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Patterns of evidence-based care for the diagnosis, staging, and first-line treatment of breast cancer by race-ethnicity: a SEER-Medicare study

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Abstract

Background.—Racial and ethnic disparities in guideline-recommended breast cancer treatment are well documented, however studies including diagnostic and staging procedures necessary to determine treatment indications are lacking. The purpose of this study was to characterize patterns in delivery of evidence-based services for the diagnosis, clinical workup, and first-line treatment of breast cancer by race-ethnicity.

Methods.—SEER-Medicare data were used to identify women diagnosed with invasive breast cancer between 2000 and 2017 at age 66 or older (n = 215,605). Evidence-based services included diagnostic procedures (diagnostic mammography and breast biopsy), clinical workup (stage and grade determination, lymph node biopsy, and HR and HER2 status determination), and treatment initiation (surgery, radiation, chemotherapy, hormone therapy, and HER2-targeted therapy). Poisson regression was used to estimate rate ratios (RRs) and 95% Confidence Intervals (CIs) for each service.

Results.—Black and American Indian/Alaska Native (AIAN) women had significantly lower rates of evidence-based care across the continuum from diagnostics through first-line treatment compared to non-Hispanic White (NHW) women. AIAN women had the lowest rates of HER2-targeted therapy and hormone therapy initiation. While Black women also had lower initiation of HER2-targeted therapy than NHW, differences in hormone therapy were not observed.

Conclusions.—Our findings suggest patterns along the continuum of care from diagnostic procedures to treatment initiation may differ across race-ethnicity groups.

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The authors declare no potential conflicts of interest.

Impact.—Efforts to improve delivery of guideline-concordant treatment and mitigate racial-ethnic disparities in healthcare and survival should include procedures performed as part of the diagnosis, clinical workup, and staging processes.

Keywords

breast cancer; patterns of care; treatment; diagnosis; disparities; equity; staging

Introduction

Improved access to breast cancer screening and development of highly effective treatments, such as tamoxifen for hormone receptor positive (HR+) tumors, have dramatically improved survival for breast cancer patients in recent decades.(1, 2) Cumulative evidence from randomized clinical trials and observational studies have resulted in consensus-based treatment guidelines from the National Comprehensive Cancer Network (NCCN) and other professional organizations.(3, 4) Surgery and axillary staging, radiation following breast conserving surgery (BCS), and adjuvant chemotherapy are Category 1 recommendations, meaning there is uniform NCCN consensus based upon high-level evidence. Hormone therapy for HR+ patients has a Category 2A recommendation, with uniform consensus based on lower-level evidence.(3) Despite general consensus on treatment standards for breast cancer, Black, American Indian and Alaska Native (AIAN), and Hispanic women are less likely to receive treatment that meet these standards, compared to non-Hispanic Whites (NHWs).(5–12)Differences in treatment result in disparities in breast cancer survival and mortality.(2, 5–8, 13–30)

Adherence to guideline-recommended treatment modalities first requires accurate diagnosis and staging. The NCCN Basic Resources Framework includes “essential services needed to provide basic minimal standard of care that improves disease-specific outcomes.”(31) These procedures, including HR testing, diagnostic mammography, and axillary staging, should be available even in resource constrained settings and are critically important in determining the appropriate course of therapy.(31) Investigations of differences in cancer care delivered at the time of diagnosis and clinical work-up are lacking. Studies that have solely focused on therapeutics cannot conclude whether improving access to treatment alone would address disparities in outcomes. To understand how and why racial and ethnic disparities in treatment occur, it is necessary to understand where along the continuum of care healthcare disparities emerge.

We hypothesized racial and ethnic differences in care would emerge before treatment initiation and persist throughout the cancer care experience, creating disparate opportunities for receipt of guideline-concordant care. The purpose of this study was to characterize utilization of evidence-based procedures for the diagnosis, staging, and first-line treatment of breast cancer. Our primary aim was to describe delivery patterns of the individual components of care recommended by clinical practice guidelines among a population-based cohort of older women by race and ethnicity. Secondarily, we explored whether these patterns differed between strata of stage at diagnosis.

Materials and Methods

Data source and study population

This retrospective cohort study used the Surveillance, Epidemiology, and End Results (SEER)-Medicare linked database to identify a diverse cohort of breast cancer patients. The SEER cancer file provided patient, tumor, and treatment information among patients diagnosed in the 18-state catchment area.(32) We used Medicare enrollment and claims files, including race and vital status information collected by the Social Security Administration, for 1999 through 2019. Fee-for-service (FFS) claims from inpatient and skilled nursing facilities (MedPAR), outpatient (OUTPAT), and professional services National Claims History (NCH) files were analyzed. We also examined Part D (prescription drug) events for patients with the corresponding coverage. This project was approved by the University of Iowa Institutional Review Board.

Women diagnosed with a first primary breast cancer between 2000 and 2017 were eligible for inclusion (Figure 1). The 'Primary Cohort' had malignant, invasive breast tumors (International Classification of Diseases for Oncology (ICD-O) behavior code 3).(33) Inflammatory carcinoma and Paget disease were excluded (ICD-O-3 histology 8530, 8540-8543). Patients of any stage at diagnosis – I-IV and those with unknown stage – were eligible. Patients diagnosed before age 66 or whose tumors were identified at time of death were excluded. At least 12 continuous months of FFS Medicare coverage prior to diagnosis was required to allow for evaluation of baseline comorbidities. Patients who died or whose FFS coverage lapsed within three months after diagnosis and those with other or unknown race were excluded. From the Primary Cohort, two distinct subsets of patients were identified: 1) Part D eligibile, defined as having three or more months of continuous Part D coverage after diagnosis; 2) those diagnosed in 2010 or later, when human epidermal growth factor receptor 2 (HER2) status was first reported in SEER.

Variables of Interest

Race and ethnicity.—Various sources of race and ethnicity data are available in SEER-Medicare; however, their reliability varies across racial groups and methods of data collection and reporting are inconsistent.(34) To improve upon data quality and make use of the best available information, we developed algorithms to classify race and ethnicity separately using data from SEER and Medicare enrollment files (Supplementary Figure 1). A final combined race-ethnicity variable was then defined using both hierarchy-based variables categorized as: AIAN, Asian or Pacific Islander (API), Black, Hispanic White (HW), and NHW.

Components of Care.—We reviewed NCCN practice guidelines and American Society of Clinical Oncology quality metrics to identify evidence-based services for diagnosis, clinical workup and staging, and first-line treatment of breast cancer.(4, 35) Outcomes of interest included recommended services (i.e., components of care) measurable using SEER-Medicare data; (definitions are provided in Supplementary Table 1).

Diagnostic procedures (diagnostic mammography and initial needle breast biopsy) were identified from claims data during the three months before through three months after diagnosis (hereafter referred to as the diagnostic period). Clinical workup and staging procedures identified from the SEER cancer file included determination of stage, grade, HR status, and HER2 status; lymph node biopsies were identified using both SEER and claims data.(36) Stage was defined according to the American Joint Commission on Cancer edition available at the date of diagnosis; 6th edition was used for patients diagnosed through 2015 and 7th edition was used for patients diagnosed 2017 or later.

First-line treatments (surgery, radiation, chemotherapy, HER2-targeted agents, and hormonal therapy) were identified from claims during the treatment period, defined as one month prior through 12 months after diagnosis. Surgery, radiation, and chemotherapy were also captured in SEER. Hormonal therapies were identified via generic drug names from Part D events. Chemotherapy and HER2-targeted agents identified in Part D events were also included, however Part D coverage was not required for these treatments because a near-zero proportion of additional treatment was identified via Part D alone. Where applicable, treatment outcomes were evaluated in the subgroups of patients for whom each treatment is indicated according to NCCN guidelines. Radiation was analyzed within subgroups of surgery modalities (breast conserving surgery, mastectomy-treated patients with N2+ or T3 tumors, or no surgery). Chemotherapy was evaluated among triple negative patients (HR− and HER2−) and HER2-targeted therapy was examined among HER2+ patients. Hormone therapy was examined among HR+, Part D eligible patients.

Covariates.—The SEER file provided demographics (age at diagnosis, year of diagnosis, marital status), and tumor characteristics. Medicare enrollment data were used to define a dichotomous indicator for receipt of low-income subsidy for at least one month in the year prior to cancer diagnosis (a proxy measure of low individual-level income). Continuous comorbidity and frailty scores were generated from baseline (i.e., 12 months prior to diagnosis) claims using validated algorithms (NCI weighted comorbidity score and Kim et al. claims-based frailty index).(37–40) Primary care utilization and hospitalizations were identified from baseline claims occurring 3 or more months before diagnosis. Distinct primary care visits were identified via CPT codes.(41) Hospitalizations were defined as having one or more MedPAR claims.

Statistical analysis

Rate ratios (RRs) for each component of care by race-ethnicity were estimated using log-linear Poisson regression models. Rates were calculated as a function of person-time (months) of follow-up for outcomes during the treatment period by including an offset in the Poisson models. NHW patients were selected as the reference group for RRs because they were the largest race-ethnicity group. Crude and adjusted RRs with corresponding 95% confidence intervals (CIs) were estimated with robust variance estimators. All analyses were also performed stratified by stage at diagnosis (I-III, IV, and unknown/missing) and age at diagnosis (66-69, 70-75, 76-80, 81+), shown in Supplementary Tables 2–3. Patient demographic and health status covariates were adjusted for in all models and analyses of first-line treatment controlled for stage at diagnosis and HR status, if not already accounted

for by subgroup selection or stratification. To assess the importance of demographics – a mediator of the relationship between race-ethnicity and receipt of care – to observed associations, we performed sensitivity analyses adjusted for all covariates except marital status and low-income subsidy (Supplementary Table 4).

Two-tailed tests with a significance level of 0.05 were utilized for all analyses. All analyses were performed in SAS software (v9.4; RRID:SCR_008567). Data visualization was performed using R (v4.2.1; RRID:SCR_001905) with the ggplot2 package (RRID:SCR_014601).

Data Availability

SEER-Medicare data are available upon NCI approval of a specific research project; more information can be found at https://healthcaredelivery.cancer.gov/seermedicare/obtain/.

Results

The Primary Cohort consisted of 215,605 women meeting all eligibility criteria (Figure 1). About a third (37.4%) of the Primary cohort were Part D eligible (n=80,689); over 40% were diagnosed in 2010 or later, when HER2 status data became available (n=94,264; 43.7%). The median follow-up time for the Primary Cohort was 66 months (interquartile range (IQR) 35-112, mean 77.9, standard deviation (SD) 54.1), including 3 months of required follow-up. Most of the Primary Cohort had HR+ tumors (n=168,396; 78.1%) and most patients with HER2 status available were HER2− (n=77,075; 81.8%). Cohort descriptive statistics by race-ethnicity are provided in Table 1.

Diagnostic procedures

Approximately 90% of the Primary Cohort had a claim for diagnostic mammography (Table 2). Most patients (82.9%) had the guideline-preferred initial breast biopsy performed percutaneously.

NHW women had the highest percentage of patients receiving diagnostic mammography and API had the highest proportion receiving an initial needle breast biopsy (Figure 2A). Conversely, Black and AIAN women had the lowest proportions of patients to receive diagnostic mammography and initial needle breast biopsy. All race-ethnicity groups had statistically significantly lower rates of diagnostic mammogram compared to NHW women (Table 3). However, only Black and AIAN women had significantly lower rates of both diagnostic mammogram and initial needle breast biopsy compared to NHW. In stratified analyses, Black and AIAN women had significantly lower rates of diagnostics primarily among women with non-metastatic (stage 1-3) disease and those diagnosed at younger ages (66-69 years; Supplementary Tables 2–3)).

Clinical Workup and Staging Procedures

Over 80% of the Primary Cohort received a lymph node biopsy (Table 2). Stage at diagnosis and tumor grade were documented for 93.2% and 90.5%, respectively, of the Primary

Cohort. HR status was determined for 90% of the Primary Cohort and HER2 status was determined for 92.0% of patients with the HER2 variable available.

Black women had the lowest proportion of patients with known grade at diagnosis, to receive any lymph node biopsy, and to have HR status determined (Figure 2B). RRs for Black women compared to NHW were significantly lower for these three outcomes before and after adjustments (Table 3). The difference in known grade between Black and NHW women was largest among patients with unknown stage at diagnosis; effects were statistically significant for unknown and stage 1-3 patients and across all age groups (Supplementary Tables 2–3).

AIAN women had the lowest proportions with known stage at diagnosis or documented HR status (Figure 2B). AIAN women were significantly less likely to have known stage than NHW (Table 3). Among patients diagnosed at stage 4, AIAN women had notably lower rates of HR and HER2 status determination than NHW ($RR_{HR,\ adjusted}$ (95% CI) 0.85 (0.7-1.0); $RR_{HER2,\ adjusted}$ 0.72 (0.52-0.99); Supplementary Table 2).

API patients had the highest proportion of patients receiving all clinical workup and staging procedures (Figure 2B). API women were significantly more likely to have known grade and HR status than NHW women before and after adjustments (Table 3). Stage-stratified analyses revealed statistically significant increased rate of node biopsy for API versus NHW women among the stratum of stage 4 patients (Supplementary Table 2).

First-line treatment

Over 90% of the Primary Cohort had cancer-directed surgery (91.6%); 49.2% received breast conserving surgery (BCS) and 42.5% received mastectomy (Figure 3A). Radiation, which is guideline-recommended for all patients who receive BCS, as well as patients who receive mastectomy and have N2+ or T3 disease, was provided to 78.3% of BCS-treated patients and 60.9% of mastectomy-treated patients eligible for radiation. Radiation is not guideline-recommended for patients who do not receive surgery but was received by 21.8% of these patients. Chemotherapy is recommended for all women with triple negative tumors and 59.6% of these patients received it. HER2-targeted therapy was observed in 59.7% of HER2+ patients. Most (79.5%) HR+ patients with Part D eligibility received at least one dose of hormone therapy.

Black women had the lowest proportion of patients to receive cancer-directed surgery (Figure 3A). Black women were significantly less likely to receive any cancer-directed surgery compared to NHW after adjusting for patient and tumor characteristics (Table 3). The magnitude of the disparity was largest among patients with unknown stage and aged 81 or older at diagnosis (Supplementary Tables 2–3). AIAN women had the second-lowest proportion to receive surgery of any race-ethnicity group; RRs for surgery compared to NHW were not statistically significant after adjustment for clinical and demographic characteristics.

Among women who received BCS, AIAN and Black women had the lowest proportions to receive radiation (Figure 3B). Both AIAN and Black women had 0.99 times the rate

of radiation as NHW among BCS-treated women, however effects for AIAN women were not statistically significant (Table 3). Conversely, API and HW women had significantly higher rates of radiation than NHW among BCS-treated patients. Of all mastectomy-treated patients eligible for radiation, AIAN and API women had the highest proportions to receive radiation therapy and were significantly more likely to receive radiation relative to NHW women. There were no significant differences in the rate of radiation therapy among patients who did not receive any surgery.

Among triple negative patients, HW and Black women had the highest proportion of patients receiving chemotherapy, while NHW had the lowest (Figure 3C). HW and Black women were significantly more likely to initiate chemotherapy compared to NHW before and after adjustment for patient and tumor characteristics (Table 3). Black women had significantly higher rates of chemotherapy among stage 1-3 and 4 and among patients diagnosed at the youngest and oldest ages (Supplementary Tables 2–3). HW women only had significantly higher rates among stage 4, compared to NHW (Supplementary Table 2).

Among HER2+ patients, AIAN and Black women had the lowest proportions of patients to receive HER2-targeted therapy while API women had the highest initiation proportion (Figure 2E). There were no statistically significant differences in HER2 therapy initiation for AIAN or Black women compared to NHW, however the magnitude of effect may reflect clinically significant differences ($RR_{AIAN,\ adjusted}$ 0.82 (0.62-1.08); $RR_{Black,\ adjusted}$ 0.95 (0.90-1.01)).

AIAN women had the lowest proportion of patients to receive hormone therapy among HR+ patients with Part D coverage while API women had the highest (Figure 3C). Additionally, AIAN women were the only group with significantly lower rates of hormone therapy initiation than NHW before and after adjustments ($RR_{adjusted}$ 0.92 (0.85-0.99); Table 3). The disparity in hormone therapy initiation was largest among unknown and stage 4 patients, but neither were statistically significant ($RR_{Stage\ Unknown,\ adjusted}$ 0.81 (0.50-1.32); $RR_{Stage\ 4,\ adjusted,}$ 0.85 (0.53-1.35); Supplementary Table 2). Among stage 1-3 patients, AIAN women had lower rate of hormone therapy initiation, but the effect was only significant after adjustments ($RR_{adjusted}$ 0.93 (0.86-0.99)). API had significantly higher rates of hormone therapy initiation compared to NHW before and after adjustments in the overall analysis and among stage 1-3 patients.

Sensitivity analyses

RRs from models adjusted for all covariates except marital status and low-income subsidy tended to be farther from the null (i.e., magnitude of the difference was larger) than primary models (Supplementary Table 4). API and HW women were significantly less likely to receive an initial needle biopsy compared to NHW in the sensitivity analysis, however the disparity was still larger for Black and AIAN women. Without adjustment for demographics, AIAN women were significantly less likely to receive a node biopsy and to have HR status documented than NHW ($RR_{Node\ biopsy}$ 0.96 (0.94-0.99); $RR_{HR\ documentation}$ 0.98 (0.95-0.99)). Black women had significantly lower rates of known stage at diagnosis and HER2-targeted therapy compared to NHW (RR_{Stage} 0.992 (0.987-0.996); RR_{HER2} 0.93

(0.88-0.99)). There were no significant differences between HW and NHW for any primary treatment modality when marital status and low-income subsidy were not adjusted for.

Discussion

This investigation characterized patterns of care for the diagnosis, clinical work-up and staging, and first-line treatment of breast cancer by race-ethnicity among a large, diverse cohort of older women enrolled in Medicare. Disparities in evidence-based care began early in the clinical course and persisted throughout the continuum of care. Sensitivity analyses – adjusting multivariable models for all covariates except marital status and low-income subsidy – suggested demographic characteristics may be a mediator of racial-ethnic differences in evidence-based breast cancer care, however, disparities persist independently of those effects. Black and AIAN patients were disproportionately likely to receive nonstandard care that conflicts with practice recommendations. However, the points along the continuum of care where evidence-based care was inequitably delivered varied across race-ethnicity, reflecting differences in the barriers and facilitators across patient groups. Without explicit attention to these differences, we miss opportunities to address disparities in health and health outcomes and fail to characterize the full continuum of breast cancer care for a large portion of women in the US.

Black and AIAN women were the only race-ethnicity groups with significantly lower rates of evidence-based care across all diagnostics and most clinical workup procedures compared to NHW. Tumor characteristics determined during these early clinical encounters are necessary to determine appropriate subsequent treatment. Examinations of racial-ethnic differences in diagnostic breast cancer care are limited; however, lower rates of initial needle biopsy and HR and HER2 testing have been documented for Black women, compared to NHW.(8, 9, 26, 42–44) Additionally, disproportionately high rates of missing tumor characteristic data, such as tumor subtype and stage, among Black and AIAN breast cancer patients have been described.(11, 24, 45, 46) These findings demonstrate an important point of failure that impact not only subsequent treatment, but are reflected in surveillance and research efforts, including eligibility for clinical trials which have documented disparities in participation by race-ethnicity.(47–49) Providers and healthcare systems should consider diagnostic/clinical procedures in quality assessment to provide a more comprehensive picture of opportunities to mitigate disparities in treatment and outcomes. Because these characteristics are commonly used to select patient populations for whom treatment quality can be assessed; disparities in delivery of these procedures means biased estimates of quality care.

We did not observe racial-ethnic disparities in receipt of chemotherapy among patients with triple negative disease. Black women had significantly higher rates of chemotherapy compared to NHW, however, NHW women had the lowest rate of chemotherapy use in our study population. Evidence of racial and ethnic differences in chemotherapy utilization is inconsistent; however, higher crude rates among Black, compared to White, women have been reported.(9, 50) Further investigation is needed to determine whether the patterns of chemotherapy utilization observed in this study reflect overtreatment of Black patients.

Racial-ethnic disparities observed in cancer-directed surgery and radiation following BCS were consistent with previous work using SEER-Medicare as well as other patient populations.(7, 11, 25, 51–53) We observed notable disparities in the rates of HER2-targeted therapy for Black and AIAN women; however, these analyses were underpowered due to small sample sizes of patients with HER2+ disease. Few studies have examined racial-ethnic differences in HER2-targeted therapy. Lower rates of HER2 treatment for Black women compared to NHW women were documented in two studies of early-stage breast cancer patients.(54, 55) However, another investigation documented no difference in initiation, but significantly lower odds of anti-HER2 therapy completion between Black and White women.(56) To our knowledge, this has not been examined among AIAN patients. This is an important area for further investigation, especially considering the disparity in HER2 testing for these patient populations.

Patterns of care for AIAN and Black women differed for hormone therapy. Among patients with HR+ tumors, AIAN patients were less likely to initiate hormonal therapy than NHW women. However, Black women had equivalent rates of hormone therapy initiation compared to NHW women. Lower rates of adjuvant therapy among AIAN compared to White patients have been reported, but to our knowledge, endocrine therapy has not been explicitly examined.(7) Evidence of disparities in hormone therapy for Black women is inconsistent across studies.(57) Several studies have documented no difference, but some have described lower initiation and at least one study observed higher initiation of hormone therapy among Black women compared to White.(9, 11, 15, 57–61) The lack of evidence for AIAN patients – for hormone therapy and other outcomes – implores research be conducted in order to better understand and address the burden of breast cancer disparities among Indigenous women.

Strengths and Limitations

Due to the nature of secondary data analyses, our study is prone to some limitations that warrant consideration in interpretation of the findings. Selection bias may result from differences in age at diagnosis and life expectancies between race-ethnicity groups. Rather than excluding patients with missing values of any variable, we treated unknown as its own value, to mitigate selection bias from demonstrated racial-ethnic patterns of missing data.(45, 62) Interpretation of unknown values requires the assumption that this information would also be unknown to the patients' providers. We believe this to be reasonable based on the completeness of the SEER-Medicare database, however this may not be correct in all cases.(62) Over one-third of the initial population was excluded due to lack of continuous Medicare coverage in the year prior to diagnosis; of note – this population may be more vulnerable to disparities in care than the eligible study population with continuous coverage. Survival bias may have been introduced by requiring patients lived at least 3 months post-diagnosis. However, this was necessary to provide adequate time for patients to receive some cancer care services. The number of analyses performed increases the chance of finding a significant effect as an artifact of multiple testing, however the potential implications of finding a spurious association outweigh the risks of not doing this work.(63) Moreover, while some comparisons were based on small sample sizes, particularly among

AIAN patients in stage-stratified analyses, it remains important to conduct analyses with/for small populations despite wide confidence intervals.(64)

This study has several strengths. This is the first study to examine differences in treatment within the context of earlier components of care that may contribute to differences in treatment later in the continuum of care. We used multiple sources of data to maximize the accuracy of our race-ethnicity characterization. We imposed minimal cohort criteria to maximize generalizability to the broader population of older women with breast cancer in the United States. Our measures of evidence-based care were identified from multiple clinical practice guidelines and quality metrics, maximizing the relevance of these findings to routine clinical settings. Rate ratios are the preferred comparative effect estimate for cohort studies and common outcomes.(65–67) Additionally, the RR accounted for each patients' duration of follow-up, which allowed us to minimize eligibility criteria while still appropriately accounting for the amount of time in which the outcome could be observed.

Conclusions

This investigation elucidated distinct points along the continuum of breast cancer care at which access to evidence-based services differ for racially and ethnically diverse patients. We demonstrated disparities in quality care manifest in more ways than just undertreatment; failures of quality include overtreatment and use of more invasive/extensive procedures than necessary. Our findings indicate a need to consider clinical experiences preceding first-line treatment, with implications for efforts to promote equitable access to cancer care in both clinical and surveillance/research settings. Quality improvement efforts and national quality metrics for breast cancer should consider including services such as HR status documentation and staging, as these are necessary precursors to treatment administration with direct implications for racial equity. Further research should examine how social, structural, and institutional factors create disparate contexts within which patients seek care. To address disparities in quality of care and outcomes, providers and healthcare systems must consider the structural root causes of these disparities to deploy solutions that address the specific barriers their patients face. Without understanding the upstream social and structural determinants of health and healthcare access, racial disparities in breast cancer will likely persist, even as screening and treatment improve.(68)

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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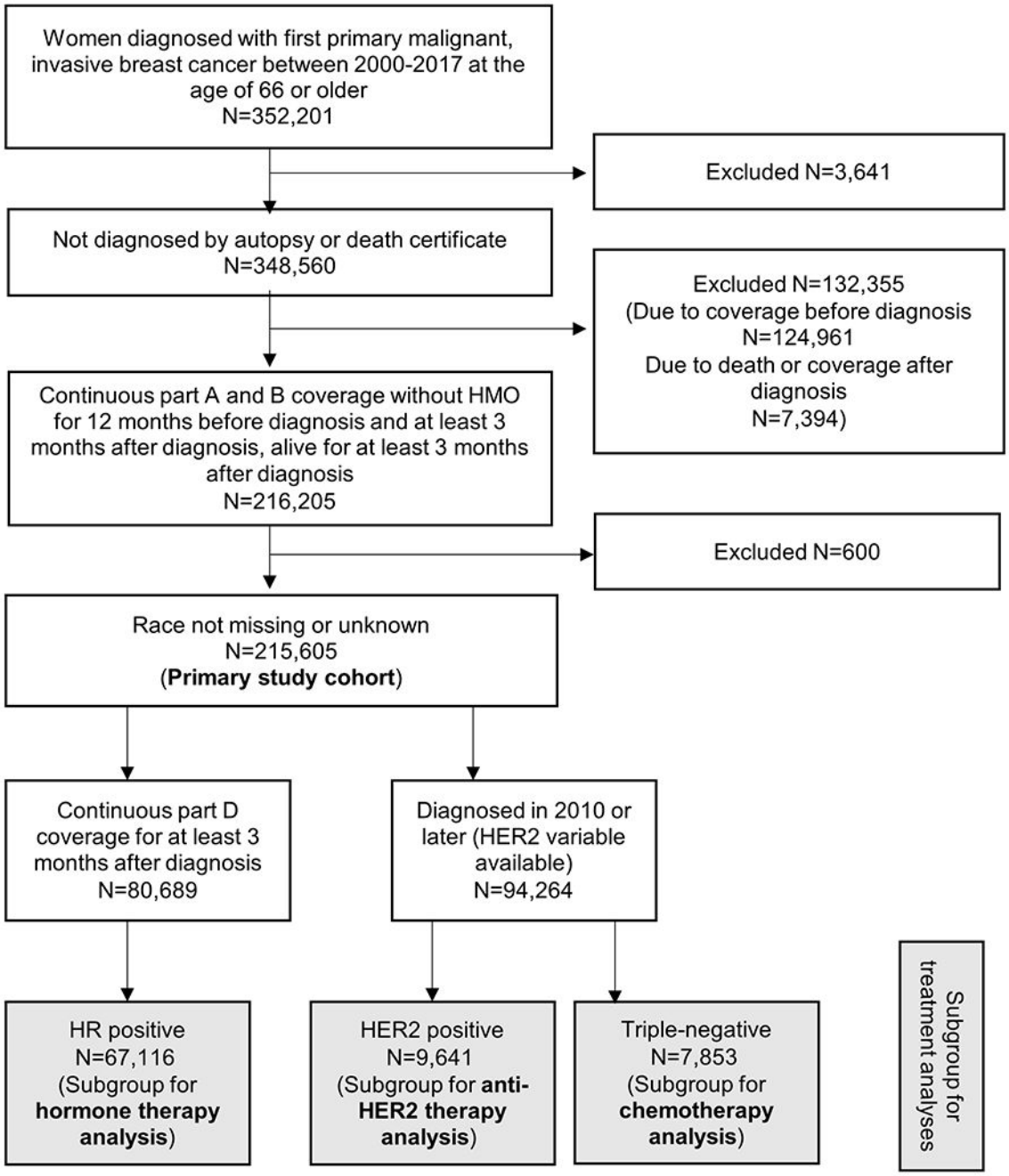

Figure 1. Flow diagram of cohort selection criteria.

This figure depicts sequential application of cohort selection criteria, including the number of participants excluded at each step, to arrive at the primary study cohort consisting of 215,605 patients.

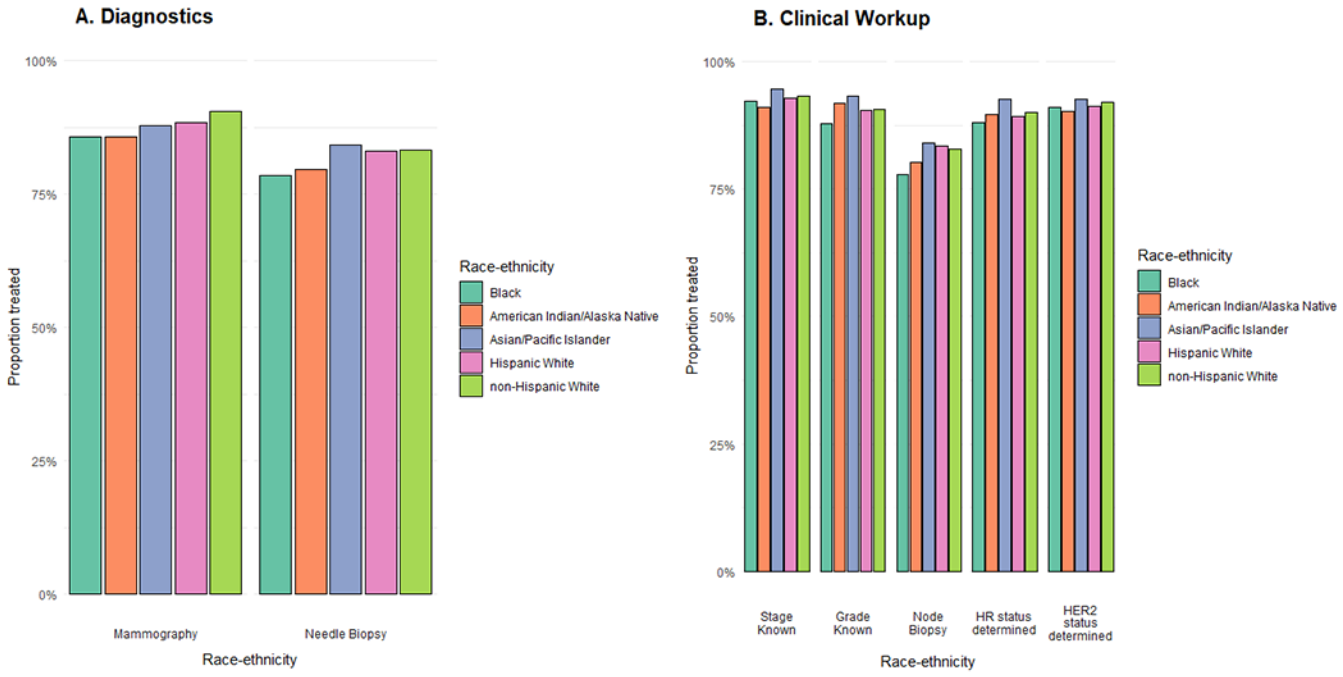

Figure 2. (2A-2B). Proportions receiving each component of care for diagnostics and clinical workup by race-ethnicity.

Bar charts with proportions of patients in each race-ethnicity group to receive each component of care for diagnostics and clinical workup. Among women diagnosed with first primary invasive breast cancer between 2000-2017, captured in the SEER-Medicare database, with continuous fee-for-service Medicare coverage for at least 12 months prior and at least 3 months after index cancer diagnosis (n=215,605). Abbreviations: HR=hormone receptor; HER2=Human Epithelial Growth Factor 2

Figure 2A is comprised of bar charts for the two diagnostic procedures: diagnostic mammography and receipt of an initial needle breast biopsy.

Figure 2B is comprised of bar charts for clinical workup procedures, including known stage and grade at diagnosis, receipt of lymph node biopsy, and hormone receptor (HR) and human epithelial growth factor receptor 2 (HER2) status determination.

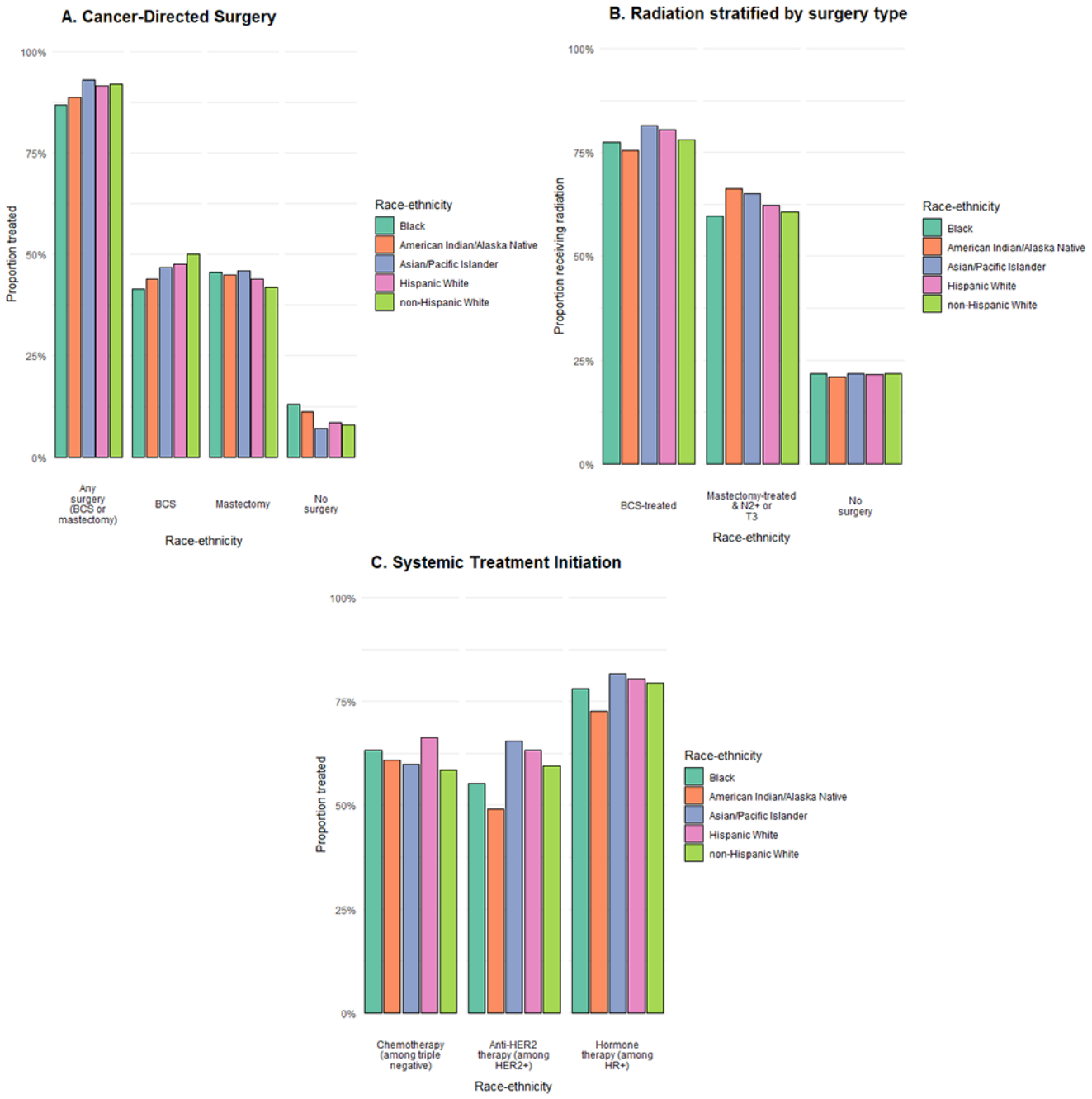

Figure 3. (3A-3C). Proportions receiving each component of care for cancer-directed treatment initiation by race-ethnicity.

Bar charts with proportions of patients in each race-ethnicity group to receive each component of care for diagnostics and clinical workup. Among women diagnosed with first primary invasive breast cancer between 2000-2017, captured in the SEER-Medicare database, with continuous fee-for-service Medicare coverage for at least 12 months prior and at least 3 months after index cancer diagnosis (n=215,605). Abbreviations: BCS=breast conserving surgery; N2+=nodal stage 2 or 3; T3=tumor size 3; HER2+= Human Epithelial Growth Factor 2-positive; HR+= hormone receptor -positive.

Figure 3A is comprised of bar charts for cancer-directed surgery overall, and for each surgery outcome individually (breast conserving surgery, mastectomy, and no surgery). Figure 3B is comprised of bar charts for receipt of radiation in each surgery subgroup – breast conserving surgery, radiation-eligible mastectomy (N2+ or T3), and no surgery. Figure 3C is comprised of bar charts for initiation of each systemic therapy among the corresponding eligible subgroups: chemotherapy among triple-negative patients (N=7,853), HER2-targeted therapy among HER2-positive patients (N=9,641), and hormone therapy among HR-positive patients with corresponding Part D (prescription drug) coverage (N=67,116).

Table 1.
Descriptive Statistics by Race-Ethnicity.

Among women diagnosed with first primary invasive breast cancer between 2000-2017, captured in the SEER-Medicare database, with continuous fee-for-service Medicare coverage for at least 12 months prior and at least 3 months after index cancer diagnosis (n=215,605).

Covariate	Level	Black N=16495	American Indian/Alaska Native N=890	Asian/Pacific Islander N=8780	Hispanic White N=10067	Non-Hispanic White N=179373
Stage	I	6566 (39.8)	415 (46.6)	4581 (52.2)	4600 (45.7)	92894 (51.8)
	II	5542 (33.6)	270 (30.3)	2664 (30.3)	3211 (31.9)	51347 (28.6)
	III	2054 (12.5)	81 (9.1)	745 (8.5)	1067 (10.6)	15544 (8.67)
	IV	1041 (6.3)	44 (4.9)	312 (3.6)	463 (4.6)	7457 (4.2)
	Unknown	1292 (7.8)	80 (9.0)	478 (5.4)	726 (7.2)	12131 (6.8)
Grade	I	2693 (16.3)	234 (26.3)	2007 (22.9)	2171 (21.6)	43410 (24.2)
	II	6125 (37.1)	352 (39.6)	3992 (45.5)	4250 (42.2)	76302 (42.5)
	III & IV	5663 (34.3)	232 (26.1)	2185 (24.9)	2680 (26.6)	42803 (23.9)
	Unknown	2014 (12.2)	72 (8.1)	596 (6.8)	966 (9.6)	16858 (9.4)
Diagnosis Year	Mean (SD)	2008.6 (5.2)	2009.5 (5.1)	2009.6 (5.0)	2009.1 (5.1)	2008.3 (5.2)
Age (diagnosis)	Mean (SD)	75.6 (7.2)	74.7 (6.7)	75 (6.7)	74.9 (6.8)	76.3 (7.2)
Comorbidity score	Mean (SD)	0.4 (0.6)	0.4 (0.5)	0.3 (0.4)	0.3 (0.5)	0.3 (0.4)
Frailty score	Mean (SD)	0.17 (0.1)	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)
PCP visits	Mean (SD)	6.0 (5.4)	6.2 (5.7)	5.8 (5.5)	6.3 (5.6)	6.2 (5.5)
Marital status at diagnosis	Married	4050 (24.6)	321 (36.1)	4413 (50.3)	4020 (39.9)	78949 (44.0)
	Previously married	9003 (54.6)	373 (41.9)	3295 (37.5)	4415 (43.9)	78912 (44.0)
	Single	2436 (14.8)	102 (11.5)	722 (8.2)	1108 (11.0)	12396 (6.9)
	Unknown	1006 (6.1)	94 (10.6)	350 (4.0)	524 (5.2)	9116 (5.1)
Low-income subsidy		6088 (36.9)	303 (34.0)	2746 (31.3)	4029 (40.0)	17051 (9.5)
Hospitalization (1 or more)		2274 (13.8)	146 (16.4)	679 (7.73)	1135 (11.3)	20696 (11.5)
HER2 eligible cohort [a]		7379 (44.7)	479 (53.8)	4700 (53.5)	4938 (49.1)	76768 (42.8)
HER2 status	Positive	845 (11.5)	53 (11.1)	558 (11.9)	547 (11.1)	7638 (10.0)
	Negative	5866 (79.5)	379 (79.1)	3800 (80.9)	3957 (80.1)	63073 (82.2)
	Borderline or unknown	668 (9.1)	47 (9.8)	342 (7.3)	434 (8.8)	6057 (7.9)
Triple Negative		1146 (15.5)	41 (8.6)	374 (8.0)	440 (8.9)	5852 (7.6)
Part D eligible cohort [b]		6565 (39.8)	359 (40.3)	4002 (45.6)	4655 (46.2)	65108 (36.3)
HR status	Positive	4809 (73.3)	282 (78.6)	3308 (82.7)	3764 (80.9)	54953 (84.4)
	Negative	1344 (20.5)	47 (13.1)	513 (12.8)	607 (13.0)	7280 (11.2)
	Borderline or unknown	412 (6.3)	30 (8.4)	181 (4.5)	284 (6.1)	2875 (4.4)

Percents are column (i.e., race-ethnicity group-specific) percentages. HR status based on ER and PR status in SEER, following SEER breast subtype algorithm. Comorbidity score defined using the NCI comorbidity index. Low-income subsidy defined as state buy-in for at least one month prior to diagnosis. Hospitalizations defined as MEDPAR stays in year prior to diagnosis.

[a] HER2 eligible cohort were diagnosed in 2010 or later (when HER2 status variable was first reported).

[b] Part D eligible cohort were diagnosed in 2007 or later and had at least 3 months of continuous coverage after diagnosis.

Abbreviations: Hormone receptor (HR), Estrogen Receptor (ER), Progesterone Receptor (PR), Human epidermal growth factor receptor 2 (HER2), Breast conserving surgery (BCS), HR-positive (HR+), HR-negative (HR−), HER2-positive (HER2+), HER2-negative (HER2−), Triple negative (HR− & HER2−).

Table 2.

Frequencies and proportions of patients receiving each component of care overall and by race-ethnicity.

Among women diagnosed with first primary invasive breast cancer between 2000-2017, captured in the SEER-Medicare database, with continuous fee-for-service Medicare coverage for at least 12 months prior and at least 3 months after index cancer diagnosis (n=215,605).

	Overall	Black	American Indian/ Alaska Native	Asian/Pacific Islander	Hispanic White	Non-Hispanic White
Mammography	194033 (90.0)	14141 (85.7)	763 (85.7)	7714 (87.9)	8909 (88.5)	162506 (90.6)
Initial needle breast biopsy	178832 (82.9)	12955 (78.5)	709 (79.7)	7390 (84.2)	8353 (83.0)	149425 (83.3)
Node biopsy	178072 (82.6)	12848 (77.9)	715 (80.3)	7385 (84.1)	8398 (83.4)	148726 (82.9)
Stage known	200910 (93.2)	15204 (92.2)	810 (91.0)	8302 (94.6)	9341 (92.8)	167253 (93.2)
Grade known	195099 (90.5)	14481 (87.8)	818 (91.9)	8184 (93.2)	9101 (90.4)	162515 (90.6)
HR documentation	194019 (90)	14512 (88.0)	798 (89.7)	8136 (92.7)	8991 (89.3)	161582 (90.1)
HER2 documentation	86716 (92)	6711 (90.9)	432 (90.2)	4358 (92.7)	4504 (91.2)	70711 (92.1)
Cancer-directed Surgery	197571 (91.6)	14338 (86.9)	790 (88.8)	8155 (92.9)	9209 (91.5)	165079 (92.0)
Radiation among BCS-treated	83003 (78.3)	5291 (77.4)	294 (75.4)	3351 (81.5)	3851 (80.4)	70216 (78.1)
Radiation among mastectomy N2+/T3	11428 (60.9)	1179 (59.7)	49 (66.2)	490 (65.1)	642 (62.3)	9068 (60.8)
Radiation among no surgery	3922 (21.7)	468 (21.7)	21 (21.0)	136 (21.8)	185 (21.6)	3112 (21.8)
Chemotherapy	4683 (59.6)	725 (63.3)	25 (61.0)	224 (59.9)	292 (66.4)	3417 (58.4)
HER2 therapy	5752 (59.7)	468 (55.4)	26 (49.1)	365 (65.4)	346 (63.3)	4547 (59.5)
Hormonal therapy	53360 (79.5)	3756 (78.1)	205 (72.7)	2703 (81.7)	3030 (80.5)	43666 (79.5)

Abbreviations: Hormone receptor (HR), Human epidermal growth factor receptor 2 (HER2), Breast conserving surgery (BCS), HR-positive (HR+), HR-negative (HR−), HER2-positive (HER2+), HER2-negative (HER2−), Triple negative (HR− & HER2−).

Table 3.
Crude and adjusted rate ratios (RRs) and 95% confidence intervals (CIs).

Among women diagnosed with first primary invasive breast cancer between 2000-2017, captured in the SEER-Medicare database, with continuous fee-for-service Medicare coverage for at least 12 months prior and at least 3 months after index cancer diagnosis (n=215,605).

		Black	American Indian/ Alaska Native	Asian/Pacific Islander	Hispanic White
Diagnostics					
Mammography	Crude	**0.98 (0.97-0.99)**	**0.98 (0.96-0.999)**	1.0 (0.99-1.01)	**1.01 (1.001-1.02)**
	Adjusted[a]	**0.97 (0.96-0.97)**	**0.95 (0.93-0.98)**	**0.97 (0.96-0.98)**	**0.98 (0.98-0.99)**
Initial needle breast biopsy	Crude	**0.94 (0.94-0.95)**	**0.96 (0.92-0.99)**	**1.01 (1.001-1.02)**	0.996 (0.99-1.01)
	Adjusted[a]	**0.96 (0.96-0.97)**	**0.95 (0.92-0.98)**	0.99 (0.98-1.002)	0.998 (0.99-1.01)
Clinical workup					
Node biopsy	Crude	**0.96 (0.95-0.97)**	0.98 (0.95-1.01)	**1.01 (1.003-1.02)**	**1.01 (1.001-1.02)**
	Adjusted[a]	**0.98 (0.98-0.99)**	0.98 (0.95-1.01)	1.0 (1.0-1.01)	**1.01 (1.001-1.02)**
Stage known	Crude	**0.99 (0.98-0.99)**	**0.98 (0.96-0.997)**	**1.01 (1.01-1.02)**	1.00 (0.99-1.00)
	Adjusted[a]	1.0 (0.99-1.0)	**0.98 (0.96-0.99)**	1.0 (1.0-1.01)	**0.99 (0.99-1.00)**
Grade known	Crude	**0.97 (0.96-0.97)**	1.01 (0.99-1.03)	**1.03 (1.02-1.03)**	1.00 (0.99-1.00)
	Adjusted[a]	**0.98 (0.97-0.99)**	1.01 (0.99-1.03)	**1.02 (1.01-1.03)**	1.00 (0.99-1.00)
HR documentation	Crude	**0.98 (0.97-0.98)**	1.0 (0.97-1.02)	**1.03 (1.02-1.03)**	**0.99 (0.98-0.998)**
	Adjusted[a]	**0.99 (0.98-0.99)**	0.99 (0.97-1.01)	**1.01 (1.004-1.02)**	**0.99 (0.98-0.996)**
HER2 documentation (n=94264)	Crude	**0.99 (0.98-0.99)**	0.98 (0.95-1.01)	1.01 (1-1.02)	**0.99 (0.98-0.999)**
	Adjusted[a]	1.0 (0.99-1.01)	0.99 (0.96-1.02)	1.01 (1.0-1.01)	0.995 (0.99-1.00)
Treatments					
Surgery	Crude	**0.97 (0.96-0.97)**	**0.97 (0.95-0.99)**	**1.01 (1.001-1.01)**	1.00 (0.99-1.00)
	Adjusted[b]	**0.99 (0.98-0.99)**	0.99 (0.97-1.01)	1.002 (0.96-1.01)	**1.01 (1.003-1.01)**
Radiation among BCS-treated (n=106014)	Crude	1.01 (0.99-1.02)	0.97 (0.91-1.02)	**1.04 (1.03-1.06)**	**1.03 (1.02-1.05)**
	Adjusted[b]	**1.02 (1.003-1.03)**	0.97 (0.92-1.02)	**1.02 (1.003-1.03)**	**1.02 (1.01-1.04)**
Radiation among mastectomy-treated N2+ or T3 (n=18755)	Crude	0.997 (0.96-1.04)	1.09 (0.93-1.28)	**1.07 (1.02-1.13)**	1.03 (0.98-1.08)
	Adjusted[b]	**1.05 (1.01-1.09)**	1.03 (0.88-1.2)	**1.06 (1.01-1.12)**	1.04 (0.99-1.09)
Radiation among no surgery (n=18034)	Crude	1.02 (0.93-1.11)	0.999 (0.68-1.47)	0.98 (0.84-1.14)	0.98 (0.86-1.12)
	Adjusted[b]	1.004 (0.92-1.1)	0.999 (0.71-1.42)	1.004 (0.87-1.16)	0.96 (0.85-1.1)
Chemotherapy among triple-negative (n=7853)	Crude	**1.11 (1.05-1.16)**	1.06 (0.83-1.35)	1.03 (0.95-1.12)	**1.14 (1.06-1.23)**
	Adjusted[c]	**1.09 (1.04-1.14)**	1.01 (0.78-1.32)	1.03 (0.95-1.10)	**1.08 (1.01-1.16)**
HER2 among HER2+ (n=9641)	Crude	0.95 (0.89-1.01)	0.82 (0.62-1.08)	**1.09 (1.03-1.16)**	1.06 (0.99-1.14)
	Adjusted[b]	0.95 (0.90-1.01)	0.82 (0.62-1.08)	1.05 (0.99-1.12)	**1.07 (1.01-1.14)**
Hormonal among HR+ (n=67116)	Crude	1.01 (0.99-1.02)	**0.92 (0.86-0.99)**	**1.03 (1.01-1.05)**	**1.02 (1.003-1.04)**
	Adjusted[c]	1.01 (1.00-1.03)	**0.92 (0.85-0.99)**	**1.02 (1.005-1.04)**	1.02 (1.00-1.03)

[a]Adjusted model includes: marital, low-income subsidy, hospitalizations, year, age, PCP count, NCI index, frailty.

[b]Adjusted model includes: HR status, stage, and marital, low-income subsidy, hospitalizations, year, age, PCP count, NCI index, frailty.

[c]Adjusted model includes: stage and marital, low-income subsidy, hospitalizations, year, age, PCP count, NCI index, frailty.

Bolded values reflect significant associations, with respect to non-Hispanic White patients, at the 0.05 significance level. HER2 status was first made available for cases diagnosed in 2010; HER2 status available refers to patients from the Primary cohort diagnosed 2010 or later. Part D eligible patients were those with at least three months of continuous Part D prescription drug coverage after diagnosis. Radiation was analyzed within subgroups of surgery type; mastectomy-treated patients were further restricted to patients for whom radiation with mastectomy is indicated (AJCC >=N2 or T3). Stage known refers to known clinical or pathologic stage. Abbreviations: Hormone receptor (HR), Human epidermal growth factor receptor 2 (HER2), Breast conserving surgery (BCS), HR-positive (HR+), HR-negative (HR−), HER2-positive (HER2+), HER2-negative (HER2−), Triple negative (HR− & HER2−).