Original Study

Examining Associations of Racial Residential Segregation With Patient Knowledge of Breast Cancer and Treatment Receipt

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Abstract

The purpose of this study was to investigate the relationship between racial residential segregation and patient knowledge of their breast cancer as well as receipt of adjuvant therapy. In this study, we found no significant differences in receipt of care according to different levels of black and Hispanic segregation, however, there were some differences in knowledge of tumor characteristics. Future studies should assess multiple geographic regions to measure the role of segregation on cancer disparities along the spectrum of diagnosis to treatment.

Background: The effect of racial residential segregation on breast cancer treatment disparities is unclear. We examined whether racial segregation is associated with adjuvant treatment receipt and patient knowledge of disease. **Patients and Methods:** We surveyed a population-based sample of women in Northern California with stage I to III breast cancer diagnosed in 2010 to 2011 (participation rate = 68.5%, 500 patients). For black, Hispanic, and white women, we measured black and Hispanic segregation using the location quotient (LQ) of racial residential segregation, a proportional measure of the size of a minority group in the census tract compared with the larger metropolitan statistical area. We categorized LQ values for black and Hispanic participants into quartiles, with quartile 1 representing a lower relative level of segregation than quartile 4. We used multivariable logistical regression to assess the odds of receiving guideline-recommended adjuvant therapy and patient knowledge of tumor characteristics according to relative residential segregation. **Results:** We observed greater residential segregation for black versus Hispanic patients ($P < .05$). Overall, there were no treatment differences according to Hispanic or black LQ, except for black LQ quartile 3 (vs. 1) for which we observed higher odds of hormonal therapy. Knowledge of disease did not vary according to black LQ, but patients in the Hispanic LQ quartile 3 (vs. quartile 1) had less tumor knowledge. **Conclusion:** We did not find clear associations for racial residential segregation and treatment or cancer knowledge in Northern California, an area with low levels of segregation. Additional research should assess the effect of segregation on breast cancer treatment disparities in a variety of geographical locations.

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Introduction

Racial and ethnic disparities in breast cancer treatment are well documented and contribute to worse outcomes for racial and ethnic minorities.[1,2] Mortality rates for black (vs. white) women have remained substantially higher over time, with a widening of disparities in breast cancer mortality in recent decades.[3,4]

Racial residential segregation, defined as the degree to which 2 or more groups live separately from each other, has been suggested to be a fundamental cause of racial and ethnic disparities by causing racial differences in socioeconomic status, access to services, and environments harmful for health.[5,6] Growing evidence suggests that

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racial residential segregation (referred to as segregation hereafter) of racial and ethnic minorities might be associated with racial disparities in the diagnosis, treatment, and mortality rates of breast cancer and other cancers.[7-10]

Previous literature on segregation and breast cancer disparities has focused primarily on black-white and Hispanic-white segregation, and studies have shown mixed results.[11-13] This might be because of variability in geographical areas used in analysis, measures of segregation, and geographic locations of patient cohorts.[11-13] However, a new segregation measure, location quotient (LQ) of residential segregation, has increasingly been used in health disparities literature. It is a measure of the relative concentration (or ratio) of individuals in a minority group in a large geographical unit (metropolitan statistical area [MSA]) compared with a small geographical unit (census tract).[6] The strength of this measure is that it allows for comparison across different geographical units and assesses differences in the racial composition of individual's neighborhood compared with the larger MSA.[6,12] The primary benefit of LQ compared with traditional measures of segregation such as isolation index and dissimilarity index, is that it is a relative measure comparing 2 geographic units as opposed to an analysis of 1 concrete geographic unit allowing for assessment of relative deprivation. Recent research has suggested that societal inequities, including health inequity, is best studied by assessing relative differences between groups or individuals as opposed to assessing in isolation.[14] Additionally, traditional measures of segregation such as index of dissimilarity, have historically been used to examine larger population levels such as cities or MSAs. Specifically, these measures have sought to identify the likelihood of different racial/ethnic groups interacting within a larger geographical unit. The use of LQ, as a small area metric, allows for comparison of the immediate racial/ethnic composition of the environment in which an individual lives compared with the surrounding area.[15] A recent analysis using LQ determined that greater levels of racial and ethnic minority segregation had an independent adverse association with breast cancer mortality.[12] However, to our knowledge, no previous study has assessed LQ and its association with intermediate factors to mortality, including patient knowledge of disease and adjuvant treatment receipt, or whether relative changes in LQ are associated with breast cancer outcomes.

Many patients lack knowledge of their own tumor characteristics, and less knowledge is associated with less receipt of guideline-recommended adjuvant treatments.[16,17] Black and Hispanic women, for instance, are less likely to know their own tumor stage, estrogen receptor (ER) status and HER2 status than white women.[17] One previous study showed that greater black and Hispanic segregation was associated with less receipt of adequate care; this study was a claims-based analysis, focused on older patients only, and did not define adequate treatment on the basis of tumor characteristics.[11]

In this study, we examined whether relative increases of segregation of racial and ethnic minorities, measured according to LQ, was associated with women's knowledge about their breast cancers and with adjuvant receipt of hormonal therapy, radiation, and chemotherapy among women with early-stage breast cancer. We hypothesized that segregation might contribute to disparities in treatment and cancer knowledge (Figure 1).

Patients and Methods

Study Design

Figure 1 represents our conceptual model for how segregation of racial and ethnic minorities might contribute to disparities in treatment and patient knowledge. This model suggests that reduced access to medical services and neighborhood characteristics in geographical areas with racial and ethnic minority segregation leads to reduced cancer care treatment and limited patient knowledge. To address our question, we completed a secondary analysis of data previously collected as part of a telephone-based survey, which primarily examined surgeon and hospital selection and treatment receipt for a population-based sample of breast cancer patients residing in Northern California.[16] The details of our survey have been previously published.[16-18] In brief, we mailed study invitation letters to eligible participants with breast cancers reported to the California Cancer Registry (CCR) and then contacted them by phone to schedule interviews. All surveys were conducted via telephone using computer-assisted telephone interview software and participants received $20. Interviews were conducted in English and Spanish.

Participants

The study cohort and exclusion criteria have been previously reported.[16,17] A total of 1118 white, black, or Hispanic women

Figure 1 Conceptual Model of Relationship Between Racial Residential Segregation and Treatment Receipt and Patient Knowledge

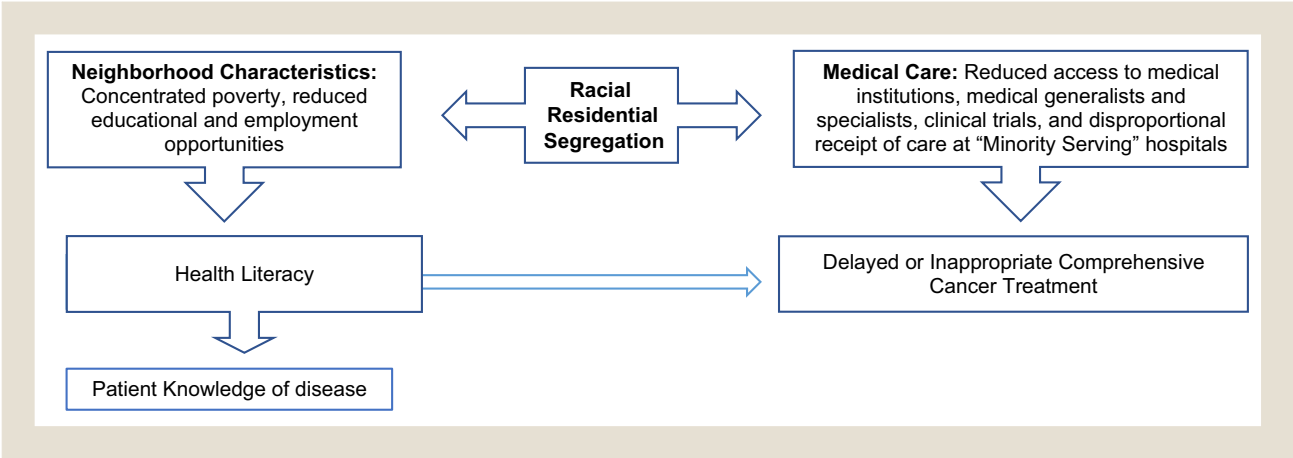


Table 1 Characteristics of the Entire Cohort and According to Adjuvant Therapy Eligibility

	Entire Cohort (n = 386)	Hormonal Therapy-Eligible (n = 295)	Radiation Therapy-Eligible (n = 236)	Chemotherapy-Eligible (n = 173)
Age, Years[a]				
<50	103 (26.68)	75 (25.42)	56 (23.73)	57 (32.95)
50-59	114 (29.53)	81 (27.46)	70 (29.66)	58 (33.53)
≥60	169 (43.78)	129 (47.12)	110 (46.61)	58 (33.53)
Race[b]				
Non-Hispanic white	163 (42.23)	128 (43.39)	101 (42.80)	66 (38.15)
Non-Hispanic black	124 (32.12)	92 (31.19)	69 (29.24)	65 (37.57)
Hispanic	99 (25.65)	75 (25.42)	66 (27.97)	42 (24.28)
Educational Attainment[b]				
High school or less	129 (33.42)	98 (33.22)	77 (32.63)	53 (30.64)
Some college	121 (31.35)	93 (31.53)	79 (33.47)	54 (31.21)
College graduate	136 (35.35)	104 (35.25)	80 (33.90)	66 (38.15)
Annual Household Income, $[b]				
<20,000	80 (20.73)	54 (18.31)	48 (20.34)	40 (23.12)
20,000-39,999	72 (18.65)	54 (18.31)	41 (17.37)	34 (19.65)
40,000-59,999	57 (14.77)	46 (15.59)	37 (15.68)	21 (12.14)
>60,000	138 (35.75)	107 (36.27)	81 (34.32)	65 (37.57)
Unknown	39 (10.10)	34 (11.53)	29 (12.29)	13 (7.51)
Marital Status[b]				
Unmarried/unknown	178 (46.11)	137 (46.44)	111 (47.03)	79 (45.66)
Married	208 (53.89)	158 (53.56)	125 (52.97)	94 (54.34)
Insurance Status[b]				
None	23 (5.96)	14 (4.75)	12 (5.08)	13 (7.51)
Veterans Administration	5 (1.30)	3 (1.02)	2 (0.85)	2 (1.16)
Medicaid	26 (6.73)	20 (6.77)	13 (5.50)	15 (8.67)
Medicare	95 (22.61)	78 (26.44)	64 (27.12)	28 (16.18)
Medicare-Medicaid	17 (4.40)	11 (3.73)	10 (4.24)	7 (4.05)
Private	219 (56.74)	169 (57.29)	134 (56.78)	107 (61.85)
Other	1 (0.26)	0 (0.00)	1 (0.42)	1 (0.58); 13 (7.51)
Tumor Stage[a]				
I	186 (48.19)	151 (51.19)	125 (52.97)	43 (24.86)
II	154 (39.90)	109 (36.95)	68 (28.31)	84 (48.55)
III	46 (11.92)	35 (11.86)	43 (18.22)	46 (26.59)
Tumor Size[a]				
<1 cm	96 (24.87)	81 (27.46)	64 (27.12)	18 (10.40)
>1 cm	290 (75.13)	214 (72.54)	172 (72.88)	155 (89.60)
Mean Health Literacy Score (SD)[c]	1.85 (1.08)	1.75 (1.01)	1.80 (1.06)	1.66 (0.95)
Comorbidity Score[b]				
0	235 (60.88)	176 (59.66)	145 (61.44)	110 (63.58)
1	103 (26.68)	81 (27.46)	66 (27.97)	43 (24.86)
≥2	48 (12.44)	38 (12.88)	25 (10.59)	20 (11.56)
Black Location Quotient				
Quartile 1	96 (24.87)	70 (25.08)	69 (29.24)	42 (24.28)
Quartile 2	96 (24.87)	74 (25.08)	57 (24.15)	48 (27.75)
Quartile 3	97 (25.13)	82 (27.80)	59 (25.00)	31 (17.92)
Quartile 4	97 (25.13)	69 (23.39)	51 (21.61)	52 (30.06)
Hispanic Location Quotient				
Quartile 1	96 (24.87)	75 (25.42)	64 (27.12)	44 (25.43)
Quartile 2	97 (25.13)	76 (25.76)	56 (23.73)	40 (23.12)

Table 1 Continued

	Entire Cohort (n = 386)	Hormonal Therapy-Eligible (n = 295)	Radiation Therapy-Eligible (n = 236)	Chemotherapy-Eligible (n = 173)
Quartile 3	96 (24.87)	68 (23.05)	60 (25.42)	50 (28.90)
Quartile 4	97 (25.13)	76 (25.76)	56 (23.73)	39 (22.54)
Knowledge Composite Score				
0	54 (13.99)	44 (14.92)	28 (11.86)	27 (15.61)
1	107 (27.72)	92 (23.83)	63 (26.69)	40 (23.12)
2	104 (26.94)	73 (24.74)	67 (28.39)	42 (24.28)
3	94 (24.35)	67 (22.71)	60 (25.42)	50 (28.90)
4	27 (6.99)	19 (6.44)	18 (7.63)	14 (8.09)

Data are presented as n (%) except where otherwise noted.
[a]Registry report: age, tumor stage, and tumor size.
[b]Self-report: race/ethnicity, education attainment, marital status, insurance, and comorbidities.
[c]Health literacy scores were calculated using a series of 3 questions: (1) "How confident are you filling out medical forms?"; (2) "How often do you have someone help you read hospital materials?"; and (3) "How often do you have problems learning about your medical conditions?" All responses used a 5-item Likert scale with 1 representing the most confidence and fewest problems.[19]

from regions 1/8 (San Francisco/Santa Cruz) and region 3 (Sacramento) of the CCR were identified. All 1118 patients (see Supplemental Figure 1 in the online version), received a diagnosis of stage 0 to III breast cancer in 2010 to 2011 and received primary breast surgery. Among the 1118 patients identified, 231 refused participation, 317 could not be reached, and 68 were deceased or ill (response rate = 47.8%; participation rate among patients whose contact information was available = 68.5%). Among the 502 survey respondents, 2 self-identified as Asian American and were excluded because our focus was on the care of black and Hispanic patients. Of these remaining 500 study participants, all participants with stage 0 (n = 86) disease were excluded from the present analysis because of variability in treatment recommendations. An additional 28 participants were excluded because of inability to geocode their addresses. The final cohort included 386 study participants who self-identified as non-Hispanic white (n = 163), non-Hispanic black (n = 124), or Hispanic (n = 99). The racial and ethnic demographic data for each individual participant's block group, census tract, county, and MSA were obtained from the 2010 US Census.

Ethical Approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. We obtained study approvals from the CCR, the California Health and Human Services Agency Committee for the Protection of Human Subjects, and Harvard Medical School's Committee on Human Studies.

Variables

Our primary outcomes of interest were breast cancer knowledge and receipt of guideline-recommended adjuvant treatment. Breast cancer knowledge was defined as patient knowledge of her own breast cancer characteristics (stage, grade, and ER and HER2 status) and was measured as an ordinal score of 0 to 4 (number of answers correct). As per previous definitions, answers were considered "correct" if a participant's answer matched the characteristic according to the CCR or if the CCR result was 'unknown," "not performed," or missing. One woman who reported having stage IV disease was considered to correctly report stage in case her cancer (originally diagnosed as stage 0-III in the CCR) recurred.[16]

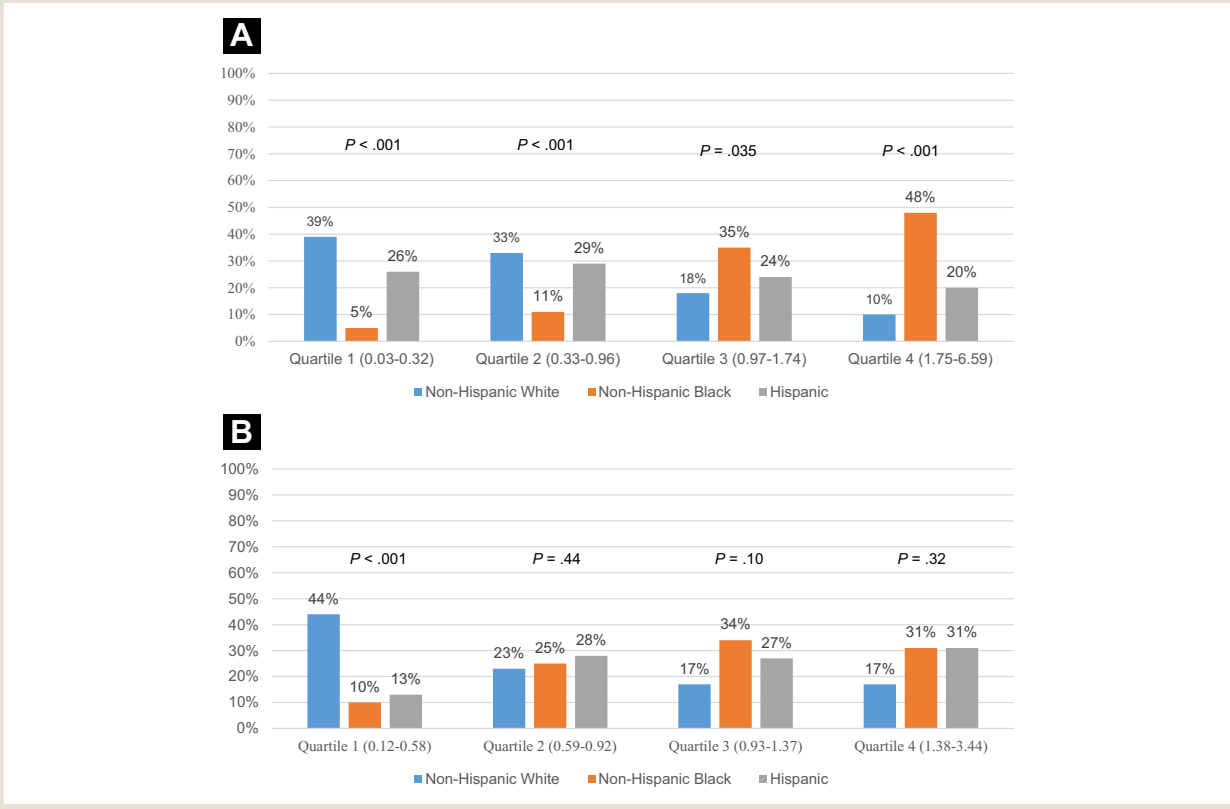
Adjuvant treatment receipt was defined as either self-reported or CCR report of various treatments for breast cancer. For this analysis, patients were divided into treatment cohorts according to their tumor characteristics, so that receipt of adjuvant chemotherapy, radiation, and hormonal therapy could be examined. The chemotherapy cohort (n = 173) was defined as study participants with the following disease criteria: stage IIB (any subtype), stage III (any subtype), tumor >1 cm if ER- and progesterone receptor (PR)-negative, or tumor >1 cm if HER2-positive. The radiation therapy cohort (n = 236) included those who underwent breast-conserving surgery or unilateral or bilateral mastectomy for stage III disease. The hormonal therapy cohort (n = 295) included participants with

Table 2 Interquartile Range of Black LQ and Hispanic Location Quotient

	Segregation Variables							
	Mean ± SD	Median (IQR)	Minimum	Maximum	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Black LQ	1.213 ± 1.15	0.96 (0.32-1.74)	0.03	6.59	0.03-0.32	0.33- 0.96	0.97- 1.74	1.75-6.59
Hispanic LQ	1.06 ± 0.66	0.92 (0.58-1.37)	0.12	3.34	0.12-0.58	0.58-0.92	0.92-1.37	1.38-3.44

The values represent the proportion of each minority group in a census tract compared with the proportion in the metropolitan statistical area. Higher black LQ and Hispanic LQ values represent higher levels of segregation.[6]
Abbreviations: IQR = interquartile range; LQ = location quotient.

Figure 2 (A) Black Location Quotient According to Race/Ethnicity. (B) Hispanic Location Quotient According to Race/Ethnicity. Unadjusted Proportion of Study Cohort Participants According to Race/Ethnicity Within Each Quartile of Black LQ and Hispanic LQ. *P* Values Are According to χ^2 Testing Comparing the Proportion of Patients of Each Race/Ethnicity Within Quartile. Quartile 1 Represents the Lowest Segregation and Quartile 4 Represents the Highest Segregation. Blue Bars Represent Non-Hispanic White Participants, Orange Bars Represent Non-Hispanic Black Participants, and Gray Bars Represent Hispanic Participants. The Values in Parentheses Represent Percent of Racial Group Within Each LQ Quartile for Non-Hispanic Black and Hispanic Segregation



Abbreviation: LQ = location quotient.

stage I to III, ER- or PR-positive cancers. Study participants could be included in more than 1 treatment group, depending on disease characteristics.

Quantitative Variable

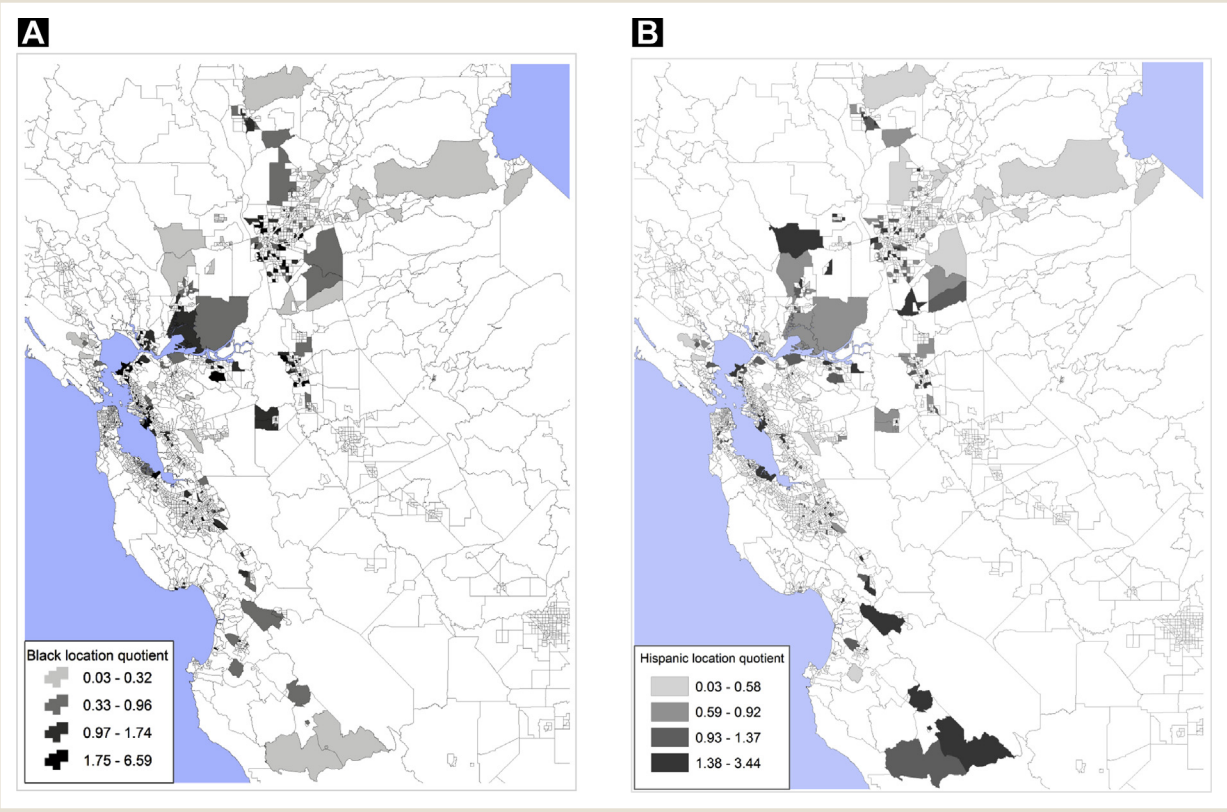
Our independent variable of interest was LQ of racial residential segregation.[6] LQ is a relative measure of 2 proportions that compares the proportion of minority group *m* in census tract relative to the proportion of minority group *m* in the larger MSA for comparison across different geographical units, allowing for assessment of differences in the racial composition of individual's neighborhood compared with the larger MSA.[6,12]

The formula is calculated with the following:

- $LQ_{im} = (x_{im}/X_i) / (Y_m/Y)$
- LQ_{im} = the value of *i*th census tract in a MSA for minority group *m*
- x_{im} = the number of individuals from minority group *m* living in the *i*th census tract;
- Xi = the total number of residents in the *i*th track
- Ym = the total number of individuals from minority group *m* in the MSA
- Y = total number of residents in the MSA

The LQ ranges from 0 to infinity, with values <1 indicating that the proportion of minority group *m* in the census tract is less than the proportion of the same group in the larger MSA. A LQ >1 indicates that the proportion of minority group *m* in the census tract is more than the proportion of the same group in the larger MSA. For instance, an LQ = 2 describes that the census tract proportion of minority group *m* is 2 times the proportion of the same group in the MSA.[6] For each patient, black LQ and Hispanic LQ, were calculated and analyzed using quartiles, with quartile 1 representing the lowest relative level of segregation in our analysis. Because black or Hispanic LQ values range from 0 to infinity, the use of quartiles allows for the assessment of how relative increases in black or Hispanic segregation affects the outcomes of interest. We selected quartiles to evaluate LQ because previous cited cutoffs in the literature have not been extensively validated for black and Hispanic segregation and were not easily applied to our population of patients

Figure 3 (A) Black Location Quotient of Study Participant Census Tracts. (B) Hispanic Location Quotient of Study Participant Census Tracts. The Census Tracts Included Are Within the San Francisco, Santa Cruz, and Sacramento Regions in the California Cancer Registry



who resided in lower-segregation areas.[6] The use of quartiles allowed for analysis to be conducted with the intent of evaluation of how incremental increases in segregation within our study population affected patient knowledge and treatment receipt. The categories for black LQ quartiles in our analysis were the following: quartile 1 (0.03-0.32), quartile 2 (0.33-0.96), quartile 3 (0.97-1.74), and quartile 4 (1.75-6.59). The cutoffs for Hispanic LQ quartiles were the following: quartile 1 (0.12-0.58), quartile 2 (0.59-0.92), quartile 3 (0.93-1.37), and quartile 4 (1.38-3.44). We mapped the LQ quartiles assigned to each geocode of residence for the included CCR areas. For each black LQ and Hispanic LQ quartile, analyses were conducted to examine associations of race/ethnicity, adjuvant treatment receipt, and patient knowledge with different levels of segregation.

Control variables of interest included tumor characteristics as well as variables previously shown to affect treatment and knowledge, including race/ethnicity, age, educational attainment, tumor stage, health literacy, and comorbidities, all categorized similarly to past analyses.[18,19] The comorbidity variable was determined on the basis of the Charlson index and by adding the number of self-reported medical conditions.[20,21] Variables were defined and categorized as per Table 1.[19]

Statistical Methods

We used χ^2 tests and Kruskal–Wallis tests to assess differences in baseline participant and tumor variables according to each relevant treatment group. We also examined differences in black LQ and Hispanic LQ according to study participant race/ethnicity using χ^2 tests. An additional analysis was done to evaluate differences in patient knowledge of each tumor characteristic (stage, grade, ER and HER2 status) according to black LQ and Hispanic LQ.

Next, we performed multivariable logistic regression for adjuvant treatment receipt and ordinal logistic regression for patient knowledge (summing outcome of answering more tumor characteristics questions correctly, 0-4), first with a base model, which assessed the odds of each outcome of interest (adjuvant treatment receipt and patient knowledge), adjusting for race/ethnicity, age, education, tumor size, health literacy, and comorbidity. We did not include insurance in models because few were uninsured (n = 23). In a second set of models, we added black and Hispanic LQ separately, to assess the association between (1) segregation and treatment receipt for each treatment-eligible cohort; and (2) patient knowledge with black LQ and Hispanic LQ quartile 1, the lowest relative level of segregation, as the reference group. In a sensitivity analysis, we repeated models comparing quartile 4 for black LQ and Hispanic LQ

Table 3 Unadjusted Percentage and Adjusted OR for Knowledge (n = 386) and for Adjuvant Treatment Receipt Among Each Treatment-Eligible Group

	Patient Knowledge	Treatment Receipt								
	Having More Answers Correct (n = 386)	HT Receipt (n = 244)[a]	*P*[a]	Adjusted OR for HT Receipt[b]	RT Receipt (n = 216)[a]	*P*[a]	Adjusted OR for RT Receipt[b]	CT Receipt (n = 142)[a]	*P*[a]	Adjusted OR for CT Receipt[b]
Age, Years[c]										
<50	1.00	67 (89.33)	**.003**	1.00	49 (87.50)	.464	1.00	53 (92.98)	**.0009**	1.00
50-59	**0.60 (0.36-0.99)**	73 (90.12)		1.22 (0.39-3.85)	65 (92.86)		1.61 (0.42-6.13)	50 (86.21)		0.46 (0.12-1.82)
≥60	**0.26 (0.156-0.43)**	104 (74.82)		**0.25 (0.09-0.69)**	102 (92.73)		1.12 (0.31-4.08)	39 (67.24)		0.08 (0.02-0.33)
Race[d]						.791				
Non-Hispanic white	1.00	109 (85.16)	.238	1.00	91 (90.10)		1.00	57 (86.36)	.360	1.00
Non-Hispanic black	**0.49 (0.30-0.82)**	71 (77.17)		**0.38 (0.15-0.95)**	64 (92.75)		1.12 (0.30-4.21)	50 (76.92)		0.70 (0.18-2.65)
Hispanic	0.59 (0.35-1.00)	64 (85.33)		0.99 (0.37-2.67)	61 (92.42)		1.25 (0.35-4.48)	35 (83.33)		0.45 (0.11-1.86)
Education Attainment[d]										
High school or less	1.00	77 (78.57)	.062	1.00	73 (94.81)	.229	1.00	45 (84.91)	.595	1.00
Some college	**3.17 (1.92-5.25)**	84 (90.32)		2.37 (0.91-6.14)	69 (87.34)		0.39 (0.10-1.48)	42 (77.78)		**0.23 (0.06-0.87)**
College graduate	**2.23 (1.35-3.70)**	83 (79.81)		0.57 (0.24-1.37)	74 (92.50)		0.72 (0.16-3.19)	55 (83.33)		0.54 (0.16-1.84)
Tumor Stage[e]										
I	1.00	115 (76.16)	**.0008**	1.00	115 (92.00)	.0880	1.00	29 (67.44)	**.0097**	1.00
II	1.37 (0.92-2.05)	102 (93.58)		**5.99 (2.34-15.34)**	65 (95.59)		1.98 (0.49-8.03)	71 (84.52)		4.66 (.53-14.17)
III	1.14 (0.63-2.09)	27 (77.14)		1.06 (0.39-2.86)	36 (82.72)		0.53 (0.17-1.66)	42 (91.30)		7.13 (1.74-29.31)
Mean Health Literacy Score (continuous)[e]		1.74	.329	0.96 (0.66-1.40)	1.81	.689	0.94 (0.54-1.63)	1.69	.515	1.34 (0.719-2.49)
Comorbidity Score[d]										
0	1.00	148 (84.09)		1.00	131 (90.34)	.614	1.00	90 (81.82)	.564	1.00
1	0.78 (0.50-1.21)	65 (80.25)	.736	1.40 (0.63-3.11)	61 (92.42)		1.46 (0.46-4.60)	37 (86.05)		4.07 (1.08-15.36)
≥2	0.95 (0.52-1.74)	31 (81.58)		1.97 (0.66-5.89)	24 (96.00)		2.62 (0.30-23.24)	15 (75.00)		1.88 (0.44-0.81)
Black Location Quotient										
Quartile 1	1.00	57 (81.43)	.170	1.00	62 (89.86)	.749	1.00	35 (83.33)	.667	1.00
Quartile 2	1.11 (0.65-1.90)	62 (83.78)		1.27 (0.46-3.47)	51 (89.47)		0.98 (0.27-3.58)	40 (83.33)		0.77 (0.20-2.94)
Quartile 3	1.41 (0.79-2.52)	73 (89.02)		**4.06 (1.26-12.93)**	55 (93.22)		1.52 (0.33-7.05)	27 (87.10)		0.78 (0.15-4.14)
Quartile 4	0.96 (0.52-1.78)	52 (75.36)		1.04 (0.35-3.13)	48 (94.12)		1.86 (0.32-10.68)	40 (76.92)		0.61 (0.13-2.85)

Table 3 Continued

	Patient Knowledge	Treatment Receipt								
	Having More Answers Correct (n = 386)	HT Receipt (n = 244)[a]	P^a	Adjusted OR for HT Receipt[b]	RT Receipt (n = 216)[a]	P^a	Adjusted OR for RT Receipt[b]	CT Receipt (n = 142)[a]	P^a	Adjusted OR for CT Receipt[b]
Hispanic Location Quotient										
Quartile 1	1.00	66 (88.00)	.454	1.00	58 (90.63)	.810	1.00	36 (81.82)	.248	1.00
Quartile 2	0.83 (0.48-1.45)	63 (82.89)		0.49 (0.16-1.52)	51 (91.07)		0.83 (0.19-3.57)	35 (87.50)		2.66 (0.62-11.36)
Quartile 3	**0.53 (0.30-0.96)**	53 (77.94)		0.51 (0.16-1.6)	54 (90.00)		0.71 (0.17-3.04)	43 (86.00)		2.63 (0.62-11.15)
Quartile 4	0.76 (0.42-1.36)	62 (81.58)		0.78 (0.25-2.48)	53 (94.64)		1.20 (0.23-6.30)	28 (71.79)		0.89 (0.22-3.64)

All data are presented as whole number, percentage or OR (95% CI). Values in bold represent $P < .05$.
Abbreviations: HT = hormonal therapy; RT = radiation therapy; CT = chemotherapy; OR = odds ratio.
[a]Percentages represent the unadjusted proportion of the treatment-eligible cohort that received treatment according to each variable listed. P values were calculated using χ^2 for the categorical variables and Kruskal–Wallis test for health literacy.
[b]Using multivariable logistic regression, adjusting for all variables in the table.
[c]Registry report: age, tumor stage, and tumor size.
[d]Self-report: race/ethnicity, education attainment, marital status, insurance, and comorbidities.
[e]Health literacy scores were calculated using a series of 3 questions: (1) "How confident are you filling out medical forms?"; (2) "How often do you have someone help you read hospital materials?"; and (3) "How often do you have problems learning about your medical conditions?" All responses used a 5-item Likert scale with 1 representing the most confidence and fewest problems.[19]

with the remaining quartiles, because this quartile included women with the most evident segregation relative to the larger MSA. With the use of quartile 4 as the reference group, this sensitivity analysis allowed for assessment of the association between relative decreases in segregation and the outcome variables of interests. Ultimately, the comparison of analysis with quartile 1 and 4 as the reference groups allowed for assessment for how increases and decreases in racial and ethnic segregation affected the outcomes of interest.

Results

The baseline characteristics of each treatment-eligible cohort are summarized in Table 1. Overall, the study cohort was 42% non-Hispanic white, 32% non-Hispanic black, and 26% Hispanic. Most participants were aged older than 50 years (Table 1). Within the adjuvant chemotherapy-eligible cohort, approximately 82% received chemotherapy (142 patients). Among those eligible for hormonal therapy, 83% received hormonal therapy (244 patients), and 92% of those eligible for radiation received treatment (216 patients).

Racial Segregation

Overall, the average black LQ value was larger than for Hispanic LQ segregation (1.21 vs. 1.06) indicating overall higher relative levels of black segregation compared with Hispanic segregation (Table 2).[6] There were significant differences in the proportion of non-Hispanic white, non-Hispanic black, and Hispanic participants in each quartile of black LQ but only within quartile 1 for Hispanic LQ (all $P < .05$; Figure 2). The black LQ and Hispanic LQ quartiles for the census tracts in Northern California in which our study participants resided are shown in Figure 3.

Adjusted Results

Adjuvant Treatment Receipt. In the base model for adjuvant hormonal therapy and in the model adjusted for racial segregation, there were significant differences in the adjusted odds of treatment according to age, race/ethnicity, and tumor stage, which persisted after adjusting for LQ (Table 3).[19] Black women were less likely to receive hormonal therapy compared with white women (odds ratio [OR], 0.38; 95% confidence interval [CI], 0.15-0.95). In addition, individuals age older than 60 years had significantly lower odds of hormonal therapy receipt than those aged younger than 50 years (OR, 0.25; 95% CI, 0.09-0.69) and those with stage II (vs. I) disease had higher odds of hormonal therapy. Participants with a black LQ in quartile 3 were more likely to receive adjuvant hormonal therapy than those in quartile 1 (OR, 4.06; 95% CI, 1.26-12.93). For the radiation-eligible cohort, there were no significant differences in treatment according to subgroup or for black LQ or Hispanic LQ. In the chemotherapy-eligible cohort, age 60 years or older (vs. younger than 50 years) and having some college (vs. no high school diploma) were associated with lower odds of chemotherapy, whereas higher stage (II-III vs. I) was associated with higher odds of treatment. There were no differences observed in chemotherapy receipt according to race/ethnicity or according to Hispanic or black LQ. In our sensitivity analysis with quartile 4 versus other groups, there were no significant differences in adjuvant treatment receipt according to black LQ or Hispanic LQ (data not shown).

Patient Knowledge. We observed significant differences in summed knowledge scores for tumor characteristics according to age, race, education, and health literacy in the base ordinal logistic regression model (Table 3). Knowledge of disease did not vary significantly according to black LQ. However, participants with Hispanic LQ in quartile 3 answered significantly fewer questions correctly regarding their tumor characteristics compared with quartile 1 (OR, 0.53; 95% CI, 0.30-0.96). When we examined associations of knowledge of specific tumor variables, a higher proportion of women reported correct ER status in quartile 1 of black LQ (68%) compared with those residing in quartile 4 (45%; $P = .02$; see Supplemental Figure 2 in the online version). In addition, the proportion of women reporting correct ER status was significantly different according to Hispanic LQ quartiles (76% in quartile 1 vs. 40% in quartile 4; $P < .0001$). We also observed significant differences according to quartiles of Hispanic LQ for knowledge of stage, with those residing in Hispanic quartile 1 having the highest proportion of women reporting correct disease stage (69% in Hispanic LQ quartile 1 vs. 48% in quartile 4 areas; $P < .05$). Knowledge of HER2 status and grade were not associated with Hispanic or black LQ quartiles (see Supplemental Figure 3 in the online version). In our sensitivity analysis using comparisons with Quartile 4, there were no significant differences in patient knowledge according to black or Hispanic LQ.

Discussion

In this population-based analysis of women with early stage breast cancer, we found limited associations between relative increases in segregation and treatment receipt as well as overall patient knowledge, but potential associations of segregation with knowledge of individual tumor variables such as ER and stage. In contrast to our hypothesis, despite observing differences in the degree of segregation for black and Hispanic women, there was no consistent association between women who lived in areas with relatively higher levels of black or Hispanic segregation for treatment receipt of adjuvant chemotherapy, hormonal therapy, or chemotherapy.

Several studies have suggested that segregation contributes to neighborhood variation in health outcomes and health care access.[22-26] Segregation, as the result of state and federal policies, remains relevant to neighborhood composition and social polarization, with African American individuals living in the most segregated communities followed by Hispanic individuals.[26] In areas with higher levels of segregation, there are lower levels of economic and education opportunities, higher rates of concentrated poverty, and reduced access to medical services.[5,27] Thus, segregation might serve as a contributor to racial and ethnic heath disparities, although the extent to which segregation might contribute to cancer treatment disparities is not well understood.

Our results are not consistent with a previous study, which suggested that as black and Hispanic segregation increased, black and white women living in these areas were less likely to receive adequate breast cancer care.[11] However, another study showed that the black/white and Hispanic/white disparity in breast cancer stage (early vs. late) at diagnosis was largest in lower-income, less segregated areas, and smallest in areas with more segregation.[28] Conflicting findings are due to differences in segregation measures used, criteria regarding treatment receipt, cohort variation, and variability of geographical distribution. Further, these studies in conjunction with our findings suggest that segregation might have variable effects along the spectrum of diagnosis to treatment (eg, targeted outreach for breast cancer screening in segregated neighborhoods might reduce disparities in stage at diagnosis but might not affect treatment receipt).

Our study represents, to our knowledge the first analysis, to examine potential associations between relative increases in segregation and 2 intermediate contributors to racial disparities in breast cancer mortality, patient knowledge of disease and receipt of adjuvant therapy. Although we found no clear associations, it will be important to assess if knowledge of one's disease is associated with segregation in other populations.

Our study has several limitations. First, all study participants had geographical addresses in Northern California, which has had historically lower levels of racial segregation compared with other metropolitan areas, such as Detroit or Chicago, potentially limiting our ability to assess the effects of more extreme levels of segregation.[29] For instance, it has been previously reported that among the largest 25 cities in the United States, cities in Northern California, specifically San Francisco and San Jose, are among the cities where the mortality rates between non-Hispanic black and non-Hispanic white women were not significantly different, which might be secondary to the relatively small percentage of non-Hispanic black individuals in these cities and/or the low levels of segregation.[30] Further, not all census tracts in Northern California were represented by our study population (Figure 2). Second, some subgroups were small and the proportion of women who received adjuvant treatment was high, and we might have had limited power to detect meaningful associations between segregation and outcome variables. Third, we only included individuals who self-identified as black, white, or Hispanic, so generalizability to other racial and ethnic groups is limited. Fourth, our study focused on care during 2010 to 2011; and did not reflect care with more recently approved treatments. Last, LQ is a relatively new measure of segregation used in the health services literature. As a relative measure, it only considers 1 minority group at 2 different geographical units, which might limit the ability to assess segregation patterns including multiple racial/ethnic groups or to detect true segregation within one given geographical area. However, by assessing LQ with quartiles, we were able to assess trends in relative increase and decrease in segregation.

Conclusion

We did not find clear associations between racial residential segregation and receipt of recommended treatment or patient's knowledge of one's illness. To clarify the effect of racial segregation further, future studies should focus on associations between residential racial segregation and racial differences in breast cancer mortality and should include varying measures of segregation, different geographic locations, and assessment of potential mediating factors that contribute to persistent racial and ethnic disparities in cancer mortality.

Clinical Practice Points

- Although major advancements in breast cancer care have occurred in the past 20 years, there remains persistent disparities in mortality and receipt of care, particularly between racial and ethnic groups.
- To address these persistent disparities, it is important to evaluate the factors within and outside of the health care system that might affect diagnosis and treatment.
- The role of segregation in breast cancer outcomes has been mixed, often because of heterogenous variables and geographical locations studied.
- In this study we found no significant association between segregation and treatment receipt but did identify a discrepancy in patient knowledge of disease, specifically for Hispanic patients, which has not previously been evaluated.
- In the future, researchers should seek to determine if residential segregation contributes to patterns of where patients receive care and the value of care received.

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Disclosure

The authors have stated that they have no conflicts of interest.

Supplemental Data

Supplemental figures accompanying this article can be found in the online version at https://doi.org/10.1016/j.clbc.2018.12.001.

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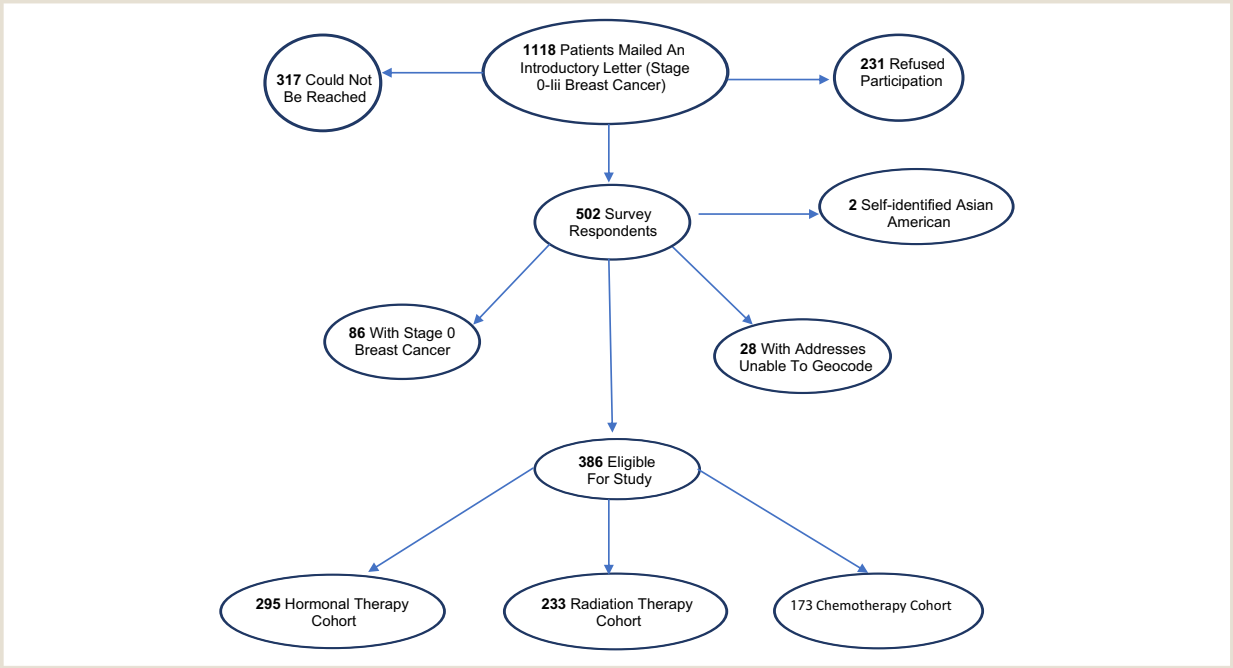
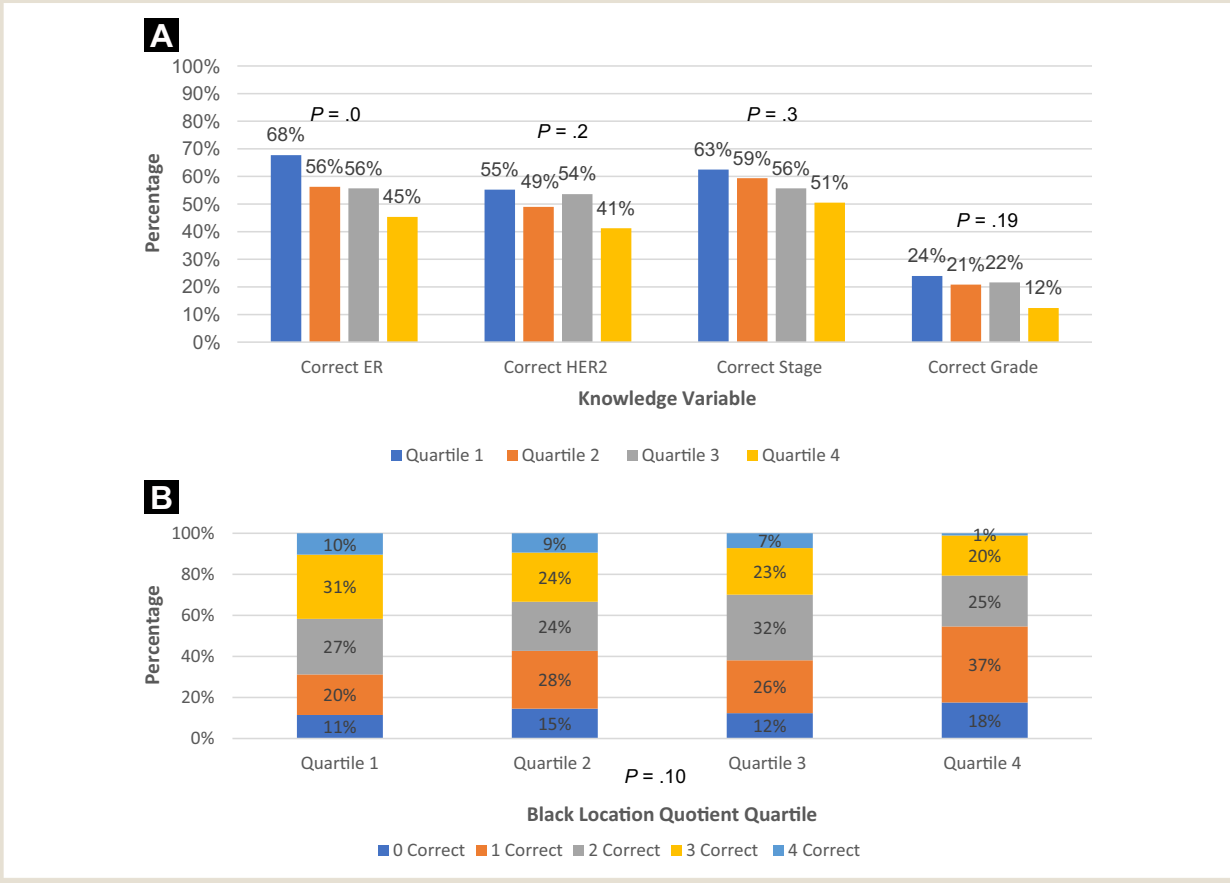
Supplemental Data

Supplemental Figure 1 **Consort Diagram of Participant Enrollment. This Diagram Shows Participant Enrollment. There Is Overlap in the Treatment Cohorts Because of the Multimodality Treatment Required Depending on Breast Cancer Stage**

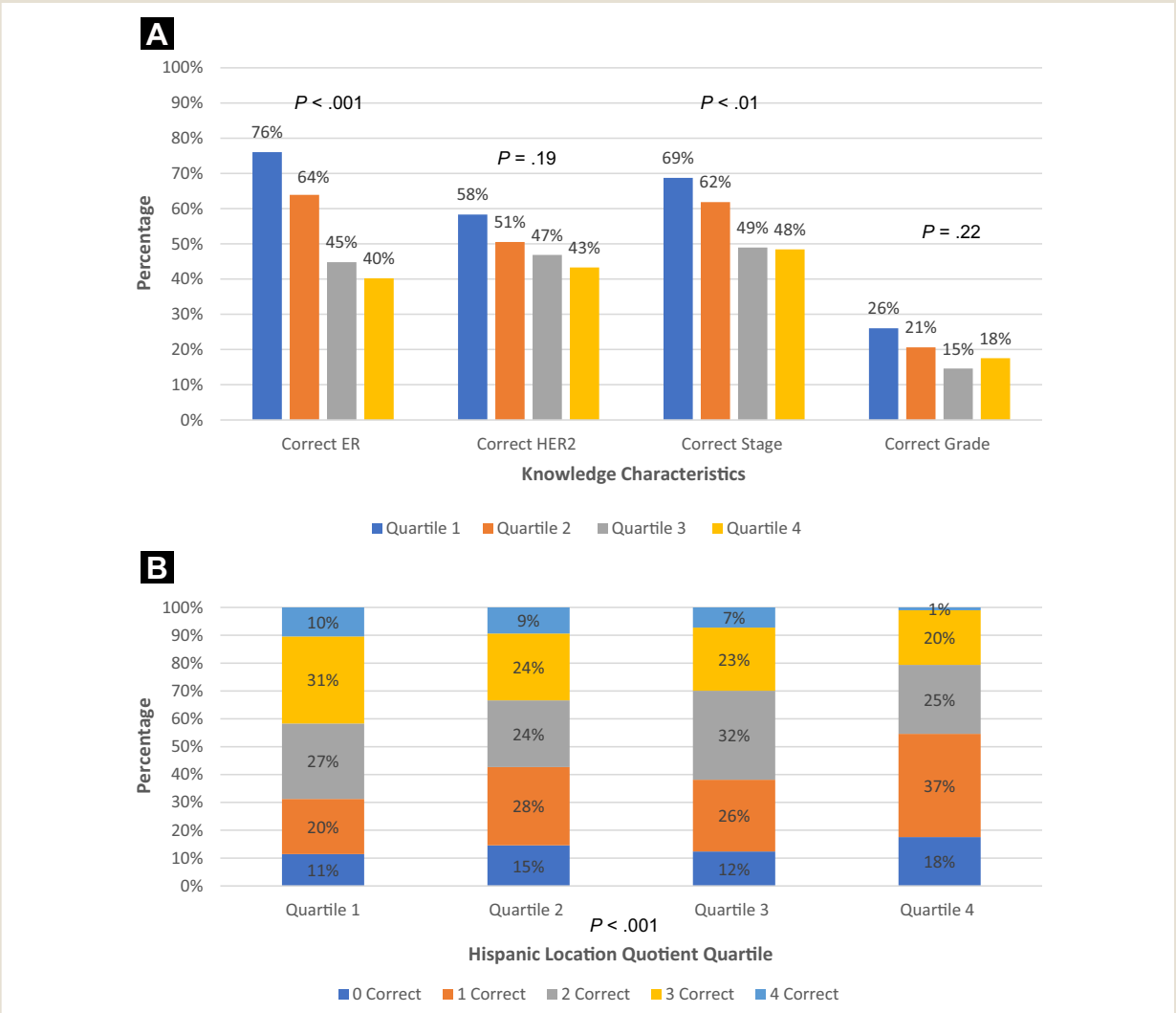


Supplemental Figure 2 (A) Black LQ Quartile and Patient Knowledge of Tumor Characteristics. (B) Black LQ Quartile and Total Number of Correct Tumor Characteristics



Abbreviations: ER = estrogen receptor; LQ = location quotient.

Supplemental Figure 3 (A) Hispanic LQ Quartile and Patient Knowledge of Tumor Characteristics. (B) Hispanic LQ Quartile and Total Number of Correct Tumor Characteristics



Abbreviations: ER = estrogen receptor; LQ = location quotient.