive	9784 (61.07)	2276 (75.02)	
Median Income Quartiles 2016-2020	< $46,277	3147 (19.64)	321 (10.58)	**<.001**
	$46,227-$57,856	3820 (23.85)	443 (14.6)	
	$57,857-$74,062	3749 (23.4)	673 (22.18)	
	>= $74,063	5304 (33.11)	1597 (52.64)	
Age by Strata	18 - 30	160 (1)	68 (2.24)	**<.001**
	31 - 40	1031 (6.44)	434 (14.3)	
	41 - 50	2512 (15.68)	860 (28.35)	
	51 - 65	6636 (41.42)	1307 (43.08)	
	66 - 80	5681 (35.46)	365 (12.03)	

* The parametric p-value is calculated by chi-square test.

Table 15: Descriptive Statistics for Overall Survival in Stage 3 Breast Cancer

The four tables (Tables 12–15) provide a stratified descriptive analysis of surgical type (mastectomy only vs. implant-based reconstruction) across different cancer stages. Across all stages, the majority of patients underwent mastectomy alone, with the proportion opting for reconstruction decreasing as cancer stage advanced. In Stage 0 (Table 12), 44.2% of patients underwent implant-based reconstruction, whereas by Stage III (Table 15), only 16.3% did, suggesting a higher likelihood of reconstruction at earlier stages. Facility type distributions show that patients treated at comprehensive

community cancer programs and academic/research programs had higher rates of reconstruction across all stages, while those treated at community cancer programs had the lowest. Similarly, facility location trends indicate higher reconstruction rates in urban areas and lower rates in regions such as the East South Central and West North Central regions.

Across all stages, White patients had the highest rates of reconstruction, while Black, Hispanic, and Asian patients had lower rates (Tables 12–15). Insurance status was also associated with reconstruction rates, with privately insured patients having the highest proportion of reconstruction and uninsured patients the lowest. Government-insured patients had intermediate rates across all cancer stages. Charlson-Deyo comorbidity scores were inversely associated with reconstruction, with patients having fewer comorbidities being more likely to undergo reconstruction. Patients with a score of 0 comprised the majority of the reconstruction group in all cancer stages, while those with higher scores were less likely to receive reconstruction. Similarly, vital status varied by surgery type, with a higher proportion of deceased patients in the mastectomy-only group compared to the reconstruction group across all stages.

Income level followed a consistent trend, with higher-income patients more likely to undergo reconstruction, particularly in the ≥$74,063 income bracket (Tables 12–15). Age stratification reveals that younger patients were more likely to undergo reconstruction, with the highest proportion in the 41–50 age group across all cancer stages. In contrast, older patients (ages 66–80) had the lowest reconstruction rates. This trend was consistent across all cancer stages, though the magnitude of difference was more pronounced at earlier stages. Overall, these tables highlight differences in reconstruction rates by demographic, socioeconomic, and clinical factors, with noticeable disparities in access and utilization across cancer stages.

Table 16: Adjusted Hazard Ratios for Overall Survival by Cancer Stage

			Months (OS)	
Covariate	**Level**	**N**	**Hazard Ratio (95% CI)**	**HR P-value**
Surgery – Stage 0	Reconstruction	14880	0.49 (0.44-0.54)	**<.001**
	Mastectomy only	18750	REF	REF
Surgery – Stage 1	Reconstruction	21336	0.44 (0.39-0.50)	**<.001**
	Mastectomy only	44494	REF	REF
Surgery – Stage 2	Reconstruction	14852	0.39 (0.35-0.43)	**<.001**
	Mastectomy only	43016	REF	REF
Surgery – Stage 3	Reconstruction	3034	0.73 (0.68-0.79)	**<.001**
	Mastectomy only	16020	REF	REF

* Number of observations in the original data set = 176382. Number of observations used = 174944. Stage 0 included age and insurance as time-dependent covariates. Stage included reconstruction, insurance, comorbidity score, and age as time-dependent covariates. Stage 2 included reconstruction, insurance and age as time-dependent covariates. Stage 3 included age as a time-dependent covariate.

Table 16 presents the adjusted hazard ratios (HR) for overall survival (OS) comparing reconstruction to mastectomy-only patients, stratified by cancer stage. Across all stages, reconstruction is associated with a lower hazard of mortality compared to mastectomy alone. For Stage 0 patients, the hazard ratio for reconstruction is 0.49 (95% CI: 0.44–0.54), while Stage 1 patients have a hazard ratio of 0.44 (95% CI: 0.39–0.50). The hazard ratio further decreases for Stage 2 patients, at 0.39 (95% CI: 0.35–0.43), indicating the lowest relative hazard among the groups. However, in Stage 3 patients, the hazard ratio is higher at 0.73 (95% CI: 0.68–0.79), though still significantly lower than the reference group (mastectomy only). These results suggest that the relative survival benefit associated with reconstruction varies by stage, with the most pronounced difference observed in Stage 2 patients.

AGE STRATA

Table 16: Descriptive Statistics for Breast Cancer Patients Aged 18–30

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 539	Implant Based Reconstruction N (%) = 502	
Facility Type	Community Cancer Program	0	0	**NA**
	Comprehensive Community Cancer Program	0	0	
	Academic/Research Program	0	0	
	Integrated Network Cancer Program	0	0	
Facility Location	New England	0	0	**NA**
	Middle Atlantic	0	0	
	South Atlantic	0	0	
	East North Central	0	0	
	East South Central	0	0	
	West North Central	0	0	
	West South Central	0	0	
	Mountain	0	0	
	Pacific	0	0	
Race	White	282 (52.32)	319 (63.55)	**<.001**
	Black	93 (17.25)	82 (16.33)	
	Hispanic	82 (15.21)	39 (7.77)	
	Asian	82 (15.21)	62 (12.35)	
Insurance Status	Not Insured	81 (15.03)	22 (4.38)	**<.001**
	Government Insurance	36 (6.68)	21 (4.18)	
	Private Insurance	422 (78.29)	459 (91.43)	

Table 16: Descriptive Statistics for Breast Cancer Patients Aged 18–30

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 539	Implant Based Reconstruction N (%) = 502	
AJCC 7th Edition Cancer Stage	Stage 0	29 (5.38)	90 (17.93)	**<.001**
	Stage I	87 (16.14)	120 (23.9)	
	Stage II	263 (48.79)	224 (44.62)	
	Stage III	160 (29.68)	68 (13.55)	
Charlson-Deyo Score	0	512 (94.99)	477 (95.02)	0.583
	1	23 (4.27)	24 (4.78)	
	2	3 (0.56)	1 (0.2)	
	>= 3	1 (0.19)	0 (0)	
Vital Status	Dead	118 (21.89)	65 (12.95)	**<.001**
	Alive	421 (78.11)	437 (87.05)	
Median Income Quartiles 2016-2020	< $46,277	115 (21.34)	56 (11.16)	**<.001**
	$46,227-$57,856	134 (24.86)	104 (20.72)	
	$57,857-$74,062	127 (23.56)	109 (21.71)	
	>= $74,063	163 (30.24)	233 (46.41)	

* The parametric p-value is calculated by chi-square test.

Patients 35 and under had facility location and type omitted by NCDB.

Table 17: Descriptive Statistics for Breast Cancer Patients Aged 31–40

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 3,988	Implant Based Reconstruction N (%) = 4,217	
Facility Type	Community Cancer Program	53 (6.79)	29 (2.84)	**<.001**
	Comprehensive Community Cancer Program	338 (43.28)	362 (35.42)	
	Academic/Research Program	289 (37)	427 (41.78)	
	Integrated Network Cancer Program	101 (12.93)	204 (19.96)	
Facility Location	New England	24 (3.07)	72 (7.05)	**<.001**
	Middle Atlantic	70 (8.96)	215 (21.04)	
	South Atlantic	171 (21.9)	207 (20.25)	
	East North Central	111 (14.21)	190 (18.59)	
	East South Central	54 (6.91)	36 (3.52)	
	West North Central	52 (6.66)	63 (6.16)	
	West South Central	113 (14.47)	83 (8.12)	
	Mountain	32 (4.1)	35 (3.42)	
	Pacific	154 (19.72)	121 (11.84)	
Race	White	2183 (54.74)	2639 (62.58)	**<.001**
	Black	656 (16.45)	601 (14.25)	
	Hispanic	558 (13.99)	357 (8.47)	
	Asian	591 (14.82)	620 (14.7)	
Insurance Status	Not Insured	476 (11.94)	120 (2.85)	**<.001**
	Government Insurance	277 (6.95)	140 (3.32)	
	Private Insurance	3235 (81.12)	3957 (93.83)	

Table 17: Descriptive Statistics for Breast Cancer Patients Aged 31–40

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 3,988	Implant Based Reconstruction N (%) = 4,217	
AJCC 7th Edition Cancer Stage	Stage 0	435 (10.91)	956 (22.67)	**<.001**
	Stage I	730 (18.3)	1249 (29.62)	
	Stage II	1792 (44.93)	1578 (37.42)	
	Stage III	1031 (25.85)	434 (10.29)	
Charlson-Deyo Score	0	3695 (92.65)	3931 (93.22)	0.422
	1	255 (6.39)	259 (6.14)	
	2	28 (0.7)	20 (0.47)	
	>= 3	10 (0.25)	7 (0.17)	
Vital Status	Dead	659 (16.52)	356 (8.44)	**<.001**
	Alive	3329 (83.48)	3861 (91.56)	
Median Income Quartiles 2016-2020	< $46,277	689 (17.28)	426 (10.1)	**<.001**
	$46,227-$57,856	883 (22.14)	616 (14.61)	
	$57,857-$74,062	872 (21.87)	896 (21.25)	
	>= $74,063	1544 (38.72)	2279 (54.04)	

* The parametric p-value is calculated by chi-square test.

Patients 35 and under had facility location and type omitted by NCDB.

Table 18: Descriptive Statistics for Breast Cancer Patients Aged 41–50

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 13,400	Implant Based Reconstruction N (%) = 14,859	
Facility Type	Community Cancer Program	954 (7.12)	480 (3.23)	**<.001**
	Comprehensive Community Cancer Program	5637 (42.07)	5139 (34.59)	
	Academic/Research Program	4553 (33.98)	6120 (41.19)	
	Integrated Network Cancer Program	2256 (16.84)	3120 (21)	
Facility Location	New England	580 (4.33)	1009 (6.79)	**<.001**
	Middle Atlantic	1461 (10.9)	3306 (22.25)	
	South Atlantic	3303 (24.65)	3473 (23.37)	
	East North Central	2043 (15.25)	2439 (16.41)	
	East South Central	845 (6.31)	530 (3.57)	
	West North Central	823 (6.14)	918 (6.18)	
	West South Central	1522 (11.36)	966 (6.5)	
	Mountain	591 (4.41)	462 (3.11)	
	Pacific	2232 (16.66)	1756 (11.82)	
Race	White	8156 (60.87)	10470 (70.46)	**<.001**
	Black	2063 (15.4)	1748 (11.76)	
	Hispanic	1314 (9.81)	921 (6.2)	
	Asian	1867 (13.93)	1720 (11.58)	
Insurance Status	Not Insured	1146 (8.55)	324 (2.18)	**<.001**
	Government Insurance	1064 (7.94)	571 (3.84)	
	Private Insurance	11190 (83.51)	13964 (93.98)	

Table 18: Descriptive Statistics for Breast Cancer Patients Aged 41–50

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 13,400	Implant Based Reconstruction N (%) = 14,859	
AJCC 7th Edition Cancer Stage	Stage 0	1966 (14.67)	4451 (29.95)	**<.001**
	Stage I	3573 (26.66)	5327 (35.85)	
	Stage II	5349 (39.92)	4221 (28.41)	
	Stage III	2512 (18.75)	860 (5.79)	
Charlson-Deyo Score	0	11934 (89.06)	13491 (90.79)	**<.001**
	1	1211 (9.04)	1238 (8.33)	
	2	185 (1.38)	97 (0.65)	
	>= 3	70 (0.52)	33 (0.22)	
Vital Status	Dead	1893 (14.13)	848 (5.71)	**<.001**
	Alive	11507 (85.87)	14011 (94.29)	
Median Income Quartiles 2016-2020	< $46,277	2323 (17.34)	1269 (8.54)	**<.001**
	$46,227-$57,856	2889 (21.56)	2082 (14.01)	
	$57,857-$74,062	3166 (23.63)	3098 (20.85)	
	>= $74,063	5022 (37.48)	8410 (56.6)	

* The parametric p-value is calculated by chi-square test.

Table 19: Descriptive Statistics for Breast Cancer Patients Aged 51–65

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 44,210	Implant Based Reconstruction N (%) = 24,859	
Facility Type	Community Cancer Program	3673 (8.31)	924 (3.72)	**<.001**
	Comprehensive Community Cancer Program	19557 (44.24)	9248 (37.2)	
	Academic/Research Program	13046 (29.51)	9285 (37.35)	
	Integrated Network Cancer Program	7934 (17.95)	5402 (21.73)	
Facility Location	New England	1735 (3.92)	1514 (6.09)	**<.001**
	Middle Atlantic	5011 (11.33)	5007 (20.14)	
	South Atlantic	10166 (22.99)	5683 (22.86)	
	East North Central	7581 (17.15)	4219 (16.97)	
	East South Central	3449 (7.8)	1128 (4.54)	
	West North Central	3674 (8.31)	1783 (7.17)	
	West South Central	4312 (9.75)	1762 (7.09)	
	Mountain	1680 (3.8)	897 (3.61)	
	Pacific	6602 (14.93)	2866 (11.53)	
Race	White	30679 (69.39)	19143 (77.01)	**<.001**
	Black	6491 (14.68)	2726 (10.97)	
	Hispanic	2295 (5.19)	1069 (4.3)	
	Asian	4745 (10.73)	1921 (7.73)	
Insurance Status	Not Insured	2086 (4.72)	336 (1.35)	**<.001**
	Government Insurance	10331 (23.37)	2854 (11.48)	
	Private Insurance	31793 (71.91)	21669 (87.17)	

Table 19: Descriptive Statistics for Breast Cancer Patients Aged 51–65

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 44,210	Implant Based Reconstruction N (%) = 24,859	
AJCC 7th Edition Cancer Stage	Stage 0	7033 (15.91)	6976 (28.06)	**<.001**
	Stage I	14827 (33.54)	10070 (40.51)	
	Stage II	15714 (35.54)	6506 (26.17)	
	Stage III	6636 (15.01)	1307 (5.26)	
Charlson-Deyo Score	0	34717 (78.53)	21285 (85.62)	**<.001**
	1	7250 (16.4)	3041 (12.23)	
	2	1581 (3.58)	425 (1.71)	
	>= 3	662 (1.5)	108 (0.43)	
Vital Status	Dead	8192 (18.53)	1914 (7.7)	**<.001**
	Alive	36018 (81.47)	22945 (92.3)	
Median Income Quartiles 2016-2020	< $46,277	8360 (18.91)	2577 (10.37)	**<.001**
	$46,227-$57,856	10371 (23.46)	3852 (15.5)	
	$57,857-$74,062	10593 (23.96)	5635 (22.67)	
	>= $74,063	14886 (33.67)	12795 (51.47)	

* The parametric p-value is calculated by chi-square test.

Table 20: Descriptive Statistics for Breast Cancer Patients Aged 66–80

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 60,143	Implant Based Reconstruction N (%) = 9,665	
Facility Type	Community Cancer Program	5532 (9.2)	366 (3.79)	**<.001**
	Comprehensive Community Cancer Program	27891 (46.37)	3965 (41.02)	
	Academic/Research Program	14585 (24.25)	3253 (33.66)	
	Integrated Network Cancer Program	12135 (20.18)	2081 (21.53)	
Facility Location	New England	2468 (4.1)	559 (5.78)	**<.001**
	Middle Atlantic	7572 (12.59)	1862 (19.27)	
	South Atlantic	13843 (23.02)	2459 (25.44)	
	East North Central	10527 (17.5)	1438 (14.88)	
	East South Central	4729 (7.86)	410 (4.24)	
	West North Central	5597 (9.31)	668 (6.91)	
	West South Central	5358 (8.91)	721 (7.46)	
	Mountain	2276 (3.78)	369 (3.82)	
	Pacific	7773 (12.92)	1179 (12.2)	
Race	White	46226 (76.86)	7960 (82.36)	**<.001**
	Black	6773 (11.26)	789 (8.16)	
	Hispanic	2290 (3.81)	382 (3.95)	
	Asian	4854 (8.07)	534 (5.53)	
Insurance Status	Not Insured	360 (0.6)	27 (0.28)	**<.001**
	Government Insurance	52081 (86.6)	7998 (82.75)	
	Private Insurance	7702 (12.81)	1640 (16.97)	

Table 20: Descriptive Statistics for Breast Cancer Patients Aged 66–80

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 60,143	Implant Based Reconstruction N (%) = 9,665	
AJCC 7th Edition Cancer Stage	Stage 0	9287 (15.44)	2407 (24.9)	**<.001**
	Stage I	25277 (42.03)	4570 (47.28)	
	Stage II	19898 (33.08)	2323 (24.04)	
	Stage III	5681 (9.45)	365 (3.78)	
Charlson-Deyo Score	0	42179 (70.13)	7756 (80.25)	**<.001**
	1	12960 (21.55)	1533 (15.86)	
	2	3430 (5.7)	295 (3.05)	
	>= 3	1574 (2.62)	81 (0.84)	
Vital Status	Dead	17321 (28.8)	1139 (11.78)	**<.001**
	Alive	42822 (71.2)	8526 (88.22)	
Median Income Quartiles 2016-2020	< $46,277	11016 (18.32)	997 (10.32)	**<.001**
	$46,227-$57,856	14378 (23.91)	1626 (16.82)	
	$57,857-$74,062	14686 (24.42)	2165 (22.4)	
	>= $74,063	20063 (33.36)	4877 (50.46)	

* The parametric p-value is calculated by chi-square test.

The stratification of age into five groups (18–30, 31–40, 41–50, 51–65, and 66–80 years) provides insight into how patient demographics and clinical characteristics vary across different age ranges in relation to surgical choice (Tables 16–20). Across all age groups, the proportion of patients undergoing implant-based reconstruction is consistently higher among younger patients, while the proportion of patients undergoing mastectomy without reconstruction increases with age. Younger patients (Tables 16–17) who underwent either mastectomy alone or reconstruction were more likely to

be treated at academic/research programs, whereas older patients (Tables 19–20) had a higher percentage of cases managed at comprehensive community cancer programs. Facility location patterns were relatively consistent across age strata, with a higher proportion of patients treated in the South Atlantic and East North Central regions, regardless of surgical choice.

Racial distribution showed that White patients comprised the majority in all age groups, with a decreasing percentage of Black, Hispanic, and Asian patients as age increased (Tables 16–20). The proportion of uninsured patients was lowest in younger age groups, while government insurance coverage was more prevalent among older patients, particularly in those aged 51 and above (Tables 18–20). Charlson-Deyo comorbidity scores were heavily skewed by age, with almost all younger patients (Tables 16–17) having a score of 0, while a greater proportion of older patients (Tables 18–20) had higher comorbidity scores, particularly those undergoing mastectomy alone. Mortality rates increased with age, with the highest proportion of deceased patients observed in the oldest age strata (Tables 19–20).

Socioeconomic disparities were evident, as younger patients were more frequently in the highest median income quartile (≥$74,063), while older patients were more represented in lower-income quartiles, particularly those who underwent mastectomy alone. Across all age groups, implant-based reconstruction was more common among patients in higher-income quartiles, whereas mastectomy-only procedures were more frequent in lower-income groups. Overall, younger patients had higher rates of reconstruction, were more likely to be treated at academic institutions, and had fewer comorbidities compared to older patients, who had higher rates of mastectomy alone, increased comorbidity burden, and greater representation in government-insured or lower-income groups.

Table 21: Adjusted Hazard Ratios for Overall Survival by Age

			Months (OS)	
Covariate	**Level**	**N**	**Hazard Ratio (95% CI)**	**HR P-value**
Surgery – Age 18-30	Reconstruction	539	0.78 (0.56-1.07)	0.130
	Mastectomy only	502	REF	REF
Surgery – Age 31-40	Reconstruction	4217	0.47 (0.37-0.60)	**<.001**
	Mastectomy only	3988	REF	REF
Surgery – Age 41-50	Reconstruction	14859	0.50 (0.43-0.59)	**<.001**
	Mastectomy only	13400	REF	REF
Surgery – Age 51-65	Reconstruction	24859	0.50 (0.45-0.55)	**<.001**
	Mastectomy only	44210	REF	REF
Surgery – Age 66-80	Reconstruction	9665	0.39 (0.35-0.44)	**<.001**
	Mastectomy only	60143	REF	REF

* Number of observations in the original data set = 176382. Number of observations used = 174944. Age 18-30 included stage as a time-dependent covariate. Age 31-40 included reconstruction, and stage as time-dependent covariates. Age 41-50 included reconstruction, stage and income as time-dependent covariates. Age 51-65 included reconstruction, stage, and income as a time-dependent covariates. Age 66-80 included reconstruction, stage, and comorbidity index score as time-dependent covariates.

Table 21 presents the hazard ratios (HRs) for overall survival stratified by age group, comparing patients who underwent breast reconstruction to those who received mastectomy alone. The analysis includes five age strata: 18–30, 31–40, 41–50, 51–65, and 66–80 years.

For the youngest age group (18–30 years), the hazard ratio for reconstruction was 0.78 (95% CI: 0.56–1.07) with a p-value of 0.130, indicating no statistically significant difference in survival between reconstruction and mastectomy alone. In contrast, patients in the 31–40 age group who underwent reconstruction had a significantly lower hazard of mortality (HR = 0.47, 95% CI: 0.37–0.60, $p < 0.001$)

compared to those who had mastectomy alone. Similarly, in the 41–50 age group, reconstruction was associated with a hazard ratio of 0.50 (95% CI: 0.43–0.59, $p < 0.001$), and in the 51–65 age group, the hazard ratio was 0.50 (95% CI: 0.45–0.55, $p < 0.001$), both indicating significantly lower mortality risk compared to mastectomy alone.

For the oldest age group (66–80 years), reconstruction was still associated with a significantly lower hazard ratio of 0.39 (95% CI: 0.35–0.44, $p < 0.001$), suggesting a persistent association between reconstruction and lower mortality across most age groups.

Race Strata

Table 22: Descriptive Statistics for White Breast Cancer Patients

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 87,526	Reconstruction N (%) = 40,531	
Facility Type	Community Cancer Program	7961 (9.31)	1429 (3.74)	**<.001**
	Comprehensive Community Cancer Program	40132 (46.95)	14618 (38.22)	
	Academic/Research Program	20964 (24.53)	13965 (36.52)	
	Integrated Network Cancer Program	16422 (19.21)	8232 (21.52)	
Facility Location	New England	4080 (4.77)	2687 (7.03)	**<.001**
	Middle Atlantic	9662 (11.3)	7515 (19.65)	
	South Atlantic	18995 (22.22)	8432 (22.05)	
	East North Central	16347 (19.12)	6798 (17.78)	
	East South Central	6800 (7.96)	1708 (4.47)	
	West North Central	8650 (10.12)	3019 (7.89)	
	West South Central	6768 (7.92)	2466 (6.45)	
	Mountain	3669 (4.29)	1477 (3.86)	
	Pacific	10508 (12.29)	4142 (10.83)	
Insurance Status	Not Insured	1607 (1.84)	364 (0.9)	**<.001**
	Government Insurance	48275 (55.16)	9202 (22.7)	
	Private Insurance	37644 (43.01)	30965 (76.4)	
AJCC 7th Edition Cancer Stage	Stage 0	12637 (14.44)	10888 (26.86)	**<.001**
	Stage I	33820 (38.64)	16650 (41.08)	
	Stage II	30380 (34.71)	10938 (26.99)	
	Stage III	10689 (12.21)	2055 (5.07)	

Table 22: Descriptive Statistics for White Breast Cancer Patients

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 87,526	Reconstruction N (%) = 40,531	
Charlson-Deyo Score	0	67232 (76.81)	35513 (87.62)	**<.001**
	1	15022 (17.16)	4299 (10.61)	
	2	3723 (4.25)	566 (1.4)	
	>= 3	1549 (1.77)	153 (0.38)	
Vital Status	Dead	20690 (23.64)	3230 (7.97)	**<.001**
	Alive	66836 (76.36)	37301 (92.03)	
Median Income Quartiles 2016-2020	< $46,277	12623 (14.42)	2970 (7.33)	**<.001**
	$46,227-$57,856	21313 (24.35)	6039 (14.9)	
	$57,857-$74,062	22497 (25.7)	8967 (22.12)	
	>= $74,063	31093 (35.52)	22555 (55.65)	
Age by Strata	18 - 30	282 (0.32)	319 (0.79)	**<.001**
	31 - 40	2183 (2.49)	2639 (6.51)	
	41 - 50	8156 (9.32)	10470 (25.83)	
	51 - 65	30679 (35.05)	19143 (47.23)	
	66 - 80	46226 (52.81)	7960 (19.64)	

* The parametric p-value is calculated by chi-square test.

Table 23: Descriptive Statistics for Black and Afro-Latino Breast Cancer Patients

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 16,076	Reconstruction N (%) = 5,946	
Facility Type	Community Cancer Program	897 (5.81)	127 (2.35)	**<.001**
	Comprehensive Community Cancer Program	5942 (38.5)	1647 (30.54)	
	Academic/Research Program	5640 (36.55)	2416 (44.8)	
	Integrated Network Cancer Program	2954 (19.14)	1203 (22.31)	
Facility Location	New England	297 (1.92)	176 (3.26)	**<.001**
	Middle Atlantic	1941 (12.58)	1279 (23.72)	
	South Atlantic	5881 (38.11)	2053 (38.07)	
	East North Central	2266 (14.68)	795 (14.74)	
	East South Central	1695 (10.98)	276 (5.12)	
	West North Central	547 (3.54)	114 (2.11)	
	West South Central	1915 (12.41)	430 (7.97)	
	Mountain	113 (0.73)	50 (0.93)	
	Pacific	778 (5.04)	220 (4.08)	
Insurance Status	Not Insured	884 (5.5)	142 (2.39)	**<.001**
	Government Insurance	8181 (50.89)	1247 (20.97)	
	Private Insurance	7011 (43.61)	4557 (76.64)	
AJCC 7th Edition Cancer Stage	Stage 0	2873 (17.87)	1860 (31.28)	**<.001**
	Stage I	4640 (28.86)	1948 (32.76)	
	Stage II	5759 (35.82)	1636 (27.51)	
	Stage III	2804 (17.44)	502 (8.44)	

Table 23: Descriptive Statistics for Black and Afro-Latino Breast Cancer Patients

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 16,076	Reconstruction N (%) = 5,946	
Charlson-Deyo Score	0	11000 (68.42)	4762 (80.09)	**<.001**
	1	3638 (22.63)	969 (16.3)	
	2	910 (5.66)	164 (2.76)	
	>= 3	528 (3.28)	51 (0.86)	
Vital Status	Dead	4526 (28.15)	644 (10.83)	**<.001**
	Alive	11550 (71.85)	5302 (89.17)	
Median Income Quartiles 2016-2020	< $46,277	6762 (42.06)	1613 (27.13)	**<.001**
	$46,227-$57,856	3902 (24.27)	1260 (21.19)	
	$57,857-$74,062	2740 (17.04)	1254 (21.09)	
	>= $74,063	2672 (16.62)	1819 (30.59)	
Age by Strata	18 - 30	93 (0.58)	82 (1.38)	**<.001**
	31 - 40	656 (4.08)	601 (10.11)	
	41 - 50	2063 (12.83)	1748 (29.4)	
	51 - 65	6491 (40.38)	2726 (45.85)	
	66 - 80	6773 (42.13)	789 (13.27)	

* The parametric p-value is calculated by chi-square test.

Table 24: Descriptive Statistics for White-Latino Breast Cancer Patients

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 6,539	Reconstruction N (%) = 2,768	
Facility Type	Community Cancer Program	444 (7.37)	102 (4.16)	**<.001**
	Comprehensive Community Cancer Program	2561 (42.52)	879 (35.85)	
	Academic/Research Program	2172 (36.06)	945 (38.54)	
	Integrated Network Cancer Program	846 (14.05)	526 (21.45)	
Facility Location	New England	128 (2.13)	84 (3.43)	**<.001**
	Middle Atlantic	625 (10.38)	499 (20.35)	
	South Atlantic	920 (15.27)	529 (21.57)	
	East North Central	402 (6.67)	200 (8.16)	
	East South Central	38 (0.63)	13 (0.53)	
	West North Central	97 (1.61)	27 (1.1)	
	West South Central	1680 (27.89)	378 (15.42)	
	Mountain	433 (7.19)	122 (4.98)	
	Pacific	1700 (28.23)	600 (24.47)	
Insurance Status	Not Insured	1124 (17.19)	217 (7.84)	**<.001**
	Government Insurance	2450 (37.47)	479 (17.3)	
	Private Insurance	2965 (45.34)	2072 (74.86)	
AJCC 7th Edition Cancer Stage	Stage 0	959 (14.67)	719 (25.98)	**<.001**
	Stage I	1872 (28.63)	988 (35.69)	
	Stage II	2594 (39.67)	883 (31.9)	
	Stage III	1114 (17.04)	178 (6.43)	

Table 24: Descriptive Statistics for White-Latino Breast Cancer Patients

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 6,539	Reconstruction N (%) = 2,768	
Charlson-Deyo Score	0	5090 (77.84)	2364 (85.4)	**<.001**
	1	1152 (17.62)	345 (12.46)	
	2	207 (3.17)	47 (1.7)	
	>= 3	90 (1.38)	12 (0.43)	
Vital Status	Dead	1076 (16.46)	179 (6.47)	**<.001**
	Alive	5463 (83.54)	2589 (93.53)	
Median Income Quartiles 2016-2020	< $46,277	1699 (25.98)	412 (14.88)	**<.001**
	$46,227-$57,856	1413 (21.61)	447 (16.15)	
	$57,857-$74,062	1616 (24.71)	722 (26.08)	
	>= $74,063	1811 (27.7)	1187 (42.88)	
Age by Strata	18 - 30	82 (1.25)	39 (1.41)	**<.001**
	31 - 40	558 (8.53)	357 (12.9)	
	41 - 50	1314 (20.09)	921 (33.27)	
	51 - 65	2295 (35.1)	1069 (38.62)	
	66 - 80	2290 (35.02)	382 (13.8)	

* The parametric p-value is calculated by chi-square test.

Table 25: Descriptive Statistics for Asian Breast Cancer Patients

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 12,139	Reconstruction N (%) = 4,857	
Facility Type	Community Cancer Program	910 (7.85)	141 (3.27)	**<.001**
	Comprehensive Community Cancer Program	4788 (41.28)	1570 (36.38)	
	Academic/Research Program	3697 (31.87)	1759 (40.76)	
	Integrated Network Cancer Program	2204 (19)	846 (19.6)	
Facility Location	New England	302 (2.6)	207 (4.8)	**<.001**
	Middle Atlantic	1886 (16.26)	1097 (25.42)	
	South Atlantic	1687 (14.54)	808 (18.72)	
	East North Central	1247 (10.75)	493 (11.42)	
	East South Central	544 (4.69)	107 (2.48)	
	West North Central	852 (7.35)	272 (6.3)	
	West South Central	942 (8.12)	258 (5.98)	
	Mountain	364 (3.14)	114 (2.64)	
	Pacific	3775 (32.55)	960 (22.24)	
Insurance Status	Not Insured	534 (4.4)	106 (2.18)	**<.001**
	Government Insurance	4883 (40.23)	656 (13.51)	
	Private Insurance	6722 (55.38)	4095 (84.31)	
AJCC 7th Edition Cancer Stage	Stage 0	2281 (18.79)	1413 (29.09)	**<.001**
	Stage I	4162 (34.29)	1750 (36.03)	
	Stage II	4283 (35.28)	1395 (28.72)	
	Stage III	1413 (11.64)	299 (6.16)	

Table 25: Descriptive Statistics for Asian Breast Cancer Patients

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 12,139	Reconstruction N (%) = 4,857	
Charlson-Deyo Score	0	9715 (80.03)	4301 (88.55)	**<.001**
	1	1887 (15.54)	482 (9.92)	
	2	387 (3.19)	61 (1.26)	
	>= 3	150 (1.24)	13 (0.27)	
Vital Status	Dead	1891 (15.58)	269 (5.54)	**<.001**
	Alive	10248 (84.42)	4588 (94.46)	
Median Income Quartiles 2016-2020	< $46,277	1419 (11.69)	330 (6.79)	**<.001**
	$46,227-$57,856	2027 (16.7)	534 (10.99)	
	$57,857-$74,062	2591 (21.34)	960 (19.77)	
	>= $74,063	6102 (50.27)	3033 (62.45)	
Age by Strata	18 - 30	82 (0.68)	62 (1.28)	**<.001**
	31 - 40	591 (4.87)	620 (12.77)	
	41 - 50	1867 (15.38)	1720 (35.41)	
	51 - 65	4745 (39.09)	1921 (39.55)	
	66 - 80	4854 (39.99)	534 (10.99)	

* The parametric p-value is calculated by chi-square test.

Table 22 displays descriptive statistics for White breast cancer patients stratified by surgery type. Among 87,526 White patients who underwent mastectomy alone, the majority were treated at comprehensive community programs (46.95%), while 24.53% were treated at academic centers. In contrast, among the 40,531 White patients who underwent reconstruction, 38.22% were treated at comprehensive community centers, and 36.52% at academic centers. Private insurance coverage was

reported in 76.4% of the reconstruction group compared to 43.01% in the mastectomy-only group. A higher proportion of reconstructive patients were alive at follow-up (92.03% vs. 76.36%). Additionally, 87.62% of reconstructive patients had a Charlson-Deyo score of 0, compared to 76.81% in the mastectomy group. Patients with reconstruction more frequently belonged to higher income brackets and younger age groups.

Table 23 summarizes the characteristics for Black and Afro-Latino patients. Of 16,076 mastectomy-only patients, the majority received care at comprehensive or academic programs, with 38.5% and 36.55% respectively. Among the 5,946 patients who underwent reconstruction, the proportion treated at academic centers was higher (44.8%). Private insurance was more prevalent among reconstructive patients (76.64% vs. 43.61%). Patients with a Charlson-Deyo score of 0 made up 80.09% of the reconstruction group versus 68.42% of the mastectomy-only group. Income and age distributions also varied by surgery type, with reconstructive patients more likely to be in younger age strata and higher income quartiles.

Table 24 reports data for White-Latino breast cancer patients (N = 9,307). Of the 6,539 patients in the mastectomy-only group, 42.52% were treated at comprehensive community programs, while 36.06% were treated at academic centers. In the reconstruction group (N = 2,768), a higher percentage were treated at academic centers (38.54%). Private insurance coverage was found in 74.86% of reconstructive patients compared to 45.34% in the mastectomy-only group. A greater proportion of patients in the reconstruction group had a Charlson-Deyo score of 0 (85.4% vs. 77.84%) and were alive at follow-up (93.53% vs. 83.54%). The reconstruction group was also younger on average and more concentrated in the upper income brackets.

Table 25 presents descriptive statistics for Asian patients. Of the 12,139 mastectomy-only patients, 41.28% were treated at comprehensive community programs and 31.87% at academic centers. In the reconstruction group (N = 4,857), 40.76% were treated at academic centers and 36.38% at comprehensive community programs. The proportion with private insurance was higher in the reconstruction group (84.31% vs. 55.38%). The percentage of patients with a Charlson-Deyo score of 0 was also higher among reconstructive patients (88.55% vs. 80.03%). Finally, the reconstruction group had a larger share of younger patients and those in the highest income quartile (62.45% vs. 50.27%).

Table 26: Adjusted Hazard Ratios for Overall Survival by Race

			Months (OS)	
Covariate	**Level**	**N**	**Hazard Ratio (95% CI)**	**HR P-value**
Surgery – White	Reconstruction	40531	0.45 (0.42-0.48)	**<.001**
	Mastectomy only	87526	REF	REF
Surgery – Black/Black-Hispanic	Reconstruction	5946	0.46 (0.39-0.53)	**<.001**
	Mastectomy only	16076	REF	REF
Surgery – White-Hispanic	Reconstruction	6539	0.44 (0.33-0.60)	**<.001**
	Mastectomy only	2768	REF	REF
Surgery – Asian	Reconstruction	4857	0.45 (0.35-0.59)	**<.001**
	Mastectomy only	12139	REF	REF

* Number of observations in the original data set = 176382. Number of observations used = 174944. White included reconstruction, stage, insurance, and age as time-dependent covariates. Black/Black-Hispanic included reconstruction, stage, insurance, and age as time-dependent covariates. White-Hispanic included reconstruction, stage and age as time-dependent covariates. Asian included reconstruction, stage, and age as a time-dependent covariates.

Adjusted Cox proportional hazards models were conducted to evaluate the association between reconstruction and overall survival across racial and ethnic subgroups (Table 26). Among White patients, those who underwent reconstruction (N = 40,531) had a significantly lower hazard of death compared to those who received mastectomy alone (N = 87,526), with an adjusted hazard ratio (HR) of 0.45 (95% CI: 0.42–0.48, $p < .001$). Similarly, Black or Black-Hispanic patients who received reconstruction (N = 5,946) had an HR of 0.46 (95% CI: 0.39–0.53, $p < .001$) compared to their mastectomy-only counterparts (N = 16,076). For White-Hispanic patients, reconstruction (N = 6,539) was associated with an HR of 0.44 (95% CI: 0.33–0.60, $p < .001$) relative to mastectomy alone (N = 2,768). Among Asian patients, those who

underwent reconstruction (N = 4,857) also demonstrated improved survival, with an HR of 0.45 (95% CI: 0.35–0.59, $p < .001$), compared to the mastectomy-only group (N = 12,139).

Comorbid Strata

Table 27: Descriptive Statistics for Patients with a Charlson Comorbidity Score of 0

Covariate	Level	Surgery Type: Mastectomy only N (%) = 93,037	Surgery Type: Reconstruction N (%) = 46,940	Parametric P-value*
Facility Type	Community Cancer Program	7720 (8.62)	1562 (3.59)	**<.001**
	Comprehensive Community Cancer Program	40098 (44.78)	16227 (37.31)	
	Academic/Research Program	25092 (28.02)	16497 (37.93)	
	Integrated Network Cancer Program	16644 (18.59)	9202 (21.16)	
Facility Location	New England	3699 (4.13)	2731 (6.28)	**<.001**
	Middle Atlantic	10681 (11.93)	8927 (20.53)	
	South Atlantic	20604 (23.01)	10154 (23.35)	
	East North Central	15105 (16.87)	7108 (16.34)	
	East South Central	6641 (7.42)	1815 (4.17)	
	West North Central	7566 (8.45)	2977 (6.85)	
	West South Central	8428 (9.41)	3041 (6.99)	
	Mountain	3622 (4.04)	1560 (3.59)	
	Pacific	13208 (14.75)	5175 (11.9)	
Insurance Status	Not Insured	3451 (3.71)	731 (1.56)	**<.001**
	Government Insurance	44283 (47.6)	9201 (19.6)	
	Private Insurance	45303 (48.69)	37008 (78.84)	
Race	White	67232 (72.26)	35513 (75.66)	**<.001**
	Black	11000 (11.82)	4762 (10.14)	
	Hispanic	5090 (5.47)	2364 (5.04)	
	Asian	9715 (10.44)	4301 (9.16)	

Table 27: Descriptive Statistics for Patients with a Charlson Comorbidity Score of 0

Covariate	Level	Surgery Type: Mastectomy only N (%) = 93,037	Surgery Type: Reconstruction N (%) = 46,940	Parametric P-value*
AJCC 7th Edition Cancer Stage	Stage 0	14341 (15.41)	12824 (27.32)	**<.001**
	Stage I	33415 (35.92)	18552 (39.52)	
	Stage II	32498 (34.93)	12882 (27.44)	
	Stage III	12783 (13.74)	2682 (5.71)	
Vital Status	Dead	18434 (19.81)	3536 (7.53)	**<.001**
	Alive	74603 (80.19)	43404 (92.47)	
Median Income Quartiles 2016-2020	< $46,277	16102 (17.31)	4386 (9.34)	**<.001**
	$46,227-$57,856	21335 (22.93)	7036 (14.99)	
	$57,857-$74,062	22389 (24.06)	10238 (21.81)	
	>= $74,063	33211 (35.7)	25280 (53.86)	
Age by Strata	18 - 30	512 (0.55)	477 (1.02)	**<.001**
	31 - 40	3695 (3.97)	3931 (8.37)	
	41 - 50	11934 (12.83)	13491 (28.74)	
	51 - 65	34717 (37.32)	21285 (45.35)	
	66 - 80	42179 (45.34)	7756 (16.52)	

* The parametric p-value is calculated by chi-square test.

Table 28: Descriptive Statistics for Patients with a Charlson Comorbidity Score of 1

Covariate	Level	Surgery Type: Mastectomy only N (%) = 21,699	Surgery Type: Reconstruction N (%) = 6,095	Parametric P-value*
Facility Type	Community Cancer Program	1897 (8.83)	193 (3.29)	**<.001**
	Comprehensive Community Cancer Program	9824 (45.75)	2104 (35.84)	
	Academic/Research Program	5493 (25.58)	2198 (37.44)	
	Integrated Network Cancer Program	4259 (19.83)	1375 (23.42)	
Facility Location	New England	815 (3.8)	378 (6.44)	**<.001**
	Middle Atlantic	2559 (11.92)	1254 (21.36)	
	South Atlantic	5161 (24.03)	1434 (24.43)	
	East North Central	3726 (17.35)	981 (16.71)	
	East South Central	1801 (8.39)	235 (4)	
	West North Central	1859 (8.66)	381 (6.49)	
	West South Central	2188 (10.19)	414 (7.05)	
	Mountain	737 (3.43)	167 (2.84)	
	Pacific	2627 (12.23)	626 (10.66)	
Insurance Status	Not Insured	570 (2.63)	91 (1.49)	**<.001**
	Government Insurance	13848 (63.82)	1895 (31.09)	
	Private Insurance	7281 (33.55)	4109 (67.42)	
Race	White	15022 (69.23)	4299 (70.53)	**<.001**
	Black	3638 (16.77)	969 (15.9)	
	Hispanic	1152 (5.31)	345 (5.66)	
	Asian	1887 (8.7)	482 (7.91)	

Table 28: Descriptive Statistics for Patients with a Charlson Comorbidity Score of 1

Covariate	Level	Surgery Type: Mastectomy only N (%) = 21,699	Surgery Type: Reconstruction N (%) = 6,095	Parametric P-value*
AJCC 7th Edition Cancer Stage	Stage 0	3290 (15.16)	1760 (28.88)	**<.001**
	Stage I	8238 (37.96)	2354 (38.62)	
	Stage II	7711 (35.54)	1684 (27.63)	
	Stage III	2460 (11.34)	297 (4.87)	
Vital Status	Dead	6511 (30.01)	623 (10.22)	**<.001**
	Alive	15188 (69.99)	5472 (89.78)	
Median Income Quartiles 2016-2020	< $46,277	4663 (21.49)	767 (12.58)	**<.001**
	$46,227-$57,856	5384 (24.81)	1043 (17.11)	
	$57,857-$74,062	5263 (24.25)	1414 (23.2)	
	>= $74,063	6389 (29.44)	2871 (47.1)	
Age by Strata	18 - 30	23 (0.11)	24 (0.39)	**<.001**
	31 - 40	255 (1.18)	259 (4.25)	
	41 - 50	1211 (5.58)	1238 (20.31)	
	51 - 65	7250 (33.41)	3041 (49.89)	
	66 - 80	12960 (59.73)	1533 (25.15)	

* The parametric p-value is calculated by chi-square test.

Table 29: Descriptive Statistics for Patients with a Charlson Comorbidity Score of 2

Covariate	Level	Surgery Type: Mastectomy only N (%) = 5,227	Surgery Type: Reconstruction N (%) = 838	Parametric P-value*
Facility Type	Community Cancer Program	421 (8.1)	37 (4.5)	**<.001**
	Comprehensive Community Cancer Program	2432 (46.78)	312 (37.91)	
	Academic/Research Program	1287 (24.75)	297 (36.09)	
	Integrated Network Cancer Program	1059 (20.37)	177 (21.51)	
Facility Location	New England	214 (4.12)	31 (3.77)	**<.001**
	Middle Atlantic	616 (11.85)	168 (20.41)	
	South Atlantic	1217 (23.41)	199 (24.18)	
	East North Central	957 (18.41)	149 (18.1)	
	East South Central	439 (8.44)	42 (5.1)	
	West North Central	498 (9.58)	52 (6.32)	
	West South Central	480 (9.23)	59 (7.17)	
	Mountain	158 (3.04)	27 (3.28)	
	Pacific	620 (11.93)	96 (11.66)	
Insurance Status	Not Insured	89 (1.7)	5 (0.6)	**<.001**
	Government Insurance	3845 (73.56)	382 (45.58)	
	Private Insurance	1293 (24.74)	451 (53.82)	
Race	White	3723 (71.23)	566 (67.54)	**<.001**
	Black	910 (17.41)	164 (19.57)	
	Hispanic	207 (3.96)	47 (5.61)	
	Asian	387 (7.4)	61 (7.28)	

Table 29: Descriptive Statistics for Patients with a Charlson Comorbidity Score of 2

Covariate	Level	Surgery Type: Mastectomy only N (%) = 5,227	Surgery Type: Reconstruction N (%) = 838	Parametric P-value*
AJCC 7th Edition Cancer Stage	Stage 0	811 (15.52)	236 (28.16)	**<.001**
	Stage I	2001 (38.28)	351 (41.89)	
	Stage II	1923 (36.79)	208 (24.82)	
	Stage III	492 (9.41)	43 (5.13)	
Vital Status	Dead	2101 (40.2)	129 (15.39)	**<.001**
	Alive	3126 (59.8)	709 (84.61)	
Median Income Quartiles 2016-2020	< $46,277	1180 (22.58)	133 (15.87)	**<.001**
	$46,227-$57,856	1304 (24.95)	156 (18.62)	
	$57,857-$74,062	1241 (23.74)	189 (22.55)	
	>= $74,063	1502 (28.74)	360 (42.96)	
Age by Strata	18 - 30	3 (0.06)	1 (0.12)	**<.001**
	31 - 40	28 (0.54)	20 (2.39)	
	41 - 50	185 (3.54)	97 (11.58)	
	51 - 65	1581 (30.25)	425 (50.72)	
	66 - 80	3430 (65.62)	295 (35.2)	

* The parametric p-value is calculated by chi-square test.

Table 30: Descriptive Statistics for Patients with a Charlson Comorbidity Score of 3 or Greater

Covariate	Level	Surgery Type		Parametric P-value*
		Mastectomy only N (%) = 2,317	Reconstruction N (%) = 229	
Facility Type	Community Cancer Program	174 (7.54)	7 (3.13)	**<.001**
	Comprehensive Community Cancer Program	1069 (46.32)	71 (31.7)	
	Academic/Research Program	601 (26.04)	93 (41.52)	
	Integrated Network Cancer Program	464 (20.1)	53 (23.66)	
Facility Location	New England	79 (3.42)	14 (6.25)	**0.006**
	Middle Atlantic	258 (11.18)	41 (18.3)	
	South Atlantic	501 (21.71)	35 (15.63)	
	East North Central	474 (20.54)	48 (21.43)	
	East South Central	196 (8.49)	12 (5.36)	
	West North Central	223 (9.66)	22 (9.82)	
	West South Central	209 (9.06)	18 (8.04)	
	Mountain	62 (2.69)	9 (4.02)	
	Pacific	306 (13.26)	25 (11.16)	
Insurance Status	Not Insured	39 (1.68)	2 (0.87)	**<.001**
	Government Insurance	1813 (78.25)	106 (46.29)	
	Private Insurance	465 (20.07)	121 (52.84)	
Race	White	1549 (66.85)	153 (66.81)	0.756
	Black	528 (22.79)	51 (22.27)	
	Hispanic	90 (3.88)	12 (5.24)	
	Asian	150 (6.47)	13 (5.68)	

Table 30: Descriptive Statistics for Patients with a Charlson Comorbidity Score of 3 or Greater

Covariate	Level	Surgery Type: Mastectomy only N (%) = 2,317	Surgery Type: Reconstruction N (%) = 229	Parametric P-value*
AJCC 7th Edition Cancer Stage	Stage 0	308 (13.29)	60 (26.2)	**<.001**
	Stage I	840 (36.25)	79 (34.5)	
	Stage II	884 (38.15)	78 (34.06)	
	Stage III	285 (12.3)	12 (5.24)	
Vital Status	Dead	1137 (49.07)	34 (14.85)	**<.001**
	Alive	1180 (50.93)	195 (85.15)	
Median Income Quartiles 2016-2020	< $46,277	558 (24.08)	39 (17.03)	**<.001**
	$46,227-$57,856	632 (27.28)	45 (19.65)	
	$57,857-$74,062	551 (23.78)	62 (27.07)	
	>= $74,063	576 (24.86)	83 (36.24)	
Age by Strata	18 - 30	1 (0.04)	0 (0)	**<.001**
	31 - 40	10 (0.43)	7 (3.06)	
	41 - 50	70 (3.02)	33 (14.41)	
	51 - 65	662 (28.57)	108 (47.16)	
	66 - 80	1574 (67.93)	81 (35.37)	

* The parametric p-value is calculated by chi-square test.

Among patients with a comorbidity score of 0 (Table 27), a total of 139,977 patients were analyzed, including 93,037 (66.5%) who underwent mastectomy only and 46,940 (33.5%) who received breast reconstruction. A higher proportion of patients who underwent reconstruction were treated at academic/research programs (37.9%) compared to those in the mastectomy-only group (28.0%). Patients who underwent reconstruction were also more likely to be privately insured (78.8% vs 48.7%),

White (75.7% vs 72.3%), and reside in higher-income quartiles. Most reconstructed patients had stage I or II disease and were alive at the time of last follow-up.

For patients with a comorbidity score of 1 (Table 28), 21,699 underwent mastectomy alone (78.1%) and 6,095 underwent reconstruction (21.9%). Similar patterns were observed with higher reconstruction rates among those treated at academic facilities and among privately insured, White, and higher-income individuals. The most common stages were stage I and II, and 90% of reconstruction patients were alive at last follow-up.

Among those with a comorbidity score of 2 (Table 29), 5,227 underwent mastectomy only, while 838 received reconstruction. The reconstruction group was more likely to be privately insured (53.8% vs 24.7%) and reside in higher-income quartiles. Stage I and II disease were again the most common in this cohort, and patients undergoing reconstruction had higher survival rates at follow-up (84.6% vs 59.8%).

In the highest comorbidity group (score ≥3; Table 30), only 229 patients underwent reconstruction, compared to 2,317 who received mastectomy alone. Reconstruction patients were more commonly treated at academic centers (41.5%), had private insurance (52.8%), and were more likely to be younger, with 47.2% aged 51–65 years. Most patients in the reconstruction group had stage I or II disease and a greater proportion were alive at follow-up (85.2% vs 50.9%).

Table 31: Adjusted Hazard Ratios for Overall Survival by Charlson Comorbidity Score

			Months (OS)	
Covariate	**Level**	**N**	**Hazard Ratio (95% CI)**	**HR P-value**
Surgery – Charlson Score 0	Reconstruction	46940	0.45 (0.42-0.48)	**<.001**
	Mastectomy only	93037	REF	REF
Surgery – Charlson Score 1	Reconstruction	6095	0.46 (0.39-0.53)	**<.001**
	Mastectomy only	21699	REF	REF
Surgery – Charlson Score 2	Reconstruction	838	0.44 (0.33-0.60)	**<.001**
	Mastectomy only	5227	REF	REF
Surgery – Charlson Score ≥ 3	Reconstruction	229	0.32 (0.23-0.45)	**<.001**
	Mastectomy only	2317	REF	REF

* Number of observations in the original data set = 176382. Number of observations used = 174944. Score 0 included reconstruction, stage, income, race, insurance, and age as time-dependent covariates. Score 1 included reconstruction, stage, and insurance as time-dependent covariates. Score 2 included reconstruction, stage and age as time-dependent covariates. Score 3 included reconstruction and stage as a time-dependent covariates.

Adjusted hazard ratios for overall survival were estimated separately for each comorbidity stratum (Table 31). Among patients with a Charlson-Deyo score of 0, those who underwent reconstruction had a significantly lower risk of death compared to those who received mastectomy alone, with an adjusted hazard ratio (HR) of 0.45 (95% CI: 0.42–0.48; $p < .001$).

In patients with a comorbidity score of 1, reconstruction was similarly associated with improved survival (HR: 0.46; 95% CI: 0.39–0.53; $p < .001$). Among those with a score of 2, the adjusted hazard ratio was 0.44 (95% CI: 0.33–0.60; $p < .001$), and for patients with a score of 3 or greater, the hazard ratio remained significant at 0.32 (95% CI: 0.23–0.45; $p < .001$).

Discussion:

Summary of Key Findings

The primary objective of this study was to investigate the association between breast reconstruction and overall survival among patients undergoing mastectomy for breast cancer, using a large, nationally representative dataset from the National Cancer Database (NCDB). This retrospective cohort included 176,382 patients who underwent mastectomy or mastectomy with reconstruction between 2010 and 2017. The analysis demonstrated a significant survival benefit associated with breast reconstruction. In a multivariable Cox proportional hazards model adjusting for age, cancer stage, comorbidities, income, education, race, and insurance status, mastectomy with reconstruction was associated with a significantly lower hazard of mortality compared to mastectomy alone (adjusted HR = 0.45; 95% CI: 0.42–0.48; $p < 0.001$), as shown in Table 11. This association was consistently observed across both unadjusted and adjusted Cox models and was additionally supported by the Kaplan-Meier curves, which demonstrated higher survival probabilities for the reconstruction group at both 12 and 60 months.

Interpretation of Primary Outcome: Mastectomy vs Mastectomy with Reconstruction

The observed survival benefit in our study—reflected by an adjusted hazard ratio (aHR) of 0.45 for patients undergoing breast reconstruction compared to mastectomy alone—aligns with multiple retrospective analyses using large population-based datasets. For example, a 2021 study from the University of California San Diego demonstrated a significant overall survival advantage for patients undergoing both implant-based and autologous reconstruction, reporting an aHR of 0.47 (95% CI, 0.25–0.88) [13]. Similarly, Bezuhly et al. analyzed over 50,000 SEER database patients and found a breast

cancer-specific survival benefit in those undergoing immediate breast reconstruction, with hazard ratios ranging from 0.66 to 0.75 depending on age group [14]. Additional SEER-based studies from the University of Utah and Wu et al. further support this trend, with adjusted HRs of 0.73 [15] and 0.83 [18], respectively, in reconstructed patients. Even smaller European cohorts, such as the Swedish DIEP flap study, reported comparable effects (aHR = 0.44), suggesting that this association may extend beyond the U.S. healthcare context [16].

However, not all studies have found this association to be robust after multivariable adjustment. In the same 2023 SEER analysis by Wu et al., the survival benefit for autologous reconstruction was observed for overall survival (aHR = 0.83) but not for breast cancer-specific survival (aHR = 0.93, 95% CI: 0.82–1.07), suggesting that observed benefits may stem from non-cancer-related factors [18]. Likewise, Xiong et al. initially reported improved unadjusted survival in reconstructed patients but found no statistically significant difference in either breast cancer-specific or overall survival after adjusting for key covariates [19]. Further complicating interpretation, a 2013 study from Fudan University demonstrated that the apparent survival benefit of reconstruction was primarily limited to patients from higher-income groups, implying that socioeconomic advantage—not the surgery itself—may be driving improved outcomes [21].

Although this study found a significant survival benefit associated with breast reconstruction after mastectomy (adjusted HR 0.45, 95% CI: 0.42–0.48), caution is warranted in interpreting this association as causal. A key limitation of retrospective analyses using administrative datasets like the NCDB is the inability to account for unmeasured confounders. For example, selection bias may play a substantial role—surgeons are more likely to offer reconstruction to patients who are younger, healthier, and have better functional status. Anecdotal observations from clinical settings reflect this; for

instance, patients with complex medical histories or decreased functional reserve are often excluded from reconstruction candidacy. Functional ability, while distinct from comorbidity burden, may provide critical complementary information in predicting both treatment selection and survival outcomes — yet it is not captured in the NCDB.

Psychosocial factors may also contribute. It is plausible that patients who undergo reconstruction are more engaged in their care, have higher health literacy, and are more likely to attend follow-up visits and adhere to recommended therapies. [110] These patients may experience enhanced quality of life, which has itself been linked to improved survival. Indeed, a recent meta-analysis identified physical activity and psychosocial support interventions as some of the most effective strategies in improving overall survival among cancer patients (HR 0.50, 95% CI: 0.36–0.68). [111]

A more systemic explanation for this association is disparities in access to care. Patients from resource-poor or rural regions may not have physical access to plastic surgeons or comprehensive cancer centers. For example, patients living far from their treatment facility may be less likely to pursue or even be offered reconstruction. [112] Access barriers—such as transportation limitations, limited reconstructive availability, and provider referral patterns—can result in treatment differences that reflect broader social inequities rather than clinical appropriateness. Prior studies have shown that the farther a patient is from their treatment center, the less likely they are to receive timely adjuvant therapy or complete prescribed care plans. [113]

These unmeasured variables—functional status, psychosocial health, frequency of follow-up, and geographic access—are not captured in the NCDB and represent important sources of residual confounding. Their absence likely contributes to the observed survival difference and serves as a reminder the importance of interpreting findings from retrospective data with care. Future prospective

studies are necessary to better isolate the causal effect of reconstruction and to account for these harder-to-measure yet critically important determinants of health outcomes.

Stratified Analyses

Understanding the observed association between reconstruction and survival requires deeper examination of the clinical, demographic, and institutional characteristics of the study cohort. Among the 176,382 patients included, approximately 30.7% underwent breast reconstruction, while the remaining 69.3% received mastectomy alone (Table 3). Notably, reconstruction was more common among patients treated at Academic or Research Programs, where institutional capacity and access to reconstructive services may be greater. Conversely, patients treated at Comprehensive Community Cancer Programs—where nearly half of all mastectomy-only procedures occurred—had substantially lower rates of reconstruction. This institutional pattern reflects broader disparities in access to specialized surgical care (Tables 2 and 3).

Significant geographic and sociodemographic variability further supports the hypothesis that systemic access issues influence surgical decision-making. For instance, patients residing in New England and the Middle Atlantic regions were more likely to undergo reconstruction, while those in the South Atlantic and East North Central regions had the highest surgery volumes but lower reconstruction proportions (Table 3). This disparity suggests that regional differences in infrastructure, referral networks, and surgeon availability likely shape both treatment options and outcomes.

Patient-level characteristics also revealed marked disparities in surgical treatment patterns. White patients were more likely to undergo reconstruction than Black, Hispanic, or Asian patients (Table 2), and privately insured individuals had the highest rates of reconstruction compared to those with government or no insurance (Table 3). Patients in the highest income quartile (≥$74,063) were

significantly more likely to receive reconstruction, while those in the lowest income quartile (<$46,277) overwhelmingly underwent mastectomy alone. Educational attainment followed a similar pattern, with higher reconstruction rates observed among patients from more educated regions (Table 3). These findings underscore how socioeconomic advantage is often intertwined with access to—and utilization of—reconstructive options.

Importantly, several clinical variables associated with both treatment choice and survival were unequally distributed across groups. Older patients, particularly those aged 66–80, had the lowest reconstruction rates and the highest rates of mastectomy alone (Tables 2 and 3). Comorbidity burden, captured by the Charlson-Deyo score, also shaped surgical decisions: patients with a score of 0 made up the majority of those who underwent reconstruction, while patients with a score ≥3 were disproportionately represented in the mastectomy-only group (Table 3). These findings support the notion that reconstruction is often reserved for healthier patients—likely contributing to the observed survival benefit even after adjustment.

When examined through the lens of survival outcomes, these patterns are further reinforced. Patients who underwent reconstruction exhibited a crude hazard ratio of 0.32 (95% CI: 0.31–0.33), which remained significant after adjustment (aHR = 0.45; Table 11). However, crude hazard ratios stratified by patient characteristics revealed substantial variation in baseline risk (Table 4). For example, younger patients (aged 18–30 and 31–40) had much lower hazards of mortality compared to the reference group (aged 66–80), and this younger population was also far more likely to receive reconstruction (Tables 2 and 3). Similarly, patients with Stage 0 or I disease had markedly lower hazard ratios compared to those with Stage III cancer—and they also had higher reconstruction rates (Tables 3 and 4). These patterns indicate that many of the characteristics associated with favorable survival are

also associated with receiving reconstruction, reinforcing the potential influence of selection bias and residual confounding.

Insurance status and income level were particularly strong predictors of both treatment and survival. Patients with private insurance had the highest likelihood of receiving reconstruction and the lowest hazard of mortality, while uninsured and government-insured patients were less likely to undergo reconstruction and more likely to experience adverse outcomes (Tables 3 and 4). For example, uninsured patients had a crude HR of 1.82 and government-insured patients an HR of 2.45, compared to privately insured individuals. Income stratification showed a similar trend, with patients in the lowest income quartile exhibiting a crude HR of 1.74, compared to the highest-income group (Table 4). These results suggest that socioeconomic vulnerability may compound both clinical risk and access to comprehensive cancer care, including reconstruction.

Taken together, these findings emphasize the complex, multidimensional nature of the observed survival benefit associated with breast reconstruction. The interplay between patient demographics, socioeconomic factors, facility type, and clinical status likely drives both treatment selection and long-term outcomes. While multivariable modeling attempts to control for these confounders, residual bias almost certainly remains, particularly in retrospective datasets like the NCDB that lack detailed information on functional status, psychosocial health, and care engagement. Nonetheless, the consistency of the survival advantage across multiple subgroups suggests a persistent and potentially meaningful association that merits continued investigation.

To further illustrate these patterns and provide a visual understanding of survival differences, a series of Kaplan-Meier (KM) survival analyses were conducted. These curves consistently demonstrated significant variation in overall survival across surgical, demographic, clinical, and socioeconomic strata.

As shown in Figure 8, patients who underwent reconstruction had a higher probability of survival over time compared to those who received mastectomy alone, with a statistically significant difference between the two groups ($p < 0.0001$). While this finding is consistent with the multivariable Cox model results, it is important to interpret the KM analysis descriptively, as it does not adjust for confounding factors. Nevertheless, the divergence in survival probabilities observed at both 12 and 60 months (Table 5) adds a compelling visual complement to the primary survival analysis.

Stratified KM curves also reinforced previously observed disparities. For instance, Figure 9 and Table 6 highlight substantial racial differences in survival outcomes, with Black patients experiencing the lowest survival probabilities over time and Asian patients consistently demonstrating the highest. These findings mirror the crude hazard ratios reported earlier and support the broader conclusion that racial disparities in cancer outcomes persist despite adjustments for observable covariates.

Similarly, survival analyses by AJCC stage (Figure 10, Table 7) and Charlson-Deyo comorbidity score (Figure 11, Table 8) displayed predictable gradients, with earlier-stage disease and lower comorbidity burden associated with markedly improved survival. These results align with clinical expectations and reinforce the validity of the dataset and model structure. Patients with Stage 0 or Stage I disease and those with a Charlson-Deyo score of 0 demonstrated the most favorable 5-year survival rates, while those with Stage III disease or a Charlson-Deyo score ≥3 had substantially worse long-term outcomes.

Socioeconomic stratification of the KM curves also revealed striking differences. Survival curves stratified by insurance status (Figure 12, Table 9) showed that patients with private insurance had the highest survival probabilities, while those with government insurance had the lowest. A similar pattern was observed in Figure 13 and Table 10, where income quartile was positively associated with survival.

These trends reinforce the previously discussed observation that access to care—likely shaped by both insurance coverage and financial resources—plays a critical role in shaping long-term survival.

Although KM curves cannot account for the full range of confounders included in the multivariable models, they provide important supplementary evidence of the survival gradients associated with surgical treatment, demographic characteristics, and socioeconomic status. When interpreted alongside the adjusted Cox regression results, the consistency of these findings across methods enhances the robustness of the observed associations and underscores the structural inequalities that shape breast cancer outcomes in the United States.

Sensitivity Analysis

To further interrogate the robustness of the observed association between breast reconstruction and survival, stratified sensitivity analyses were conducted across cancer stage, age group, race/ethnicity, and comorbidity burden. These analyses, presented in Tables 12–31, were designed to assess whether the survival advantage associated with reconstruction persisted within clinically and demographically distinct subgroups.

One particularly noteworthy finding emerged from the stratification by comorbidity burden. While it has often been posited that the survival benefit associated with reconstruction reflects selection bias, wherein surgeons preferentially offer reconstruction to healthier patients, our analysis complicates this explanation. Even within strata defined by Charlson-Deyo score, reconstruction was associated with a significantly lower hazard of mortality compared to mastectomy alone (Table 31). For example, patients with a score of 0 had an adjusted hazard ratio (HR) of 0.45 (95% CI: 0.42–0.48), and this benefit was maintained across increasing comorbidity levels, including those with a score of 3 or greater (HR = 0.32; 95% CI: 0.23–0.45). While patients undergoing reconstruction were more likely to be

treated at academic centers and have private insurance across all strata (Tables 27–30), the persistence of a survival benefit even in medically complex patients suggests that comorbidity burden alone does not fully account for the observed association. That said, other important variables—such as functional status, frailty, and patient motivation—are not captured in the NCDB and may still introduce residual confounding.

Stratification by cancer stage also revealed a consistent survival benefit associated with reconstruction, though the magnitude of this association varied. As shown in Table 16, patients with Stage 0–II disease demonstrated a strong association, with the greatest relative benefit seen in Stage II (HR = 0.39; 95% CI: 0.35–0.43). Among patients with Stage III cancer, the benefit was attenuated but remained statistically significant (HR = 0.73; 95% CI: 0.68–0.79). This trend aligns with clinical expectations: earlier-stage patients may derive greater benefit due to lower disease burden and fewer competing risks, while more advanced-stage patients may face higher rates of recurrence, complications, or treatment-limiting comorbidities that could dilute the impact of reconstructive intervention on long-term outcomes.

Age-stratified analysis revealed similarly consistent, though nuanced, results (Table 21). Across most age groups, reconstruction was associated with a statistically significant reduction in mortality. The association was particularly strong in the 31–65 year age range (HRs ranging from 0.47–0.50), but remained significant even among older patients aged 66–80 years (HR = 0.39; 95% CI: 0.35–0.44). Interestingly, the youngest age group (18–30 years) did not demonstrate a statistically significant survival difference (HR = 0.78; 95% CI: 0.56–1.07; p = 0.130), likely due to limited sample size and fewer observed events. Nonetheless, the overall trend reinforces the generalizability of the survival benefit

across age strata and may reflect more consistent healthcare engagement and fewer competing mortality risks among middle-aged patients.

Stratification by race and ethnicity yielded similar conclusions (Table 26). The adjusted hazard ratio for reconstruction was remarkably consistent across racial and ethnic groups, ranging from 0.44 to 0.46. This finding is particularly striking given the persistent disparities in reconstruction utilization documented across racial groups in Tables 22–25, suggesting that once access is achieved, reconstructive surgery confers a similar relative survival benefit regardless of race. However, access itself remains unequal—patients undergoing reconstruction were consistently more likely to be younger, privately insured, and treated at academic centers, highlighting the need to improve equity in surgical oncology.

Taken together, these sensitivity analyses provide further support for the robustness of the association between reconstruction and survival. The consistency of benefit across stage, age, comorbidity, and racial/ethnic groups strengthens the case that this relationship is not merely an artifact of selection bias. At the same time, the limitations of the NCDB—particularly its lack of data on functional status, postoperative adherence, psychosocial support, and surveillance intensity—continue to challenge causal inference. Future prospective studies are needed to elucidate whether these unmeasured variables explain part—or all—of the observed survival advantage. Nonetheless, the findings underscore the importance of ensuring equitable access to reconstructive options for all appropriate candidates, particularly in underserved populations where disparities remain most pronounced.

Racial and Socioeconomic Disparities in Reconstruction Rates

Our study highlights significant disparities in access to breast reconstruction related to race, insurance type, income, and education (Table 1). Patients undergoing breast reconstruction were disproportionately White, privately insured, and from higher-income and better-educated zip codes. Conversely, non-Hispanic Black, Hispanic, uninsured, and lower-income patients were underrepresented in the reconstructive cohort. These findings are consistent with prior research indicating persistent racial and socioeconomic inequities in breast reconstruction utilization. [101]

Previous studies have similarly demonstrated that minority women—especially non-Hispanic Black and Hispanic patients—are significantly less likely to receive reconstruction following mastectomy compared to White patients, even when adjusting for clinical characteristics such as cancer stage and comorbidities. [101] Insurance disparities further compound this issue, with privately insured patients more frequently receiving reconstructive surgery than those with Medicaid or no insurance, despite federal policies mandating coverage under the Women's Health and Cancer Rights Act (WHCRA). [112] Socioeconomic status also remains a crucial determinant, with lower-income and less-educated patients consistently having lower reconstruction rates, potentially due to decreased access to specialized reconstructive services, limited knowledge about reconstruction options, and provider biases or referral practices. [112]

Future policy interventions should aim not only at ensuring insurance coverage but also at proactively reducing institutional barriers and improving healthcare access to achieve equitable reconstruction utilization and the associated long-term survival and quality-of-life benefits.

Strengths and Limitations

This study has several important strengths. First, we utilized the National Cancer Database (NCDB), a large, nationally representative dataset capturing approximately 70% of newly diagnosed

cancer cases in the United States. This extensive dataset allowed for robust statistical power, enhancing the generalizability and external validity of our findings. Additionally, we conducted detailed stratified and adjusted analyses, accounting for multiple demographic and clinical confounders such as age, cancer stage, race, socioeconomic status, and comorbidities. By employing a directed acyclic graph to identify and select confounders systematically, we minimized the risk of inappropriate adjustment and bias, ensuring more reliable hazard ratio estimates.

However, our study also has several limitations inherent to its retrospective cohort design. Retrospective analyses are susceptible to selection bias and confounding, despite careful statistical adjustments. For instance, patients who undergo reconstruction might inherently differ from those choosing mastectomy alone in terms of baseline health status, social support, health literacy, or other unmeasured confounders, potentially biasing survival estimates towards reconstruction. Moreover, the NCDB does not differentiate between immediate and delayed reconstruction, which could introduce misclassification and limit our ability to assess nuanced survival outcomes associated with the timing of reconstruction.

Additionally, important clinical data such as adjuvant therapies (chemotherapy, endocrine therapy, targeted treatments), tumor recurrence rates, and patient-reported outcomes like quality of life and psychological well-being were not available. These factors significantly influence survival and surgical decision-making, and their absence restricts our ability to fully interpret the observed survival benefits associated with breast reconstruction. Lastly, reliance on administrative coding introduces potential misclassification, particularly regarding procedural codes for surgery type or socioeconomic indicators, potentially affecting our analyses. Despite these limitations, the findings from this large-scale

national dataset provide valuable insights into surgical decision-making and survival outcomes in breast cancer management, highlighting important directions for future prospective studies.

Clinical and Policy Implications

Clinically, the observed survival benefit associated with breast reconstruction underscores the importance of discussing reconstruction as more than a cosmetic or psychological consideration. Surgeons and oncology teams should present reconstruction to eligible patients as potentially improving survival outcomes, reinforcing shared decision-making and empowering patients with comprehensive information.

From a policy perspective, notable disparities observed in breast reconstruction rates highlight ongoing barriers to equitable healthcare access, despite existing legislation. These findings support initiatives aimed at reducing structural barriers, such as expanding insurance coverage for reconstructive procedures, enhancing reimbursement rates, and improving reconstructive surgery availability in underserved settings. Policy interventions focused on patient education, outreach, and improved referral pathways could further mitigate disparities in reconstruction uptake.

Finally, given potential survival advantages associated with reconstruction, policymakers may consider allocating greater resources toward reconstructive surgery programs. Enhancing equitable access supports patient autonomy and potentially improves long-term health outcomes for diverse patient populations.

Conclusion

This study evaluated the association between breast reconstruction and overall survival following mastectomy for breast cancer, using data from over 176,000 patients in the National Cancer

Database. After adjusting for demographic, clinical, and socioeconomic covariates, breast reconstruction had remained associated with a significantly lower hazard of mortality (aHR = 0.45; 95% CI: 0.42–0.48), a finding that was evident across cancer stage, age group, comorbidity burden, and racial/ethnic subgroups. These findings contribute meaningfully to the literature by reinforcing the potential survival benefit of reconstruction, previously described in multiple population-based studies, and by demonstrating its consistency across clinically diverse patient populations.

However, interpretation of this association demands caution. The observational nature of the study, along with limitations inherent to administrative datasets such as the NCDB, restricts causal inference. Unmeasured variables—such as functional status, psychosocial support, postoperative adherence, and proximity to care—likely contribute to both treatment selection and survival, and their absence introduces residual confounding. Notably, even within strata of comorbidity and disease stage, patients who underwent reconstruction were more often privately insured, treated at academic centers, and from higher-income regions. These patterns reflect entrenched disparities in healthcare access and delivery, rather than inherent differences in patient need or clinical appropriateness.

Despite these limitations, the strength and consistency of the observed associations emphasize the importance of equitable access to reconstructive services. Racial and socioeconomic disparities in reconstruction utilization remain pronounced. Black, Hispanic, uninsured, and low-income patients were significantly less likely to receive reconstruction, despite demonstrating comparable survival benefit when access was achieved. These findings suggest that current policy measures such as the Women's Health and Cancer Rights Act, while necessary, are insufficient to ensure equity. Structural barriers—including geographic limitations, provider referral biases, and regional differences in surgical infrastructure—must be addressed through targeted interventions.

Ultimately, this study reinforces that breast reconstruction should not be viewed solely as a cosmetic or elective procedure. It may be associated with real differences in long-term survival, potentially mediated by improved follow-up, quality of life, and healthcare engagement. For patients undergoing mastectomy, reconstruction should be discussed not only as a means of restoring body image, but also as a component of holistic survivorship planning. Future prospective studies are essential to clarify causality and to identify the modifiable mediators that underlie this survival advantage. In the interim, efforts to expand access to reconstruction—especially in medically and socially underserved populations—should be prioritized as a matter of both clinical and ethical importance.

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