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Scientific Article

Characterizing the Impact of Race and Contemporary Redlining on Receipt of Guideline-Concordant Locoregional Therapy Among Older Women With Breast Cancer

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Purpose: Improving locoregional control for breast cancer (BC) results in better overall survival. Contemporary redlining is associated with worse BC survival in older patients. Self-reported race is associated with survival, redlining, and access to care. We aim to examine the relationship between race, redlining, and the receipt of guideline-concordant locoregional therapy (LRT) in older women with BC.

Methods and Materials: Women aged 66 to 90 years with stage I to III BC diagnosed in 2010 to 2017 with known metropolitan statistical area were identified in Surveillance, Epidemiology, and End Results-Medicare. Redlining was estimated using Home Mortgage Disclosure Act data. Guideline-concordant LRT was assessed based on receipt of surgery and appropriate adjuvant radiation treatment. A logistic regression model was fitted to examine the relationship between redlining and receipt of guideline-concordant LRT, accounting for covariates. Cluster bootstrap at the MSA-level was used.

Results: The cohort included 64,987 women: 31% aged 66 to 70, 82% non-Hispanic (NH) White, 12% with dual Medicaid/Medicare enrollment. Ninety-four percent underwent surgical resection; 84% received guideline compliant LRT. NH Black race was associated with lower receipt of guideline-concordant LRT compared to NH White (odds ratio [OR], 0.78; 95% CI, 0.71-0.84). No significant

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differences were noted between NH White and NH Asian or Hispanic women. Residing in high-redlining areas was associated with lower odds of receiving guideline-concordant LRT compared to low-redlining areas (OR, 0.89; 95% CI, 0.82-0.95, $P = .002$).

Conclusions: In this cohort of older women with BC, NH Black race and redlining, even after adjusting for several important clinical and demographic factors, were associated with a lower likelihood of receiving guideline-concordant LRT. This finding demonstrates the profound impact of interpersonal racism and redlining on receipt of cancer-directed therapies and highlights the need for further work to combat systemic inequities and interpersonal racism.

Introduction

Nearly 300,000 women in the United States (US) are diagnosed with breast cancer (BC) annually, leading to over 43,000 deaths.[1] BC is one of few malignancies in which improved locoregional control has been shown to improve cancer-specific and overall survival.[2,3] As such, access to appropriate, curative cancer-directed surgical management, radiation therapy, and systemic treatment are paramount for long-term prognosis.

Receipt of guideline-concordant therapy is known to differ among racial and socioeconomic groups. Studies indicate that patients residing in rural communities are less likely to complete adjuvant radiation and Black women are less likely to complete post-lumpectomy radiation therapy or adjuvant hormone therapy.[4-6] Black women residing in historically redlined areas are also less likely to undergo surgical resection.[7] Investigations into the causes of racial and socioeconomic disparities in treatment, including receipt of guideline-concordant therapy, are limited; however, implicit bias likely compounds systematic factors.[8]

Racial disparities in receipt of guideline-concordant therapy may be attributable in part to different forms of racism. Self-reported race, with its known association with decreased receipt of guideline-concordant care, has been thought to serve as a surrogate for interpersonal racism and has been shown to have independent associations with BC survival, redlining, and access to care.[9-12] Though race is often discussed, limited literature highlights the specific impact of racism on racial disparities in guideline-concordant care.[13]

Less explored are aspects of systemic, institutional, or structural racism, though it is known that these neighborhood factors, even when controlling for individual-level socioeconomic status, are associated with cancer outcomes.[14] Historical redlining dates back to restrictive policies from the 1920s and 1930s where mortgage lenders systematically denied loans to specific areas of cities, primarily those inhabited by racially and ethnically minoritized residents.[15] Despite fair housing laws and policies implemented since that time, mortgage lending disinvestment patterns remain. Measures of contemporary and historical mortgage lending disinvestment have been compared and used to examine associations with health outcomes, including BC survival.[16,17] Redlining impacts racial health disparities through residential racial segregation and economic disinvestment in neighborhoods where residents are primarily people of color. As a result, redlining can impact numerous health outcomes, including cancer survival,[18-21] and the persistent effects of redlining demonstrate the adverse effects of structural racism on cancer care.[20,22,23]

The relationships among different forms of racism and their combined impact on receipt of guideline-concordant care are not well understood.[24,25] We aim to examine the relationships among self-reported race, redlining, and the receipt of guideline-concordant locoregional therapy among older women with BC in the US.

Methods and Materials

Study cohort

Data were obtained from the Surveillance, Epidemiology, and End Results (SEER)-Medicare linked database. The cohort included women aged 66 to 90 years with an initial stage I to III invasive ductal, invasive lobular, or mixed invasive ductal and lobular BC diagnosis between 2010 and 2017 who resided in a metropolitan statistical area (MSA) within a SEER region. The cohort was restricted to women enrolled in Medicare Parts A and B and not in an health maintenance organization for 12 months prior to diagnosis who had follow-up claims information for at least 12 months after diagnosis. A total of 886 women were excluded because of insufficient information (unknown tumor size, unknown nodal status, unknown number of metastatic lymph nodes, unknown hormone receptor [HR] status) to determine treatment group and therefore inability to determine guideline concordance. Figure 1 delineates cohort construction. A total of 64,987 women were included in the final cohort.

Outcome measure

Guideline-concordant locoregional therapy was assessed based on whether patients underwent surgical resection with either a mastectomy or lumpectomy and received appropriate radiation therapy based on age, tumor size, nodal status, HR status, and type of surgery

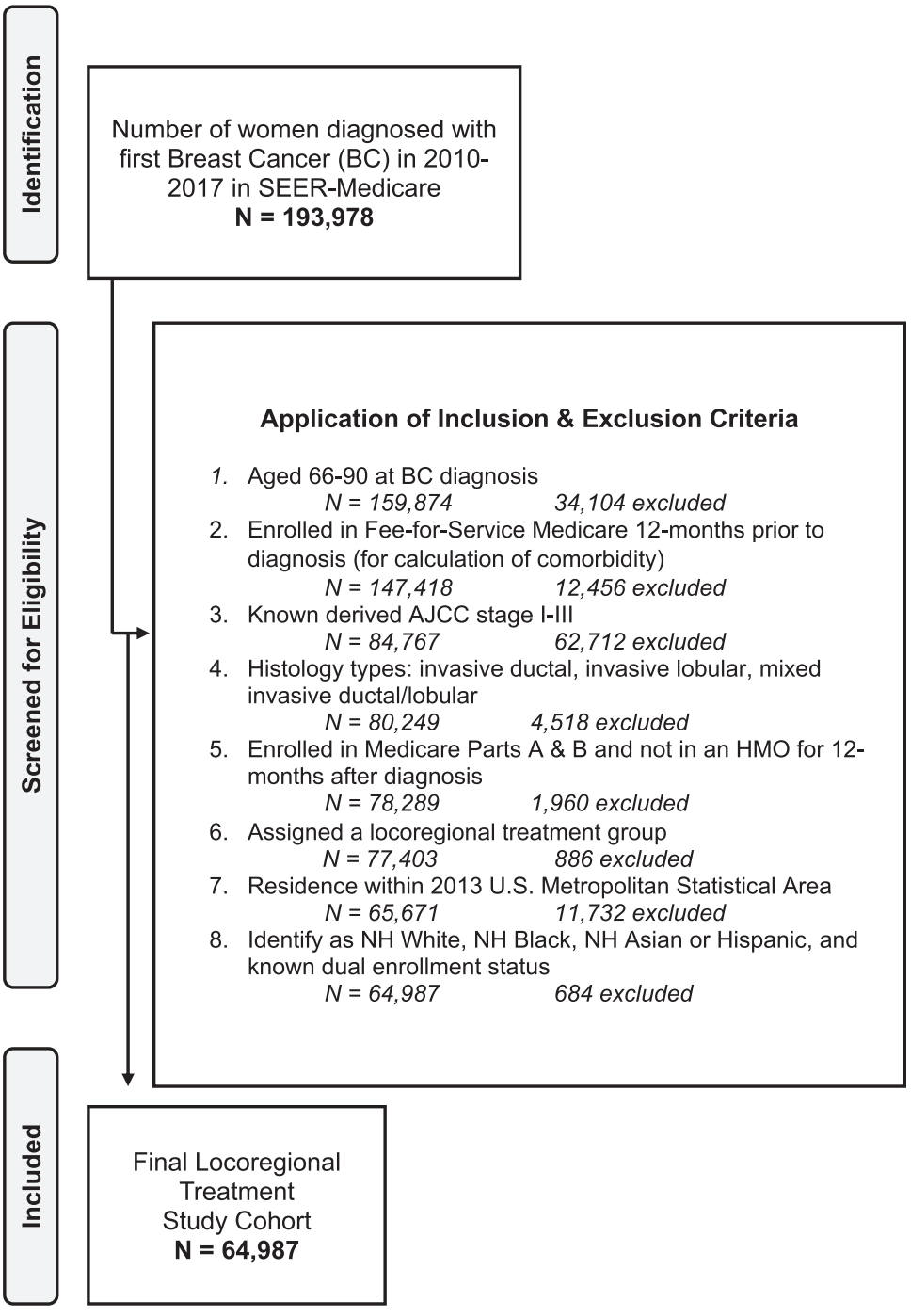

Figure 1 Flowchart delineating creation of the study cohort.

within 1 year of diagnosis, per the American College of Surgeons Commission on Cancer Quality of Care measures and National Comprehensive Cancer Network guidelines in effect during the study period.[26] Locoregional treatments were deemed nonconcordant if there was no surgical resection or if there was a surgical resection without appropriate radiation therapy. The billing codes used for determination of treatment are located in Appendix E1. Table 1 outlines the paradigms for guideline-concordant definitions used in the study. Concordance measures were reviewed by both a surgical and radiation oncologist.

Independent variables

Contemporary redlining was estimated using Home Mortgage Disclosure Act data from the Federal Financial Institutions Examination Council. Home Mortgage Disclosure Act data from 2010 to 2017 were used to estimate

Table 1 Locoregional treatment compliance by treatment group

	Treatment group				
No.	**Breast surgery**	**Tumor size**	**Nodal status**	**Guideline-concordant radiation therapy**	**No. (%) compliant**
4166	None	Any	Any	N/A	0
8625	Lumpectomy <70 years	Any	N0	Yes	7923 (92%)
<30	Lumpectomy <70 years	Any	NX	Yes	<30 (67%)
10,580	Lumpectomy for HR-positive tumor, age ≥ 70 years and receive HT	≤ 2 cm	N0	Yes or no	10,580 (100%)
2614	Lumpectomy for HR-positive tumor, age ≥ 70 years and no HT	≤2 cm	N0	Yes	1412 (54%)
6294	Lumpectomy for HR-positive tumor, age ≥ 70 years and unknown HT	≤2 cm	N0	Yes or no	6294 (100%)
4159	Lumpectomy for HR-positive tumor, age ≥ 70 years	>2 cm	N0	Yes	3013 (72%)
105	Lumpectomy for HR-positive tumor, age ≥ 70 years	Unknown	N0	Yes or no	105 (100%)
68	Lumpectomy for unknown HR, age ≥ 70 years	>2 cm	N0	Yes	42 (62%)
64	Lumpectomy, age ≥ 70 years HR+ (n = 61) HR− (n = 12) HR unknown (n = 2)	>2 cm	NX	Yes	26 (41%)
2415	Lumpectomy for HR-negative tumor, age ≥ 70 years	Any	N0	Yes	2047 (85%)
<30	Lumpectomy for HR-negative tumor, age ≥ 70 years	≤2 cm	NX	Yes	<30 (83%)
11,689	Mastectomy	≤5 cm	N0	No	10,526 (90%)
814	Mastectomy	>5 cm	N0	Yes or no	814 (100%)
6151	Lumpectomy	Any	N1-N3	Yes	5447 (89%)
2582	Mastectomy	Any	N2-N3	Yes	1804 (70%)
4631	Mastectomy	Any	N1	Yes or no	4631 (100%)
64,987	**Total cohort**	**Yes**			**54,685 (84%)**

Abbreviations: HR = hormone receptor; HT = hormonal therapy.

contemporary redlining using adaptive spatial filtering. An adaptive spatial filter was used to identify at least 5 Black and 5 White mortgage applicants and then the odds of denial of the mortgage application was estimated for individuals inside the filter compared to individuals outside the filter to identify census tracts that were more likely to be denied a mortgage (controlling for self-identified gender of the applicant and the loan amount to income ratio). In simpler terms, contemporary redlining was calculated to measure the odds ratio of a mortgage application denial for a local property compared to all other properties within the same MSA. Redlining was initially categorized as least, low, moderate, and high levels of redlining based on previous work.[19] As only 4% resided in areas classified in the least category, this category was combined with the low category for this analysis (and therefore referred to as low). Race and ethnicity were defined using SEER race categories and included non-Hispanic (NH) White, NH Black, NH Asian, and Hispanic. Those identifying as other racial or ethnic groups were excluded based on small sample size.

Covariates

Additional variables included age, comorbidities (none, 1, 2, or more), dual enrollment with Medicaid as a surrogate for individual-level socioeconomic status, American Joint Committee on Cancer (AJCC) tumor stage (I-III), tumor size, tumor receptor status (ER/PR/HER2), US Census Region (Midwest, Northeast, South, and West), and year of diagnosis (2010-2017). Comorbidity was calculated using inpatient, outpatient, and carrier Medicare claims data for the 12 months before incident BC using the Klabunde algorithm.[27]

Analysis

Descriptive statistics were calculated to summarize the characteristics of the cohort. Unadjusted models that do not include these variables were completed for redlining alone, race and ethnicity alone, and the 2 independent

variables combined. Logistic regression models with a cluster bootstrap to account for clustered data at the MSA-level estimated the odds of receiving guideline-concordant locoregional therapy. The final model considered redlining as the primary predictor and was adjusted sequentially for demographics (age, race/ethnicity, comorbidities), tumor characteristics (stage and subtype), and dual enrollment, which served as a surrogate for income. An interaction between redlining and race/ethnicity was tested.

Results

Study cohort

Cohort characteristics are summarized in Table 2A. Over half of the cohort was aged 66 to 70 (31%) or 71 to 75 (27%) years. The majority (82%) were NH White with NH Black, NH Asian, and Hispanic women comprising 7.4%, 4.7%, and 5.6% of the cohort, respectively. Half had no comorbidities and only 12% were eligible for both Medicare and Medicaid enrollment. Most women had stage I cancers (60%) and had HR-positive/HER2-negative tumors (77%). Almost half (46%) lived in the West region. Cases were evenly distributed throughout the study period with 12% to 13% diagnosed each year from 2010 to 2017. By redlining categories, 51%, 39%, and 10% lived in low, moderate, and high-redlining areas, respectively.

General trends in guideline-concordant locoregional treatment

Overall, 94% completed surgical resection and 84% received guideline-concordant locoregional therapy. By treatment group (Table 1), the lowest rates of guideline concordance locoregional treatment included women aged 70 or older who underwent a lumpectomy and had: (1) T2-T4NX tumors (n = 64, 41% compliance); (2) T1N0 HR-positive tumors without adjuvant hormonal therapy (n = 2614, 54% compliance); and (3) T2-T4NX tumors with unknown HR status (n = 68, 62% compliance). A full breakdown of compliance by treatment group is summarized in Table 1.

Guideline concordance by demographic and clinical characteristics is shown in Table 2, with redlining by demographic and clinical characteristics in Table 3. The mean age for women who were guideline-concordant was lower than for those who were not (74 vs 78 years, $P < .001$). Nonconcordance reached 23% and 41% for those aged 81 to 85 and 86 to 90 years, respectively. Those with 2 or more comorbidities had lower concordance (77%) compared to those with none or 1 ($P < .001$). Patients with later-stage tumors and those with unknown and all tumor subtypes (compared to HR-positive/HER2-negative tumors) had lower guideline concordance ($P < .001$). Geographically, concordance ranged from 84% to 85% in all census regions. Concordance decreased from 85% in 2010 to 83% in 2015 to 2017 ($P < .003$).

Redlining, race, and guideline-concordant locoregional treatment

Women in the highest redlining category had the lowest rates of guideline-concordant treatment receipt (81%) compared to 84% to 85% for low and moderately redlined areas ($P < .001$). Of women who had guideline-concordant treatment, 52% lived in low-redlining areas, 39% lived in moderate-redlining areas, and 9.6% lived in high-redlining areas.

Guideline concordance differed by race and ethnicity. NH Black women received guideline-concordant locoregional therapy 78% of the time compared to 83% to 85% for all other groups ($P < .001$). Redlining additionally differed by race and ethnicity, with 7.1% of NH White women, 41% of NH Black women, 4.7% of NH Asian women, and 14% of Hispanic women living in high-redlining areas. Those eligible for dual enrollment had lower concordance compared to those who were not eligible (75% vs 85%, $P < .001$).

Models for redlining and guideline-concordant locoregional treatment

Unadjusted models estimating locoregional guideline concordance are shown in Table 4. Compared to residing in a low-redlining area, residing in a high- or moderate-redlining area was associated with decreased guideline-concordant locoregional treatment (high: odds ratio [OR], 0.74; 95% CI, 0.67-0.82; moderate: OR, 0.91; 95% CI, 0.87-0.96; model 1). In addition, those residing in a high-redlining area had decreased receipt of guideline-concordant care compared to those residing in a moderate-redlining area ($P < .001$). Compared to NH White, NH Black race was significantly associated with decreased guideline-concordant locoregional treatment (OR, 0.64; 95% CI, 0.59-0.69; model 2). When both redlining and race/ethnicity variables were analyzed together, findings persisted (model 3). Residing in a moderate-redlining area, high-redlining area, and NH Black race continued to be significantly associated with decreased concordance (OR, 0.92; 95% CI, 0.88-0.98; OR, 0.84; 95% CI, 0.77-0.91 and OR, 0.68; 95% CI, 0.62-0.73, respectively). No interaction between redlining and race/ethnicity was noted.

Sequential adjusted model results are shown in Table 5. When controlling for demographic factors, residing in an

Table 2 Demographics and clinical characteristics of the cohort, overall and by guideline-concordant treatment outcome

Characteristic	Total No. = 64,987	Guideline-concordant treatment		
		No, no. = 10,302 16%	Yes, no. = 54,685 84%	*P* value
Age (y, [range])	75 [66, 90]	78 [66, 90]	74 [66, 90]	**<.001**
Age group (y)				**<.001**
66-70	20,043 (31%)	2348 (12%)	17,695 (88%)	
71-75	17,291 (27%)	1838 (11%)	15,453 (89%)	
76-80	13,181 (20%)	1896 (14%)	11,285 (86%)	
81-85	9225 (14%)	2091 (23%)	7134 (77%)	
86-90	5247 (8.1%)	2129 (41%)	3118 (59%)	
Race/Ethnicity				**<.001**
NH White	53,479 (82%)	8150 (15%)	45,329 (85%)	
NH Black	4815 (7.4%)	1060 (22%)	3755 (78%)	
NH Asian	3061 (4.7%)	484 (16%)	2577 (84%)	
Hispanic	3632 (5.6%)	608 (17%)	3024 (83%)	
Comorbidities				**<.001**
None	32,514 (50%)	4373 (13%)	28,141 (87%)	
1	17,151 (26%)	2470 (14%)	14,681 (86%)	
2+	15,322 (24%)	3459 (23%)	11,863 (77%)	
Dual enrollment				**<.001**
No	57,122 (88%)	8325 (15%)	48,797 (85%)	
Yes	7865 (12%)	1977 (25%)	5888 (75%)	
AJCC stage				**<.001**
Stage I	38,702 (60%)	4252 (11%)	34,450 (89%)	
Stage II	20,395 (31%)	4102 (20%)	16,293 (80%)	
Stage III	5890 (9.1%)	1948 (33%)	3942 (67%)	
Breast subtype				**<.001**
HR+/HER2−	49,755 (77%)	7349 (15%)	42,406 (85%)	
HR+/HER2+	4884 (7.5%)	841 (17%)	4043 (83%)	
HR−/HER2+	1825 (2.8%)	402 (22%)	1423 (78%)	
Triple negative	5319 (8.2%)	949 (18%)	4370 (82%)	
Unknown	3204 (4.9%)	761 (24%)	2443 (76%)	
Census region				**.008**
Midwest	6152 (9.5%)	977 (16%)	5175 (84%)	
Northeast	15,477 (24%)	2410 (16%)	13,067 (84%)	
South	13,332 (21%)	2012 (15%)	11,320 (85%)	
West	30,026 (46%)	4903 (16%)	25,123 (84%)	
Year of diagnosis				**.003**
2010	7956 (12%)	1163 (15%)	6793 (85%)	
2011	8080 (12%)	1258 (16%)	6822 (84%)	
2012	8125 (13%)	1298 (16%)	6827 (84%)	
2013	8130 (13%)	1275 (16%)	6855 (84%)	

(*continued on next page*)

Table 2 (*Continued*)

Characteristic	Total No. = 64,987	Guideline-concordant treatment		
		No, no. = 10,302 16%	Yes, no. = 54,685 84%	*P* value
2014	8139 (13%)	1242 (15%)	6897 (85%)	
2015	8234 (13%)	1359 (17%)	6875 (83%)	
2016	8285 (13%)	1370 (17%)	6915 (83%)	
2017	8038 (12%)	1337 (17%)	6701 (83%)	
Redlining Category				**<.001**
Low	33,237 (51%)		4965 (15%)	28,272 (85%)
Moderate	25,271 (39%)		4098 (16%)	21,173 (84%)
High	6479 (10.0%)		1239 (19%)	5240 (81%)

Table 3 Demographic and clinical characteristics of the cohort by redlining category

Characteristic	Total No.	No. = 64,987*	Low, no. = 33,237*	Moderate, no. = 25,271*	High, no. = 6479*	*P* value†
Age (y)	64,987	75 (6) [66, 90]	75 (6) [66, 90]	75 (6) [66, 90]	75 (6) [66, 90]	.4
SEER Race/Ethnicity	64,987					**<.001**
NH White		53,479 (82%)	29,070 (54%)	20,586 (38%)	3823 (7.1%)	
NH Black		4815 (7.4%)	1062 (22%)	1761 (37%)	1992 (41%)	
NH Asian		3061 (4.7%)	1657 (54%)	1260 (41%)	144 (4.7%)	
Hispanic		3632 (5.6%)	1448 (40%)	1664 (46%)	520 (14%)	
Comorbidities	64,987					**<.001**
None		32,514 (50%)	17,720 (54%)	12,214 (38%)	2580 (7.9%)	
1 comorbidity		17,151 (26%)	8658 (50%)	6750 (39%)	1743 (10%)	
2+ comorbidities		15,322 (24%)	6859 (45%)	6307 (41%)	2156 (14%)	
Dual enrollment	64,987	7865 (12%)	2682 (34%)	3653 (46%)	1530 (19%)	**<.001**
SEER-Medicare AJCC stage	64,987					**<.001**
Stage I		38,702 (60%)	20,453 (53%)	14,756 (38%)	3493 (9.0%)	
Stage II		20,395 (31%)	10,014 (49%)	8121 (40%)	2260 (11%)	
Stage III		5890 (9.1%)	2770 (47%)	2394 (41%)	726 (12%)	
Guideline-concordant treatment	64,987	54,685 (84%)	28,272 (52%)	21,173 (39%)	5240 (9.6%)	**<.001**

Abbreviations: SEER = Surveillance, Epidemiology, and End Results.
*Mean (SD) [range]; n (%).
†Kruskal–Wallis rank sum test; Pearson's χ^2 test.

area with high contemporary redlining was associated with a lower odds of receiving guideline-concordant locoregional therapy compared to a low- or moderate-redlining area (low: OR, 0.82; 95% CI, 0.76-0.88; moderate: $P < .001$). This finding persisted when sequential adjusting for tumor characteristics (low: OR, 0.85; 95% CI, 0.79-0.91; moderate: $P < .001$) and dual enrollment (low: OR, 0.89; 95% CI, 0.82-0.95; moderate: $P = .0085$). NH Black race was associated with a lower odds of receipt of concordant care when compared to NH White women (OR, 0.78; 95% CI, 0.71-0.84) and NH Asian women ($P < .001$) when adjusted for all covariates. No significant differences were noted between NH White and NH Asian or Hispanic women. Women eligible for dual enrollment had a lower odds of receiving guideline-concordant locoregional therapy compared to noneligible women (OR, 0.64; 95% CI, 0.58-0.71).

Compared to women aged 66 to 70, the highest rates of guideline-concordant locoregional therapy were seen in women aged 71 to 75 (OR, 1.13; 95% CI, 1.06-1.21, $P < .001$). Above 76 years, all age groups had decreased concordance. Concordance rates have decreased since 2010.

Table 4 Logistic regression models of redlining alone (model 1), race/ethnicity alone (model 2), and both redlining and race/ethnicity combined (model 3)

	Model 1			Model 2			Model 3		
Characteristic	**OR**	**95% CI***	***P* value*,†**	**OR**	**95% CI**	***P* value***	**OR**	**95% CI**	***P* value***
Redlining category			**<.001***						**<.001***
Low	—	—					—	—	
Moderate	0.91	0.87, 0.96	**<.001**				0.92	0.88, 0.98	**.003**
High	0.74	0.67, 0.82	**<.001**				0.84	0.77, 0.91	**<.001**
Moderate vs high†			**<.001**						**.009**
Race/Ethnicity						**<.001***			**<.001***
NH White				—	—		—	—	
NH Black				0.64	0.59, 0.69	**<.001**	0.68	0.62, 0.73	**<.001**
NH Asian				0.96	0.79, 1.09	.564	0.95	0.79, 1.09	.542
Hispanic				0.89	0.78, 1.01	.091	0.91	0.80, 1.03	.168
NH Black vs NH Asian†						**<.001**			**<.001**

Abbreviations: CI = confidence interval; OR = odds ratio.
*Obtained from generalized linear regression model with cluster bootstrap.
†Comparison of nonreferent groups with highest discrepancy between ORs was added as post hoc analysis.
These models do not adjust for age, comorbidities, dual enrollment, tumor stage, tumor size, tumor receptor status, US Census region, or year of diagnosis.

Discussion

In this population-based cohort of older women with stage I to III BC, NH Black race was associated with a lower likelihood of receiving guideline-concordant locoregional treatment, even after adjusting for several important clinical and demographic factors and contemporary redlining. In addition, living in a high contemporary redlining area was associated with a lower likelihood of receipt of guideline-concordant locoregional therapy compared to living in low-redlining areas when controlling for both patient race and ethnicity and dual enrollment eligibility, a proxy for individual socioeconomic status, as well as tumor factors, accounting for incidence of late-stage or more biologically aggressive malignancies. Other key findings include the impact of dual Medicare/Medicaid enrollment and year of diagnosis.

The finding that race is associated with lower likelihood of receiving guideline-concordant care reinforces existing knowledge about differences in experiences and exposures by socially constructed race in the US, including experiences of interpersonal and institutional racism. For instance, McClelland et al[28] demonstrated a decreased rate of adjuvant radiation completion among Black women with early-stage BC following lumpectomy. Further, in a 2022 national survey of cancer patients, NH Black and Hispanic patients were more likely to report negative care experiences compared to NH White patients, and were more likely to feel the health care system treats people unfairly, though experiences improved with racial concordance between patients and their treating physicians which may point to impacts of interpersonal racism.[29] This trust can impact decision making and highlights importance of patient–physician relationships in outcomes.[30-32] To seek continued improvement in guideline concordance, further investment in workforce diversity within oncology as well as increased understanding of current provider biases is needed.[33,34]

The relationship identified between redlining and guideline-concordant care builds on previous work that has found a strong impact of contemporary redlining on BC and all-cause survival, and reinforces the need to consider the ways in which institutional and structural racism can impact BC outcomes. Access to and receipt of care likely plays a role in the pathway between contemporary redlining and survival.[19] More work is needed to understand the factors that mediate the redlining–survival relationship to create additional tangible targets for improving equity in cancer care.[19-21] A focus on neighborhood factors, engagement with community leaders, and decreasing residential segregation may be key to eliminating racial and ethnic disparities in BC survival, particularly as redlined areas continue to face decreased neighborhood investment, perpetuating cycles of inequity.[35-38] Additionally, future studies investigating additional neighborhood factors including housing stability, environmental exposures, and rates of home ownership, among others, are warranted to help best use opportunities to connect with community leaders and optimally address root causes of health disparities.

Table 5 Adjusted logistic regression models with stepwise models including demographics in model 1, tumor characteristics in model 2, and dual enrollment in model 3

	Model 1 Adjusted for demographics			Model 2 Additional adjustment for tumor characteristics			Model 3 Additional adjustment for dual enrollment		
Characteristic	**OR**	**95% CI**	***P* value***	**OR**	**95% CI**	***P* value***	**OR**	**95% CI**	***P* value***
Redlining category			**<.001***			**<.001***			**.0091***
Low	—	—		—	—		—	—	
Moderate	0.93	0.89, 0.99	**.0111**	0.96	0.91, 1.02	.1264	0.98	0.93, 1.04	.5042
High	0.82	0.76, 0.88	**<.001**	0.85	0.79, 0.91	**<.001**	0.89	0.82, 0.95	**.0022**
Moderate vs high†			**<.001**			**<.001**			**.0085**
SEER Race/Ethnicity			**<.001***			**<.001***			**<.001***
NH White	—	—		—	—		—	—	
NH Black	0.66	0.61, 0.72	**<.001**	0.71	0.66, 0.78	**<.001**	0.78	0.71, 0.84	**<.001**
NH Asian	0.98	0.81, 1.14	.7642	0.98	0.81, 1.12	.7816	1.09	0.92, 1.24	.2296
Hispanic	0.91	0.79, 1.03	.1931	0.96	0.85, 1.08	.4804	1.09	0.96, 1.25	.2072
NH Black vs NH Asian†			**<.001**			**<.001**			**<.001**
SEER-Medicare age group			***<.001***‡			**<.001**‡			***<.001***‡
66-70 y	—	—		—	—		—	—	
71-75 y	1.14	1.08, 1.23	**<.001**	1.13	1.06, 1.22	**<.001**	1.13	1.06, 1.21	**<.001**
76-80 y	0.82	0.76, 0.87	**<.001**	0.82	0.76, 0.87	**<.001**	0.82	0.77, 0.87	**<.001**
81-85 y	0.47	0.42, 0.51	**<.001**	0.48	0.43, 0.53	**<.001**	0.48	0.43, 0.53	**<.001**
86-90 y	0.20	0.18, 0.22	**<.001**	0.22	0.19, 0.24	**<.001**	0.22	0.19, 0.24	**<.001**
71-75 vs 86-90 y†			**<.001**			**<.001**			**<.001**
Dual enrollment									**<.001**‡
No							—	—	
Yes							0.64	0.58, 0.71	**<.001**

Abbreviations: OR = odds ratio; SEER = Surveillance, Epidemiology, and End Results.
*Obtained from generalized linear regression model with cluster bootstrap.
†Comparison of nonreferent groups with highest discrepancy between ORs was added as post hoc analysis.
‡Global *P* value.
Model also adjusted for comorbidities, stage, breast receptor subtype, census region, and year of diagnosis.

Both dual enrollment eligibility and redlining, reflective of financial circumstances, significantly impacted receipt of guideline-concordant locoregional treatment, suggesting that economic impacts are a key driver in these inequities. An important, but often underdiscussed factor in patient decision-making lies in the financial logistical challenges of surgical recovery and daily radiation therapy. As progressively shorter breast radiation fractionations are used, oncologists may be better able to mitigate some socioeconomic barriers, allowing patients to successfully receive radiation treatment because of fewer days of lost wages, as well as decreased transportation and other logistical needs associated with 5 to 6 week courses of radiation that were prominent during this study period.[39] Increased focus on shared patient–provider decision-making that better incorporates factors such as costs, travel, lost income, and dependent care may additionally promote improved cancer outcomes for low-income patients.

In addition to race and redlining, year of diagnosis and age-based concordance changes are likely, in part, explained by a 2015 publication, PRIME II describing low 5-year ipsilateral breast tumor recurrence without adjuvant radiation in low-risk, early-stage BCs in women over age 65.[40] Though overall guideline concordance with locoregional treatment remains high at 88% for those aged 66 to 70 in this study, it is not surprising that rates have steadily decreased with more recently diagnosed cohorts, based both on evolving literature and increased emphasis on shared decision-making.[41] Despite PRIME II results, during the 2010 to 2017 timeframe for this study cohort, National Comprehensive Cancer Network guidelines recommended the consideration of omission of radiation only low-risk patients over 70 years of age who

received adjuvant hormone therapy. Therefore, all women aged 66 to 69 who underwent a lumpectomy who did not receive radiation were deemed not concordant, however, it is likely that the option to omit radiation was discussed. Shared decision-making increases patient autonomy in health care decisions by ensuring they are informed of risks and benefits of treatment, including the anticipated survival benefits and toxicities of adjuvant therapies, allowing for personalization of treatment decisions based on comorbidities, values, goals, anticipated life expectancy, and desires to avoid potential toxicities of treatment, among other factors.[42,43] Although guidelines help tailor conversations and medical advice, guideline concordance will never achieve 100% because of all the factors and nuances of each patient that should be considered when deciding on a treatment plan.

This study is subject to some important limitations. Though SEER-Medicare is a powerful tool that allows robust comparisons because of availability of comprehensive tumor and treatment-related information, it lacks information on margin status that impacts local treatment recommendations as well as individual-level income. Additionally, it limits the study population to those aged 65 and older, and, thus, the findings are not generalizable to younger populations. Nearly 900 patients were excluded, as all necessary tumor-related information was not available to determine treatment group allocation and guideline compliance, though this is counterbalanced by a large sample size. Use of the contemporary redlining variable as a measure of structural racism is a strength of this study, but to do this, the cohort was further restricted to those residing in an MSA. In addition, although redlining is historically present within urban populations, this metric was not applied to rural populations and therefore cannot describe the impact of mortgage discrimination among women residing in rural communities.

In conclusion, this study highlights the continued racial, socioeconomic, and geographic differences in receipt of guideline-concordant locoregional therapy. As contemporary redlining significantly impacted guideline-concordant locoregional treatment when controlling for multiple important factors, including dual enrollment eligibility, further work is needed to address structural racism in the housing sector and to identify additional systematic factors that could explain the associations between contemporary redlining and BC survival to better target interventions. These efforts are critically needed and combat economic inequities that serve as a key driver in treatment access among those in high-redlining areas. As the impacts of both interpersonal and systematic racism impact patient access to care and outcomes, understanding how, as providers, better assessing social determinants of health, understanding implicit and/or overt biases, and increasing the use of shared decision making with all patients are essential to increase the equity of BC care.

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.adro.2024.101688.

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