Published in final edited form as:

Ann Surg Oncol. 2021 October ; 28(11): 6489–6497. doi:10.1245/s10434-021-09657-w.

Racial Differences in Response to Neoadjuvant Chemotherapy: Impact on Breast and Axillary Surgical Management

Theresa Relation, MD, PhD¹, Samilia Obeng-Gyasi, MD, MPH¹, Oindrila Bhattacharyya, MS², Yaming Li, MD, MS¹, Mariam F. Eskander, MD, MPH¹, Allan Tsung, MD¹, Bridget A. Oppong, MD¹

¹Division of Surgical Oncology, Department of Surgery, The Ohio State University, Columbus, OH;

²Department of Economics, Indiana University Purdue University, Indianapolis, IN

Abstract

Background.—Neoadjuvant chemotherapy (NAC), an increasingly used method for breast cancer patients, has the potential to downstage patient tumors and thereby have an impact on surgical options for treatment of the breast and axilla. Previous studies have identified racial disparities in tumor heterogeneity, nodal recurrence, and NAC completion. This report compares the effects of NAC response among non-Hispanic white women and black women in relation to surgical treatment of the breast and axilla.

Methods.—A retrospective review of 85,303 women with stages 1 to 3 breast cancer in the National Cancer Database who received NAC between 1 January 2010 and 31 December 2016 was conducted. Differences in sociodemographic and clinical variables between black patients and white patients with breast cancer were tested.

Results.—The study identified 68,880 non-Hispanic white and 16,423 non-Hispanic black women who received NAC. The average age at diagnosis was 54.8 years for the white women versus 52.5 years for the black women. A higher proportion of black women had stage 3 disease, more poorly differentiated tumors, and triple-negative subtype. The black women had lower rates of complete pathologic response, more breast-conservation surgery, and higher rates of axillary lymph node dissection, but fewer sentinel lymph node biopsies. Axillary management for the women who were downstaged showed more use of axillary lymph node dissection for black women compared with sentinel lymph node biopsy.

Conclusions.—The black patients were younger at diagnosis, had more advanced disease, and were more likely to have breast-conservation surgery. De-escalating axillary surgery is being adopted increasingly but used disproportionately for white women.

B. A. Oppong, MD, bridget.oppo@osumc.edu.

DISCLOSURE

The National Cancer Database (NCDB) is a joint project of the Commission on Cancer (CoC) by the American College of Surgeons and the American Cancer Society. The NCDB of the CoC and the hospitals participating in the NCDB of the CoC are the source of the de-identified data used in this study. They have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

Breast cancer is the most commonly diagnosed cancer among women and ranks second as a cause of death from cancer.¹ Incidence rates are higher for non-Hispanic white women than for black women for most age groups.² However, breast cancer is diagnosed for black women at more advanced stages of the disease, and black women have a higher mortality rate from breast cancer than white women, with an absolute difference of 8.8 deaths per 100,000.³

Although socioeconomic barriers to timely diagnosis and treatment are some of the factors contributing to these observed disparities, biology also plays a role.^{4–7} Black women are more likely to have a diagnosis of aggressive tumor phenotypes such as triple-negative breast cancer (TNBC) and human epidermal growth factor receptor 2 (HER2)-positive tumors, higher-grade tumors, and younger age at onset of breast cancer.^{4–8} Chemotherapy, and neoadjuvant chemotherapy (NAC) in particular, is given more frequently to black than to white women with more advanced disease.

Recent work has pointed to the utility of NAC, not only in reducing morbidity from surgery, but also in overall breast cancer mortality for some subtypes, contributing to the increased rates of NAC use observed during the past decade.^{9,10} Despite the overall increased receipt of NAC, white women are more likely to complete NAC, and the response to NAC also may differ.¹¹

Previous studies show that black women have a higher proportion of heterogeneity in their tumor and are more likely to experience nodal recurrence after treatment.¹² Evidence suggests that chemotherapy may be less effective for black patients, especially for particular breast cancer subtypes. Black women are reported to have a lower rate of pathologic complete response (pCR) for estrogen receptor-negative (ER–), progesterone receptor-negative (PR–), HER2+ (43% vs. 54%; $p = 0.001$), and triple-negative tumors (37% vs. 43%; $p < 0.001$). This difference persists after adjustment for age, clinical tumor stage, clinical node stage, histology, grade, comorbidity index, facility type, geographic region, insurance status, and census-derived median income and education for the patient's zip code.

Neoadjuvant chemotherapy has the potential to downstage breast tumor and potential adenopathy, thus increasing the likelihood of less invasive surgical management of in-breast disease (i.e., increasing breast-conserving surgery) and allowing less invasive surgical treatment to the axilla.^{13–16} Especially with a pCR, NAC can have an impact on subsequent surgical treatment.

This study compared the use of NAC and the treatment response in non-Hispanic white women and black women and analyzed whether downstaged disease in the breast, axilla, or both influences surgical management.

METHODS

Female patients age 18 years and older with biopsy-proven stages 1 to 3 breast cancer who received NAC between 1 January 2010 and 31 December 2016 were identified in the National Cancer Database (NCDB). The NCDB is jointly maintained by the American

College of Surgeons and the American Cancer Society and represents 70% of cancers diagnosed in the United States.¹⁷

To elucidate potential racial differences between cohorts, the study included only non-Hispanic black and non-Hispanic white patients. The exclusion criteria for this study ruled out male patients and patients with a diagnosis of inflammatory breast cancer (T4d). The sociodemographic and clinical variables compared between the groups were age, income, race, Hispanic ethnicity, educational status, distance from home to health care facility, type of facility in which treatment was received, facility location, rural versus urban location of home, insurance status, date of primary breast cancer diagnosis, initial disease stage at diagnosis, grade, ER and PR status, HER2/neu status, comorbidities, neoadjuvant chemotherapy, pCR, surgeries for breast cancer, radiation history, adjuvant chemotherapy, hormonal therapy, targeted therapy, and date of death.

The sociodemographic and clinical characteristics between the non-Hispanic white women and non-Hispanic black women were evaluated using Pearson's chi-square test for categorical variables and using the *t* test or analysis of variance (ANOVA) for numeric variables. The complete pathologic response among non-Hispanic black women and non-Hispanic white women was stratified by subtype (ER+/PR±/HER2–, ER+/PR+/HER2+, ER–/PR–/HER2–, ER–/PR–/HER2+) and compared using Pearson's chi-square test. The NCDB describes complete pathologic response as the absence of invasive disease in the breast and lymph nodes, including the axilla. In this study, NCDB code “CS site-specific factor 21: response to neoadjuvant therapy” was used.

For the subset analysis of downstaged patients, the patients were identified by comparing clinical and pathologic stages. The patients with a lower pathologic stage than the clinical stage were categorized as downstaged. Subtype (ER+/PR±/HER2–, ER+/PR+/HER2+, ER–/PR–/HER2–, ER–/PR–/HER2+), breast surgery (mastectomy vs. breast conservation), axillary surgery (sentinel lymph node biopsy vs. axillary lymph node dissection), and receipt of reconstruction (none, tissue, or implant) were compared between the two groups. For reconstruction, only patients who underwent mastectomy were evaluated.

Statistical significance was defined as a *p* value lower than 0.05. The statistical analysis for this study was performed in Stata software, version 16.0 (Stata Corporation, College Station, TX, USA). The Ohio State University Office of Responsible Research Practices deemed this study institutional review board (IRB) exempt.

RESULTS

For this study, 68,880 non-Hispanic white and 16,423 non-Hispanic black women receiving NAC met the study criteria. The average age at diagnosis was 54.8 years for the white women and 52.5 years for the black women, with approximately 30% of both groups 51 to 60 years of age (28.9% white and 30.8% black). The median household incomes differed, with 35.6% of the black women living in neighborhoods with a median household income lower than \$38,000 per year versus 10.9% of the white women (*p* < 0.001). The black women (28.5%) were more likely than the white women (10.4%) to reside in areas that

had a high school dropout rate exceeding 21% ($p < 0.001$), were more likely to seek treatment at an academic or research facility (43.8% vs. 33.2%; $p < 0.001$), and resided more frequently in larger metropolitan areas in the South Atlantic region ($p < 0.001$). More of the black women were uninsured (4.7% vs. 1.7%; $p < 0.001$), with only 55.1% using private insurance/managed care compared with 65.9% of the white women ($p < 0.001$) (Table 1). Administration of NAC increased in both groups from 2010 to 2016 (8.8% of white women and 8.6% of black women in 2010 increasing to 20.1% of white women and 19.4% of black women in 2016; Fig. 1).

A majority of both groups presented with clinical stage 2 disease (61.1% white and 59.4% black), but a higher proportion of the black women had stage 3 disease (31.5% vs. 26.9%; $p < 0.001$; Table 2). The chemotherapy response differed significantly between the two groups, with 50.4% of the white women having a pCR compared with 49.5% of the black women ($p = 0.01$). The black women had more poorly differentiated tumors (63.6% vs. 51.4%; $p < 0.001$) and more cases of triple-negative disease (40.2% vs. 26.2%; $p < 0.001$). The black women were less likely to receive immunotherapy (19.9% of cases vs. 24.7% of cases among the white women; $p < 0.001$).

In the analysis of pathologic response (PR) by subtype (Table 3), the black women with TNBC and hormone-positive, HER2– subtypes had a lower pCR to NAC than the white women (TNBC: 41.6% vs. 43.6%, $p < 0.001$; ER/PR+ and HER2–: 62.4% vs. 65.5%, $p < 0.001$).

With surgical management, the in-breast procedure differed between the black women and the white women, with more breast-conservation surgery for the black women (partial mastectomy: 34.5% vs. 18.0%; mastectomy: 49% vs. 51.4%; $p < 0.001$; Table 2). Regarding axillary surgical management, more of the black women had axillary lymph node dissection (48.7% vs. 41.5%; $p < 0.001$) and fewer had sentinel lymph node biopsies (46.6% vs. 53.5%; $p < 0.001$). In the comparison of axillary surgery received by lymph node status before surgery, this significant difference remained (Table 4). Additionally, in the comparison of the downstaged non-Hispanic black and non-Hispanic white women (Table 5), the black women were more likely to receive partial mastectomy (44.7% vs. 39.5%; $p < 0.001$) and less likely to receive mastectomy (55.3% vs. 60.5%; $p < 0.001$).

When mastectomy was performed, the black women were more likely than the white women to forego breast reconstruction (88.2% vs. 85%; $p < 0.001$). When lymph node surgery was performed, the black women were more likely to undergo axillary lymph node dissection than the white women (40.6% vs. 33.9%; $p < 0.001$). No patients in this study were recorded as receiving an axillary lymph node dissection after sentinel lymph node biopsy. The NCDB reports patients who had both procedures as having an axillary lymph node dissection for the definitive axillary procedure.

DISCUSSION

In this analysis of women with primary breast cancer undergoing neoadjuvant chemotherapy using the NCDB, observed differences in sociodemographic variables such as income,

education, and insurance were consistent with those of previously published studies.^{4–7} A larger proportion of the black women resided in lower-income neighborhoods with lower education attainment and were uninsured.

During the study period, we found an increased overall use of NAC, with similar rates of NAC between the black women and the white women (Fig. 1). This contrasts with other reports showing a comparatively increased NAC requirement for black women given advanced disease.^{18,19} Additionally, we identified statistically significant clinical differences in response to chemotherapy, with the black women showing lower rates of pCR and more pronounced differences based on tumor subtype. Similar findings were previously reported by others,^{19–21} including Killelea et al., who found that black women had a lower rate of pCR for ER/PR–, HER2+, and triple-negative tumors.

Among the patients who were downstaged, the non-Hispanic black breast cancer patients were more likely to undergo breast-conservation surgery and axillary lymph node dissection than the non-Hispanic white women. As depicted in Table 4, the white women more frequently received sentinel lymph node biopsy, whereas the black patients had a significantly higher rate of axillary lymph node dissection. These findings are consistent with previously published studies, in which black women were more likely to receive breast-conserving surgery, were less likely to undergo mastectomy, and had a higher rate of axillary lymph node dissection than their white counterparts.^{2,22–25} The potential reasons for these observed differences include patient preference, cultural beliefs, or anatomic variations such as tumor size as a proportion of the entire breast. However, additional studies are required to explore these possibilities more accurately.

In the subset of our population downstaged after NAC (Table 5), 62.6% of the white women had a sentinel lymph node biopsy compared with 56.1% of the black women. Although it still is standard surgical management of the axilla in patients with confirmed nodal metastasis to perform complete lymph node dissection, use of the sentinel lymph node biopsy (SLNBx) after NAC is becoming increasingly popular.²⁶ This application of SLNBx for axilla staging after chemotherapy is controversial because multiple studies have shown a lower detection rate and a higher increased false-negative rate compared with axillary lymph node dissection or SLNBx in the absence of NAC.^{27,28} Two seminal studies, the SENTINA trial and The American College of Surgeons Oncology Group (ACOSOG) Z1071 trial, showed declines in false-negative rates with a higher nodal yield. For patients with examination of two or more sentinel nodes, the false-negative rate was 10% or lower, the rate expected for women undergoing SLN surgery who present with node-negative disease.²⁷ Such data show SLNBx to be both a feasible and reliable treatment option.

In the setting of NAC, SLNBx is further propelled by data expanding the indications for use to include HER2+ for disease staged greater than T2, with recommendations for chemotherapy and dual anti-HER2-targeted treatment.²⁹ With expanded indications and newer chemotherapeutic agents resulting in pCR and no residual tumor in the breast or axillary nodes for more than 40% of recipients, practice changes are anticipated.^{26,29}

Another consideration is the adverse risks associated with a full axillary dissection, including a 15% to 20% risk of lymphedema.³⁰ Axillary lymph node dissection is associated with greater than a 20% risk of lymphedema, which can be compounded with the addition of radiation, also frequently required for locally advanced breast cancer. Therefore, women can face an up to a 50% risk for lymphedema after a full axillary lymph node dissection and whole-breast irradiation after lumpectomy or post-mastectomy chest wall irradiation. Use of an SLN-only procedure results in a lymphedema risk of up to 3%.³⁰ It is important to assess the applicability of this less invasive option because black women are reported to have a higher rate of lymphedema (28% vs. 21%) after breast cancer surgery.³¹

Our study had several limitations inherent to the NCDB. We lacked some qualitative data that would have offered useful information for investigating treatment differences received by non-Hispanic white versus black breast cancer patients. Specifically, it is unclear what factors influenced the surgeon to perform a complete axillary dissection instead of a sentinel lymph node biopsy alone for the management of the axilla. It cannot be determined whether a patient had a sentinel node biopsy followed by an axillary dissection because of a positive sentinel node. The finding that response to NAC is significantly less in black patients could explain the greater number of axillary dissections among black patients. The NCDB data also do not provide insight into how patients choose the operative procedure they ultimately receive. To address these limitations, further data focused on factors driving clinical decision-making are needed.

Ultimately, de-escalating axillary surgery is increasingly adopted but disproportionately used for white women. By understanding the factors associated with this disparity, surgeons and providers are able to target those factors for redress. It is critical to ensure equitable and just delivery of health care. We can do so only by identifying, understanding, and remedying disparity within the system. Additional investigation is needed for further understanding of surgeons' management approach and the potential impact of biases that may alter practice patterns in different populations. Black patients also can benefit from education on the more advanced techniques and practices such as SLNBx to reduce the gaps in utilization.

REFERENCES

1. Fahad Ullah M Breast cancer: current perspectives on the disease status. In: Ahmad A (ed) Breast Cancer Metastasis and Drug Resistance: Challenges and Progress. Advances in Experimental Medicine and Biology Springer International Publishing, Cham, Switzerland, 2019, pp 51–64. doi:10.1007/978-3-030-20301-6_4.
2. Iqbal J, Ginsburg O, Rochon PA, Sun P, Narod SA. Differences in breast cancer stage at diagnosis and cancer-specific survival by race and ethnicity in the United States. JAMA. 2015;313:165–73. 10.1001/jama.2014.17322. [PubMed: 25585328]
3. Williams DR, Mohammed SA, Shields AE. Understanding and effectively addressing breast cancer in African American women: unpacking the social context. Cancer. 2016;122:2138–49. 10.1002/cncr.29935. [PubMed: 26930024]
4. Hill DA, Prossnitz ER, Royce M, Nibbe A. Temporal trends in breast cancer survival by race and ethnicity: a population-based cohort study. PLoS ONE. 2019;14(10). 10.1371/journal.pone.0224064.
5. Kohler BA, Sherman RL, Howlader N, et al. Annual report to the nation on the status of cancer, 1975–2011, featuring incidence of breast cancer subtypes by race/ethnicity, poverty, and state. J Natl Cancer Inst. 2015;107:djv048. doi:10.1093/jnci/djv048. [PubMed: 25825511]

6. Yedjou CG, Sims JN, Miele L, et al. Health and racial disparity in breast cancer. *Adv Exp Med Biol*. 2019;1152:31–49. 10.1007/978-3-030-20301-6_3. [PubMed: 31456178]
7. Wheeler SB, Spencer JC, Pinheiro LC, Carey LA, Olshan AF, Reeder-Hayes KE. Financial impact of breast cancer in black versus white women. *J Clin Oncol Off J Am Soc Clin Oncol*. 2018;36:1695–701. 10.1200/JCO.2017.77.6310.
8. Siddharth S, Sharma D. Racial disparity and triple-negative breast cancer in African-American women: a multifaceted affair between obesity, biology, and socioeconomic determinants. *Cancer*. 2018;10(12). 10.3390/cancers10120514.
9. Cain H, Macpherson IR, Beresford M, Pinder SE, Pong J, Dixon JM. Neoadjuvant therapy in early breast cancer: treatment considerations and common debates in practice. *Clin Oncol*. 2017;29:642–52. 10.1016/j.clon.2017.06.003.
10. Graham PJ, Brar MS, Foster T, et al. Neoadjuvant chemotherapy for breast cancer: is practice changing? A population-based review of current surgical trends. *Ann Surg Oncol*. 2015;22:3376–82. 10.1245/s10434-015-4714-x. [PubMed: 26202561]
11. Knisely AT, Michaels AD, Mehaffey JH, et al. Race is associated with completion of neoadjuvant chemotherapy for breast cancer. *Surgery*. 2018;164:195–200. 10.1016/j.surg.2018.03.011. [PubMed: 29731247]
12. Walsh SM, Zabor EC, Stempel M, Morrow M, Gemignani ML. Does race predict survival for women with invasive breast cancer? *Cancer*. 2019;125:3139–46. 10.1002/cncr.32296. [PubMed: 31206623]
13. Fayanju OM, Ren Y, Suneja G, et al. Nodal response to neoadjuvant chemotherapy predicts receipt of radiation therapy after breast cancer diagnosis. *Int J Radiat Oncol Biol Phys*. 2020;106:377–89. 10.1016/j.ijrobp.2019.10.039. [PubMed: 31678225]
14. Rastogi P, Anderson SJ, Bear HD, et al. Preoperative chemotherapy: updates of National Surgical Adjuvant Breast and Bowel Project protocols B-18 and B-27. *J Clin Oncol Off J Am Soc Clin Oncol*. 2008;26:778–85. 10.1200/JCO.2007.15.0235.
15. Gu J, Groot G, Boden C, Busch A, Holtslander L, Lim H. Review of factors influencing women's choice of mastectomy versus breast conserving therapy in early-stage breast cancer: a systematic review. *Clin Breast Cancer*. 2018;18:e539–54. 10.1016/j.clbc.2017.12.013. [PubMed: 29396079]
16. Franceschini G, Di Leone A, Natale M, Sanchez MA, Masett R. Conservative surgery after neoadjuvant chemotherapy in patients with operable breast cancer. *Ann Ital Chir*. 2018;89:290. [PubMed: 30352955]
17. National Cancer Database. American College of Surgeons. Retrieved 16 September 2020 at <https://www.facs.org/quality-programs/cancer/ncdb>.
18. Pastoriza JM, Karagiannis GS, Lin J, et al. Black race and distant recurrence after neoadjuvant or adjuvant chemotherapy in breast cancer. *Clin Exp Metastasis*. 2018;35:613–23. 10.1007/s10585-018-9932-8. [PubMed: 30136072]
19. Killelea BK, Yang VQ, Wang S-Y, et al. Racial differences in the use and outcome of neoadjuvant chemotherapy for breast cancer: results from the National Cancer Database. *J Clin Oncol Off J Am Soc Clin Oncol*. 2015;33:4267–76. 10.1200/JCO.2015.63.7801.
20. Chavez-MacGregor M, Litton J, Chen H, et al. Pathological complete response in breast cancer patients receiving anthracycline and taxane-based neoadjuvant chemotherapy: evaluating the effect of race/ethnicity. *Cancer*. 2010;116:4168–77. 10.1002/cncr.25296. [PubMed: 20564153]
21. Tichy JR, Deal AM, Anders CK, Reeder-Hayes K, Carey LA. Race, response to chemotherapy, and outcome within clinical breast cancer subtypes. *Breast Cancer Res Treat*. 2015;150:667–74. 10.1007/s10549-015-3350-2. [PubMed: 25814053]
22. Richardson LC. Patterns and trends in age-specific black-white differences in breast cancer incidence and mortality—United States, 1999–2014. *MMWR Morb Mortal Wkly Rep*. 2016;65(40). 10.15585/mmwr.mm6540a1.
23. Akinyemiju TF, Vin-Raviv N, Chavez-Yenter D, Zhao X, Budhwani H. Race/ethnicity and socioeconomic differences in breast cancer surgery outcomes. *Cancer Epidemiol*. 2015;39:745–51. 10.1016/j.canep.2015.07.010. [PubMed: 26231096]

24. Kish JK, Yu M, Percy-Laurry A, Altekruze SF. Racial and ethnic disparities in cancer survival by neighborhood socioeconomic status in Surveillance, Epidemiology, and End Results (SEER) registries. *JNCI Monogr.* 2014;2014:236–43. 10.1093/jncimonographs/igu020.
25. Vona-Davis L, Rose DP. The influence of socioeconomic disparities on breast cancer tumor biology and prognosis: a review. *J Womens Health.* 2009;18:883–93. 10.1089/jwh.2008.1127.
26. Moo T-A, Sanford R, Dang C, Morrow M. Overview of breast cancer therapy. *PET Clin.* 2018;13:339–54. 10.1016/j.cpet.2018.02.006. [PubMed: 30100074]
27. Boughey JC, Suman VJ, Mittendorf EA, et al. Sentinel lymph node surgery after neoadjuvant chemotherapy in patients with node-positive breast cancer: the ACOSOG Z1071 (Alliance) clinical trial. *JAMA.* 2013;310:1455–61. 10.1001/jama.2013.278932. [PubMed: 24101169]
28. Kuehn T, Bauerfeind I, Fehm T, et al. Sentinel lymph node biopsy in patients with breast cancer before and after neoadjuvant chemotherapy (SENTINA): a prospective, multicentre cohort study. *Lancet Oncol.* 2013;14:609–18. 10.1016/S1470-2045(13)70166-9. [PubMed: 23683750]
29. Mamtani A, Barrio AV, King TA, et al. How often does neoadjuvant chemotherapy avoid axillary dissection in patients with histologically confirmed nodal metastases? Results of a prospective study. *Ann Surg Oncol.* 2016;23:3467–74. 10.1245/s10434-016-5246-8. [PubMed: 27160528]
30. McLaughlin SA, Wright MJ, Morris KT, et al. Prevalence of lymphedema in women with breast cancer 5 years after sentinel lymph node biopsy or axillary dissection: patient perceptions and precautionary behaviors. *J Clin Oncol Off J Am Soc Clin Oncol.* 2008;26:5220–6. 10.1200/JCO.2008.16.3766.
31. Meeske KA, Sullivan-Halley J, Smith AW, et al. Risk factors for arm lymphedema following breast cancer diagnosis in black women and white women. *Breast Cancer Res Treat.* 2009;113:383–91. 10.1007/s10549-008-9940-5. [PubMed: 18297429]

FIG. 1.

Use of neoadjuvant chemotherapy (NAC) across time stratified by race, and number of patients receiving neoadjuvant chemotherapy (y-axis) across year of diagnosis (x-axis). Gray line represents non-Hispanic black patients, and black line represents non-Hispanic white patients.

TABLE 1

Sociodemographic variables

	Non-Hispanic white (n = 68,880) n (%)	Non-Hispanic black (n = 16,423) n (%)	p value
Age at diagnosis (years)	54.75 ± 12.71	52.53 ± 12.05	< 0.001
Age (years)			< 0.001
40	9843 (14.3)	2657 (16.2)	
41–50	16,329 (23.7)	4595 (28.0)	
51–60	19,926 (28.9)	5060 (30.8)	
61–70	15,274 (22.2)	2933 (17.9)	
71–80	5842 (8.5)	956 (5.8)	
81	1666 (2.4)	222 (1.4)	
Income			< 0.001
<\$38,000	7474 (10.9)	5841 (35.6)	
\$38,000–\$47,999	14,102 (20.5)	3713 (22.7)	
\$48,000–\$62,999	19,395 (28.2)	3710 (22.6)	
\$63,000	27,725 (40.4)	3122 (19.1)	
Percentage of neighborhood with high school diploma			< 0.001
21.0	7153 (10.4)	4665 (28.5)	
13.0–20.9	15,021 (21.9)	5608 (34.2)	
7.0–12.9	24,104 (35.1)	4332 (26.4)	
<7.0	22,444 (32.7)	1789 (10.9)	
Distance to facility (miles)	28.58 ± 99.51	19.60 ± 82.67	< 0.001
Facility type			< 0.001
Community cancer program	4647 (7.7)	829 (5.9)	
Comprehensive community cancer program	25,823 (42.9)	4792 (34.1)	
Academic/research program	20,003 (33.2)	6160 (43.8)	
Integrated network cancer program	9783 (16.2)	2271 (16.2)	
Rural vs. urban			< 0.001
Metro 1M	36,673 (54.8)	11,536 (71.7)	
Metro 250K–1M	14,429 (21.6)	2643 (16.4)	

	Non-Hispanic white (n = 68,880) n (%)	Non-Hispanic black (n = 16,423) n (%)	p value
Metro <250K	5850 (8.7)	835 (5.2)	< 0.001
Urban	8832 (13.2)	925 (5.8)	
Rural	1114 (1.7)	145 (0.9)	
<i>Facility location</i>			
New England	3613 (6.0)	312 (2.2)	0.19
Middle Atlantic	7908 (13.1)	1744 (12.4)	
South Atlantic	12,456 (20.7)	5492 (39.1)	
East North Central	11,036 (18.3)	2199 (15.6)	
East South Central	4311 (7.2)	1357 (9.7)	
West North Central	6227 (10.3)	598 (4.3)	
West South Central	4930 (8.2)	1595 (11.4)	
Mountain	3143 (5.2)	147 (1.0)	
Pacific	6632 (11.0)	608 (4.3)	
<i>Year of diagnosis</i>			
2010	6064 (8.8)	1417 (8.6)	
2011	6788 (9.9)	1632 (9.9)	
2012	7936 (11.5)	1960 (11.9)	
2013	9007 (13.1)	2227 (13.6)	
2014	11,769 (17.1)	2763 (16.8)	
2015	13,480 (19.6)	3238 (19.7)	
2016	13,836 (20.1)	3186 (19.4)	
<i>Primary payor</i>			< 0.001
Not insured	1202 (1.7)	777 (4.7)	
Private insurance/managed care	45,420 (65.9)	9042 (55.1)	
Medicaid	5274 (7.7)	2957 (18.0)	
Medicare	15,417 (22.4)	3185 (19.4)	
Other government	810 (1.2)	267 (1.6)	
Insurance status unknown	757 (1.1)	195 (1.2)	
Last contact or death, time from diagnosis: months (range)	35.68 (22.28–54.70)	33.51 (20.90–51.75)	

TABLE 2

Clinical variables

	Non-Hispanic white (n = 68,880) n (%)	Non-Hispanic black (n = 16,423) n (%)	p Value
<i>Clinical stage</i>			< 0.001
1	8362 (12.1)	1485 (9.0)	
2	42,014 (61.0)	9758 (59.4)	
3	18,500 (26.9)	5180 (31.5)	
<i>Pathologic stage</i>			< 0.001
0	7319 (13.8)	1753 (13.8)	
1	15,704 (29.6)	3513 (27.7)	
2	18,926 (35.6)	4584 (36.1)	
3	11,042 (20.8)	2785 (22.0)	
4	141 (0.3)	51 (0.4)	
<i>Pathologic response</i>			0.011
Complete response	20,400 (39.0)	4680 (38.9)	
Partial response	26,334 (50.4)	5958 (49.5)	
No response	5561 (10.6)	1390 (11.6)	
<i>Tumor size (cm)</i>			< 0.001
2	13,306 (19.3)	3037 (18.5)	
2 to 5	28,487 (41.4)	6608 (40.2)	
>5	12,304 (17.9)	3408 (20.8)	
Unknown	14,783 (21.5)	3370 (20.5)	
<i>Grade</i>			< 0.001
Well differentiated, differentiated, NOS	4645 (6.7)	619 (3.8)	
Moderately differentiated, moderately well-differentiated, intermediate differentiation	23,749 (34.5)	4162 (25.3)	
Poorly differentiated	35,403 (51.4)	10,451 (63.6)	
Undifferentiated, anaplastic	206 (0.3)	53 (0.3)	
Cell type not determined, not stated or not applicable, unknown primaries, high-grade dysplasia	4877 (7.1)	1138 (6.9)	
<i>Breast cancer subtypes</i>			< 0.001
ER+/PR+ or PR-/HER2-	26,978 (44.1)	5281 (36.0)	

	Non-Hispanic white (n = 68,880) n (%)	Non-Hispanic black (n = 16,423) n (%)	p Value
ER+/PR+/HER2+	10,555 (17.2)	1832 (12.5)	
ER-/PR-/HER2-	16,037 (26.2)	5894 (40.2)	
ER-/PR-/HER2+	7620 (12.5)	1661 (11.3)	
<i>Histology</i>			< 0.001
Ductal	58,175 (84.5)	14,529 (88.5)	
Lobular	4969 (7.2)	672 (4.1)	
Mixed (ductal + lobular)	2720 (3.9)	381 (2.3)	
Other	3016 (4.4)	841 (5.1)	
<i>Immunotherapy</i>			< 0.001
No	51,741 (75.1)	13,124 (79.9)	
Yes	17,039 (24.7)	3273 (19.9)	
Unknown	100 (0.1)	26 (0.2)	
<i>Radiation</i>			< 0.001
None	20,865 (30.3)	4577 (27.9)	
Yes	47,824 (69.4)	11,808 (71.9)	
Unknown	191 (0.3)	38 (0.2)	
<i>Surgery</i>			< 0.001
<i>No surgery</i>	12,431 (18.0)	2710 (16.5)	
Partial mastectomy	20,975 (30.5)	5667 (34.5)	
Mastectomy	35,435 (51.4)	8040 (49.0)	
Unknown	32 (0.0)	5 (0.0)	
Time to surgery (days)	135.74 ± 89.70	145.01 ± 98.04	< 0.001
<i>Comorbidities</i>			< 0.001
0	60,429 (87.7)	13,411 (81.7)	
1	6771 (9.8)	2360 (14.4)	
2	1680 (2.4)	652 (4.0)	
<i>Lymph node surgery</i>			< 0.001
None	2112 (5.0)	471 (4.7)	
Sentinel lymph node biopsy	22,577 (53.5)	4707 (46.6)	
Axillary lymph node dissection	17,507 (41.5)	4914 (48.7)	

NOS, not otherwise specified; ER, estrogen receptor; PR, progesterone receptor; HER2, human epidermal growth factor

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

TABLE 3

Pathologic response by subtype and race

	Complete Response	Partial response	No response	p value
ER+/PR+ or PR-/HER2-	n = 4137	n = 15,200	n = 4,057	< 0.001
Non-Hispanic white	3352 (17.1)	12,853 (65.5)	3428 (17.5)	
Non-Hispanic black	785 (20.9)	2347 (62.4)	629 (16.7)	
ER+/PR+/HER2+	n = 3,901	n = 4,605	n = 601	0.051
Non-Hispanic white	3388 (43.3)	3923 (50.2)	507 (6.5)	
Non-Hispanic black	513 (39.8)	682 (52.9)	94 (7.3)	
ER-/PR-/HER2-	n = 8,316	n = 7,172	n = 1,549	< 0.001
Non-Hispanic white	6330 (50.1)	5249 (41.6)	1046 (8.3)	
Non-Hispanic black	1986 (45.0)	1923 (43.6)	503 (11.4)	
ER-/PR-/HER2+	n = 4,933	n = 2,222	n = 258	< 0.001
Non-Hispanic white	4188 (68.0)	1772 (28.8)	198 (3.2)	
Non-Hispanic black	745 (59.4)	450 (35.9)	60 (4.8)	

ER, estrogen receptor; PR, progesterone receptor; HER2, human epidermal growth factor

TABLE 4

Comparison of surgical treatments for patients by lymph node status

	Non-Hispanic white	Non-Hispanic black	<i>p</i> value
Lymph node-negative	<i>n</i> = 21,788	<i>n</i> = 4,801	< 0.001
Sentinel lymph node biopsy	17,944 (82.4)	3826 (79.7)	
Axillary lymph node dissection	3844 (17.6)	975 (20.3)	
Lymph node-positive	<i>n</i> = 12,016	<i>n</i> = 2,501	0.005
Sentinel lymph node biopsy	4964 (41.3)	958 (38.3)	
Axillary lymph node dissection	7052 (58.7)	1543 (61.7)	

TABLE 5

Comparison of treatments for patients who were downstaged

	Non-Hispanic white (<i>n</i> = 23,248) <i>n</i> (%)	Non-Hispanic black (<i>n</i> = 5852) <i>n</i> (%)	<i>p</i> value
<i>Breast cancer subtypes</i>			
ER+/PR+ or PR−/HER2−	7,294 (35.7)	1,621 (31.4)	< 0.001
ER+/PR+/HER2+	4,231 (20.7)	731 (14.2)	
ER−/PR−/HER2−	5,941 (29.1)	2,125 (41.2)	
ER−/PR−/HER2+	2,961 (14.5)	686 (13.3)	
<i>Surgery</i>			
Partial mastectomy	7,532 (39.5)	2,200 (44.7)	< 0.001
Mastectomy	11,536 (60.5)	2,726 (55.3)	
Unknown	5 (0.0)	1 (0.0)	
<i>Lymph node surgery</i>			
None	507 (3.5)	120 (3.4)	< 0.001
Sentinel lymph node biopsy	9,020 (62.6)	2,002 (56.1)	
Axillary lymph node dissection	4,878 (33.9)	1,448 (40.6)	
<i>Reconstruction</i>			
None	19,751 (85.0)	5,162 (88.2)	< 0.001
Tissue	1,432 (6.2)	346 (5.9)	
Implant	2,065 (8.9)	344 (5.9)	

ER, estrogen receptor; PR, progesterone receptor; HER2, human epidermal growth factor