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Impact of neighborhood racial composition and metropolitan residential segregation on disparities in breast cancer stage at diagnosis and survival between black and white women in California¹

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Abstract

Objectives—We examined the impact of metropolitan racial residential segregation on stage at diagnosis and all-cause and breast cancer-specific survival between and within black and white women diagnosed with breast cancer in California between 1996 and 2004.

Methods—We merged data from the California Cancer Registry with Census indices of five dimensions of racial residential segregation, quantifying segregation among Blacks relative to Whites; block group (“neighborhood”) measures of the percentage of Blacks and a composite measure of socioeconomic status. We also examined simultaneous segregation on at least two measures (“hypersegregation”). Using logistic regression we examined effects of these measures on stage at diagnosis and Cox proportional hazards regression for survival.

Results—For all-cause and breast-cancer specific mortality, living in neighborhoods with more Blacks was associated with lower mortality among black women, but higher mortality among Whites. However, neighborhood racial composition and metropolitan segregation did not explain differences in stage or survival between Black and White women.

Conclusions—Future research should identify mechanisms by which these measures impact breast cancer diagnosis and outcomes among Black women.

Keywords

Breast cancer; Survival; Stage at diagnosis; Residential segregation; Race

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Introduction

Breast cancer is the most common cancer in women of virtually all United States (US) racial/ethnic groups. Yet, the burden of this cancer does not fall equally across all groups [1-4], and racial/ethnic disparities in mortality, particularly among African-Americans, have persisted since they were initially documented more than 20 years ago [5]. Numerous efforts have been made to understand how and why disparities occur [2,6], but answers are not straightforward, largely because disparities result from demographic, socioeconomic, and clinical factors occurring not only at the individual, but also the community levels [7-9].

Despite overall lower incidence rates, breast cancer mortality rates are higher among non-Hispanic Blacks than non-Hispanic Whites in the US. Approximately half of the two-fold worse survival among Blacks has been attributed to stage at diagnosis, likely due to disparities in early detection, and some proportion is additionally due to other factors including socioeconomic status (SES), treatment, tumor subtypes and disease aggressiveness, and comorbidities [10]. However, in most population-based studies, disparities in survival following breast cancer remain among Blacks compared to Whites.

Segregation is posited as a significant underlying cause of racial/ethnic disparities in health in this country [1-3,11]. For a variety of reasons, including racial discrimination, immigrant settling patterns and economic inequality, racial and ethnic minorities are more likely to live in poorer, clustered, urban areas than are Whites [12,13]. Research has consistently shown that Blacks are more likely than any other group to be residentially segregated and that urban areas are particularly highly segregated [14-18]. Residential segregation tends to concentrate disadvantage in minority communities [13,19] by limiting social, economic and educational opportunities and resources and concentrating poverty in these communities [20-22]. Blacks typically experience the highest degree of residential segregation of any US group [13,21,23]. Segregation of Blacks has only slightly moderated in over 50 years of research; moreover, socioeconomic status has failed to completely explain the racial/ethnic differences seen in residential patterns [13,21,23].

Besides the socioeconomic impacts, segregation can negatively impact health through exposure to substandard housing, lack of access to medical services, and social isolation, or positively affect health through co-ethnic social support networks and resource availability [24,25]. Segregation has been associated with negative health outcomes, including all-cause mortality [17,18,26,27], infant mortality [13,28,29], homicide [30,31], teen pregnancy [32], cardiovascular disease [33], tuberculosis [34], poor self-rated health [35] and exposure to environmental pollutants [36].

Understanding the impact of segregation on racial/ethnic variations in breast cancer diagnosis and outcomes could provide new insights into the long-standing disparities in breast cancer outcomes between Blacks and Whites, and provide new opportunities to inform policies toward reducing these persistent disparities. Therefore, using a large, population-based, cancer registry dataset, we examined the associations between racial residential segregation and breast cancer stage at diagnosis and survival between these two populations.

Methods

Study subjects

The California Cancer Registry (CCR) provided data on cancer cases diagnosed between 1996 and 2004 in the state of California. Subjects included in this analysis were Black and White state residents diagnosed with a first primary *in-situ* or invasive breast cancer (ICD-

O-2 codes C500-C509). Race and Hispanic ethnicity in the CCR data were obtained primarily from medical records.

Additional inclusion criteria for the study were geocoding based on complete address, and complete and valid year 2000 Census block group, tract and place. Reasons for lack of valid Census place, tract, and/or block group included: unknown or PO Box California address or a non-California address, or unsuccessful machine or manual tracting. Additionally, not all census tracts have corresponding census places.

With these restrictions, there were 10,030 Black and 113,979 White women diagnosed with breast cancer in California between 1996 and 2004, of whom 12.7% of Blacks and 25.4% of Whites did not link with the Census segregation file because not all census places appeared in the segregation data file. Segregation data were available only for places with: 1) at least 10 Census tracts; 2) total population of at least 10,000; and 3) minority population of over 100 persons [37,38]. Because the places may represent unique geographic niches, likely rural or remote areas of the state with small populations and/or few racial/ethnic minorities, women who did not link were included in our analysis and designated with an indicator variable.

Segregation data

The 2000 Census Place Excel[®] file was downloaded from the US Census Bureau's website [39], and contains 19 indices of residential segregation for six racial/ethnic groups for 1092 census places, or US metropolitan areas. Indices used in this analysis are calculated for non-Hispanic Blacks relative to non-Hispanic Whites. All index calculations used census place, a geographical or metropolitan area roughly corresponding to a town or a city, as the larger comparison area and census tracts as the component parts [40].

Racial residential segregation refers to the physical separation of two racial populations across neighborhoods (i.e., census tracts) of a given metropolitan area. It can be characterized as five distinct geographic patterns or dimensions: evenness, exposure, concentration, centralization and clustering[41,42]. We selected commonly used indices – dissimilarity, delta, isolation, relative centralization, and spatial proximity, one for each dimension [21,41-43]. A description and interpretation of each index is provided in Table 1 [44]. Because each dimension of segregation is distinct, a racial group can experience simultaneous segregation on multiple dimensions, known as “hypersegregation” [15]. Here, we define it as high segregation on two or more indices. In addition to characterizing place-level segregation for each Black and White breast cancer case, we included a block-group level measure from the 2000 Census of the percentage of non-Hispanic Blacks.

Analytical variables

Stage at diagnosis was determined using SEER summary stage 1977/2000. This is a calculated variable with summary stage based on 1977 extent of disease (EOD) criteria for cases between 1996 and 2000 and 2000 EOD criteria for cases diagnosed on or after 2001. Summary staging uses all information available in the medical record; it is a combination of the most precise clinical and pathological documentation of the extent of disease. Stage at diagnosis was identified as *in-situ*, local, regional, or remote (distant).

Excluding the 19,855 *in-situ* cases from the survival analysis, we included a sample of 8482 Black and 95,672 White cases. Date and cause of death information were obtained from the CCR via active and passive follow-up of cancer patients for vital status using linkages with state and national death indices, Centers for Medicare and Medicaid Services files, Social Security Administration files, and many other databases, as well as contact with patients, hospitals and physicians' offices. Patients were followed for vital status through December

31, 2007, which is also the date of censoring for patients who were last known to be alive. Underlying cause of death was abstracted from death certificates, and deaths assigned ICD-9 code 174 for deaths occurring 1996-1998 and ICD-10 code C50 for deaths after 1998 were identified as due to breast cancer.

Additional variables from the CCR included age, California region, marital status, year of diagnosis, first course (i.e., first four months) of surgery treatment, and estrogen (ER), and progesterone (PR). HER2Neu status was available beginning with 1999 diagnoses, and was only available for a small percentage of participants and was not used in this analysis. ER and PR data collection started with 1990 diagnoses, and is available on about 70% of diagnoses from 1996-2004. We used a previously validated neighborhood composite measure of socioeconomic status (SES) that includes Census 2000 block group-level data on education, proportion with a blue-collar job, proportion older than age 16 in the workforce without a job, median household income, proportion below 200% of the poverty level, median rent, and median house value [15,23].

Statistical analysis

All analyses were performed using SAS statistical software version 9.1. We calculated associations between stage and each of the five indices of segregation, and report odds ratios (ORs) with 95 percent confidence intervals (CI) for these associations, adjusted for age and year of diagnosis, CCR region, marital status, and neighborhood SES. We examined ORs comparing the risk of late (regional, distant) to early (*in-situ*, local) stage disease, and ORs comparing the risk of distant stage disease. After checking for proportionality of hazards for the major variables of interest, Cox proportional hazards regression was used to model the relative rates of mortality due specifically to breast cancer, as well as all-cause mortality. Survival models were adjusted for all of the above sociodemographic factors, in addition to stage, receipt of radiation (yes/no), receipt of surgery (yes/no), ER, and PR status. All of the stage and survival analyses were conducted to examine the joint effects of block group % Black and metropolitan segregation within and across racial/ethnic groups.

Results

Characteristics of study population

Blacks had a younger overall mean age at diagnosis, were more likely to be diagnosed with regional and distant stage and histologically poorly differentiated tumors, to not have had surgery for the treatment of their tumor, and to have ER-/PR- tumors (Table 2). Black patients were also more likely than Whites to reside in Los Angeles County, and in neighborhoods of lower SES, with greater proportion of black residents, and in metropolitan areas with more segregation.

There were regional variations within California in the degree of segregation within metropolitan regions. Regions within Los Angeles County had considerably more highly segregated regions than other parts of California. For example, within Los Angeles County, 48% of black cases lived in the highest quartile of the dissimilarity index, as compared to 0.7% in the Bay Area and 0% in other parts of California.

Segregation and stage at diagnosis

After adjustment there were no significant associations between segregation and odds of regional+distant (versus *in-situ*+local) stage nor odds of distant stage (versus *in-situ*+local+regional) among black or white women diagnosed with breast cancer (data not shown). Exceptions were higher odds of distant stage disease among black women living in low % Black neighborhoods within the most segregated metropolitan regions as measured by the

isolation index, compared to black women living in low % Black neighborhoods within the least segregated regions (OR = 2.11 (95% CI: 1.05-4.27)). Among white women, those living in the highest % Black neighborhoods within the most segregated regions as measured by the delta index were more likely to be diagnosed with distant stage disease (OR = 1.31 (95% CI: 1.01-1.71)) compared to white women living in the lowest % Black neighborhoods within the least segregated regions.

We also examined the impact of the block group % Black and segregation measures on the relative differences between Blacks and Whites in their diagnosis with late stage breast cancer. Blacks were more likely than Whites to be diagnosed with regional+distant stage breast cancer (OR comparing Blacks to Whites = 1.53 (95% CI: 1.46-1.59)) and nearly two-times more likely to be diagnosed with distant stage cancer. These differences were diminished after adjusting for age, year, marital status, and further diminished after adjusting for neighborhood SES (OR = 1.27 (95% CI: 2.21-1.33) for regional+late stage), but were unaffected by adjustment for % Blacks in the neighborhood and metropolitan segregation (data not shown).

Segregation and survival

We examined the adjusted relative effects of neighborhood racial/ethnic composition and segregation on breast cancer specific and all-cause mortality within each racial/ethnic group (Table 3). Among white women diagnosed with breast cancer, living in a neighborhood with greater than or equal to 10% but fewer than 20% black residents was associated with slightly higher all-cause mortality (HR = 1.07 (95% CI: 1.02-1.13)). There was a separate and synergistic effect of neighborhood racial/ethnic composition and some measures of segregation on mortality among Whites. Specifically, compared to Whites who live in a low % Black neighborhood within the least segregated regions, Whites who live in a neighborhood with greater than or equal to 10% Blacks within a moderately segregated region had about 10% higher overall mortality when segregation was measured using the dissimilarity (HR = 1.12 (95% CI: 1.02-1.24)) and spatial proximity (HR = 1.10 (95% CI: 1.00-1.21)) indices. Whites who live in a neighborhood with the highest % Blacks within the most segregated regions also had 10% higher mortality (HR = 1.09 (95% CI: 1.01-1.18)) when segregation was measured using the relative centralization index. Among Whites, there appeared to be a protective effect on mortality among those living in moderately (isolation and relative centralization) and highly (spatial proximity) segregated regions.

Among black women diagnosed with breast cancer, living in a neighborhood with greater than or equal to 20% Black residents was associated with lower breast cancer specific (HR = 0.86 (95% CI: 0.76-0.97)) and all-cause (HR = 0.90 (95% CI: 0.82-0.99)) mortality. This protective neighborhood effect persisted across nearly all levels and most dimensions of segregation, and seemed to be more pronounced in more segregated regions. For example, living in neighborhoods with greater than or equal to 10% Blacks within the most highly segregated metropolitan regions was associated with breast cancer specific HRs of 0.73 (95% CI: 0.60-0.88), 0.75 (95% CI: 0.63-0.90), 0.74 (95% CI: 0.61-0.89), 0.73 (95% CI: 0.60-0.89), and 0.76 (95% CI: 0.64-0.89) for segregation on the dissimilarity, delta, isolation, spatial proximity indices, and on two or more indices (hypersegregation), respectively.

We also examined the impact of the block group % Black and segregation measures on the relative mortality rates comparing Blacks to Whites. Black women had two-fold higher breast cancer specific (HR = 2.1 (95% CI: 2.0-2.2)) and 50% higher all-cause mortality (HR = 1.5 (95% CI: 1.4-1.5)) than White women. These differences were reduced, with HRs for both breast cancer specific and all-cause mortality of about 1.5, after adjusting for age, year, marital status, and tumor characteristics. The HRs were further reduced to about 1.4 after

adjusting for surgery, and to 1.3 after adjusting for neighborhood SES, but were unaffected by adjustment for % Blacks in the neighborhood and segregation (data not shown).

Discussion

This paper adds to a growing, but still small, body of literature on the effects of neighborhood composition and contextual factors on cancer incidence and survival [45]. Additional studies have examined cancer screening behaviors and neighborhood level factors including racial composition and poverty [46-51]. Our results, based in a large, representative, and diverse population-based sample, have important implications for informing future research to understand specific community-level factors and the mechanisms by which they impact disparities in health [52,53]. Our analysis generates two main findings. First, we show that neighborhood racial composition and metropolitan segregation measures are weakly associated with differences in risk of late-stage breast cancer and strongly with survival among black and white women, but do not explain differences between them, likely because the associations are harmful among Whites yet protective among Blacks. Second, for Blacks, across the different measures of segregation, living in areas with a higher percentage of Blacks in the block group is associated with increased survival independent of neighborhood-level socioeconomic status. This is not true for Whites, for whom living in neighborhoods with a higher percentage of Blacks was associated with lower survival.

Our ability to explain differences in breast cancer stage at diagnosis and survival within, but not between, black and white women may be attributed to differences in the meaning of segregation and neighborhood racial composition variables by race. Whites are the reference 'majority' group in our segregation measures, thus they can be interpreted as black segregation relative to Whites. For Blacks, these measures refer to their own racial group, but for Whites, they refer to living in a metropolitan area in which *Blacks* are segregated. The interpretation of percentage of Blacks in the block group varies by race as well. For Blacks, increasing percentages mean living in a neighborhood where more of the people are of their same race, while for Whites it means living in a place with more people of a different race.

One plausible mechanism for this association among Blacks is social support. Several studies have shown that women who are socially isolated have poorer survival than those with more support [15]. Black women with breast cancer living in neighborhoods with larger percentages of Blacks may benefit from increased social support in a way that white women may not. Once we have controlled for tract-level socioeconomic status, living in a neighborhoods with increasing percentages of Blacks may represent increased social capital for black women with breast cancer. Indeed, there is growing evidence that American's social networks are racially segregated [54-57]. Thus, women living in an area with increasing numbers of people outside of their race may have smaller social networks and receive less support. The effect of social networks may also act to mediate stressors associated with having breast cancer [58-60]. Higher reported stress levels have been shown to be associated with poorer breast cancer survival [61,62]. More research is needed on the specific mechanisms, whether it is through increased social networks and social support systems, for the improved survival seen among Black women living in neighborhoods with higher percentages of Blacks.

Overall, there was little effect of neighborhood composition and segregation measures on stage at diagnosis among or between black and white women. Regular, timely, quality mammography has been shown to decrease a woman's likelihood of being diagnosed with advanced stage breast cancer [63]. Mammography screening history has been shown to

explain a proportion of the Black/White disparity in breast cancer stage at diagnosis [64-66]. Recent research in Chicago has identified spatial inequity in access to free or low-cost mammography facilities and that neighborhood poverty and crime in the area surrounding mammography facilities is related to the risk of late stage disease [67]. Yet, within California, there have been intensive, statewide efforts to increase mammography rates among minorities and those of low socioeconomic status. These efforts have equalized mammography screening rates among most populations, including between Blacks and Whites [68,69].

Regardless of equalized mammography screening rates, our data, as well as those of others, clearly show that Blacks are still more likely than Whites to be diagnosed with advanced stage disease that is not explained by neighborhood composition or urban segregation. Research in Florida showed that neighborhoods of extreme or near poverty were also more likely to be neighborhoods with higher than expected incidence of late stage breast cancer [70]. Our results taken with the literature suggest that area-level socioeconomic status may be more important than racial composition and segregation for risk of late stage breast cancer. Among Blacks, these neighborhood factors may still be important to the extent that they concentrate poverty.

There are important limitations that must be considered when interpreting these results. Individual-level data were not available leaving us unable to perform a multi-level analysis to assess the extent to which observed patterns were attributable to individual or neighborhood factors. Information on patients' residential history was not available and thus we cannot estimate the 'dose' of exposure to segregation or neighborhood racial composition. As with other geographical analyses, the geographic boundaries used in this analysis may not best reflect individuals' actual residential space [71].

Despite these limitations, our findings, based on a representative and diverse socioeconomic and geographic population, are provocative and inform future research incorporating more detailed data and utilizing multi-level analysis to specifically examine the relationship and interaction between personal sociodemographic characteristics and measures of racial residential segregation. Future research should also incorporate information on experiences of racism and discrimination, and mediators including social support, to determine whether these factors mediate or modify the relationship between segregation and cancer outcomes. Qualitative studies should examine the experiences of black and white women diagnosed with breast cancer living in neighborhoods with varying racial compositions.

We set out to explain the longstanding disparity among black women in their breast cancer mortality rates by examining neighborhood and metropolitan factors. Instead, we found intriguing, protective effects indicative of increased social support within highly black neighborhoods that seem to be more pronounced within highly segregated cities. Given the documented negative health effects of racial residential segregation our results suggest that these communities have developed efficient coping mechanisms. These communities may have, out of necessity, formed social support networks to buffer against the everyday stresses associated with living in such neighborhoods. These networks may provide particularly strong support in times of intense need, such as after diagnosis of breast cancer. This support may increase adherence to treatment regimes, prevent delays in receipt of treatment and provide assistance in overcoming barriers to care. Research on the specific mechanisms for how this occurs and the nature of the social support can inform survivorship programs targeted towards improving survival after cancer diagnosis among the black population in general. We must continue the search to explain the high breast cancer mortality rates of black women in America relative to Whites.

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Table 1

Segregation Dimensions*

DIMENSION	INDEX	DESCRIPTION	INTERPRETATION
Evenness	Dissimilarity	Measures proportion of minority members that would have to change residence for each unit of analysis to have the same distribution as the larger overall area. It ranges from 0 (no segregation) to 1 (complete segregation).	Evenness is the degree to which each neighborhood has the same distribution of Blacks to Whites as the metropolitan area overall.
Concentration	Delta	Concentration represents the relative (to population size) amount of physical space occupied by a minority group in a given geographic area. Index values range from 0 to 1, representing the proportion of minority members that would have to move across neighborhoods to achieve a uniform density.	Concentration refers to the population density, or size, of Blacks across the metropolitan area relative to the density of Whites.
Exposure	Isolation	Measures extent to which minority members are exposed either only to other minority members or to members of the majority group. Index values range from 0 to 1	Exposure is the average probability of contact between Blacks and Whites at the neighborhood level.
Centralization	Relative Centralization	Relative centralization represents the proportion of the minority population that would have to change residence to match the centralization level of the majority group. Index values range between -1.0 and 1.0 with positive values indicating that minority group members reside closer to the city center than do majority members.	Centralization measures the extent to which predominantly Black neighborhoods are close to the metropolitan area's center as opposed to its suburbs.
Clustering	Spatial Proximity	Clustering measures the degree to which minority residential areas are adjacent to one another in physical space. Index values range from 1.0, where there is no difference in clustering between the minority and majority population, and greater than 1.0, when members of the minority group live closer to each other than they do to majority members.	Clustering measures the effect of "ghettoization", or the degree to which predominantly Black neighborhoods are contiguous to predominantly White neighborhoods.

* Adapted from Acevedo-Garcia D, Lochner KA, Osypuk TL, Subramanian SV. Future directions in residential segregation and health research: A multilevel approach. *Am J Public Health*. 2003;93(2):215-221.)

Table 2

Distribution of socio-demographic and clinical patient- and area-level characteristics at diagnosis by race/ethnicity among women in California diagnosed with breast cancer and with valid Census place and tract residence data, 1996-2004

CHARACTERISTIC	NON-HISPANIC WHITE N= 113,979 (%)	NON-HISPANIC BLACK N= 10,030 (%)
Patient-level characteristics		
Age		
Mean (standard deviation)	62.2 (13.9)	57.8 (14.0)
< 40	4891 (4.3)	868 (8.7)
40-49	19145 (16.8)	2287 (22.8)
50-59	27221 (23.9)	2567 (25.6)
60-69	25113 (22.0)	2138 (21.3)
70+	37609 (33.0)	2170 (21.6)
Marital Status		
Never Married	13195 (11.6)	2386 (23.8)
Married	64251 (56.4)	3811 (38.0)
Divorced/Separated Widowed	34247 (30.1)	3524 (35.1)
Unknown	2286 (2.0)	309 (3.1)
Stage at diagnosis		
<i>In-situ</i>	18307 (16.1)	1548 (15.4)
Local	61996 (54.4)	4566 (45.5)
Regional	29868 (26.2)	3308 (33.0)
Distant	3808 (3.3)	608 (6.1)
Histologic grade		
I (well differentiated)	22607 (19.8)	1105 (11.0)
II (moderately well differentiated)	41778 (36.7)	3083 (30.7)
III/IV (poorly differentiated)	33772 (29.6)	4511 (45.0)
Unknown	15822 (13.9)	1331 (13.3)
Surgery		
None	4008 (3.5)	678 (6.8)
Some surgery	109958 (96.5)	9352 (93.2)
Unknown	13 (0)	0 (0)
Estrogen receptor		
Positive	65292 (57.3)	4538 (45.2)
Negative	15220 (13.4)	2536 (25.3)
Unknown	33467 (29.4)	2956 (29.5)
Progesterone receptor		
Positive	53526 (47.0)	3431 (34.2)
Negative	23702 (20.8)	3083 (30.7)
Unknown	36751 (32.2)	3516 (35.1)

CHARACTERISTIC	NON-HISPANIC WHITE N= 113,979 (%)	NON-HISPANIC BLACK N= 10,030 (%)
Deaths due to breast cancer (% of cases)	10571 (9.3)	1762 (17.6)
Deaths due to all causes (% of cases)	26460 (23.2)	3081 (30.7)
Area-level characteristics		
Region of residence¹		
Greater Bay Area	25039 (22.0)	2243 (22.4)
Los Angeles	25464 (22.3)	4835 (48.2)
Other CA regions	63491 (55.7)	2952 (29.4)
Block-group composite SES²		
Quintile 1 (lowest)	6751 (5.9)	2901 (28.9)
Quintile 2	15049 (13.2)	2550 (25.4)
Quintile 3	22968 (20.2)	2082 (20.8)
Quintile 4	29802 (26.2)	1658 (16.5)
Quintile 5 (highest)	39409 (34.6)	839 (8.4)
% Blacks in block group		
<10%	105023 (92.1)	3029 (30.2)
10-<20%	6179 (5.4)	1680 (16.8)
≥20%	2755 (2.4)	5319 (53.0)
Unknown	22 (0)	<5 (0)
Dissimilarity³		
Quartile 1 (Q1) (lowest)	44770 (39.3)	2332 (23.3)
Quartile 2 (Q2)	21698 (19.0)	2334 (23.3)
Quartile 3 (Q3)	8485 (7.4)	1766 (17.6)
Quartile 4 (Q4) (highest)	10082 (8.9)	2325 (23.2)
Did not link ⁴	28944 (25.4)	1273 (12.7)
Dissimilarity × % Black⁵		
Low seg & low % Black	61023 (53.5)	1832 (18.3)
Low seg & high % Black	5435 (4.8)	2833 (28.3)
Medium seg & low % Black	6983 (6.1)	250 (2.5)
Medium seg & high % Black	1500 (1.3)	1515 (15.1)
High seg & low % Black	9469 (8.3)	440 (4.4)
High seg & high % Black	610 (0.5)	1885 (18.8)
Did not link & low % Black	27548 (24.2)	507 (5.1)
Did not link & high % Black	1389 (1.2)	766 (7.6)
Delta		
Q1 (lowest)	34054 (29.9)	2282 (22.8)
Q2	26718 (23.4)	2655 (26.5)
Q3	9023 (7.9)	1081 (10.8)
Q4 (highest)	15240 (13.4)	2739 (27.3)

CHARACTERISTIC	NON-HISPANIC WHITE N= 113,979 (%)	NON-HISPANIC BLACK N= 10,030 (%)
Delta × % Black		
Low seg & low % Black	55648 (48.8)	1613 (16.1)
Low seg & high % Black	5113 (4.5)	3322 (33.1)
Medium seg & low % Black	7774 (6.8)	350 (3.5)
Medium seg & high % Black	1248 (1.1)	731 (7.3)
High seg & low % Black	14053 (12.3)	559 (5.6)
High seg & high % Black	1184 (1.0)	2180 (21.7)
Isolation		
Q1 (lowest)	60001 (52.6)	2221 (22.1)
Q2	13527 (11.9)	2226 (22.2)
Q3	9915 (8.7)	2333 (23.3)
Q4 (highest)	1592 (1.4)	1977 (19.7)
Isolation × % Black		
Low seg & low % Black	67420 (59.2)	1971 (19.7)
Low seg & high % Black	6096 (5.4)	2475 (24.7)
Medium seg & low % Black	9286 (8.2)	448 (4.5)
Medium seg & high % Black	626 (0.6)	1885 (18.8)
High seg & low % Black	769 (0.7)	103 (1.0)
High seg & high % Black	823 (0.7)	1873 (18.7)
Relative Centralization		
Q1 (lowest)	14002 (12.3)	2297 (22.9)
Q2	24228 (21.3)	1692 (16.9)
Q3	15154 (13.3)	2574 (25.7)
Q4 (highest)	31651 (27.8)	2194 (21.9)
Relative Centralization × % Black		
Low seg & low % Black	34382 (30.2)	1179 (11.8)
Low seg & high % Black	3839 (3.4)	2808 (28.0)
Medium seg & low % Black	14102 (12.4)	561 (5.6)
Medium seg & high % Black	1049 (0.9)	2013 (20.1)
High seg & low % Black	28991 (25.4)	782 (7.8)
High seg & high % Black	2657 (2.3)	1412 (14.1)
Spatial Proximity		
Q1 (lowest)	51014 (44.8)	2308 (23.0)
Q2	14411 (12.6)	2257 (22.5)
Q3	9742 (8.6)	1882 (18.8)
Q4 (highest)	9868 (8.7)	2310 (23.0)
Spatial Proximity × % Black		
Low seg & low % Black	60128 (52.8)	1781 (17.8)
Low seg & high % Black	5289 (4.6)	2783 (27.8)

CHARACTERISTIC	NON-HISPANIC WHITE N= 113,979 (%)	NON-HISPANIC BLACK N= 10,030 (%)
Medium seg & low % Black	8088 (7.1)	304 (3.0)
Medium seg & high % Black	1650 (1.5)	1577 (15.7)
High seg & low % Black	9259 (8.1)	437 (4.4)
High seg & high % Black	606 (0.5)	1873 (18.7)
Hypersegregation (2 or more indices)⁶		
Yes	15741 (13.8)	3105 (31.0)
No	69294 (60.8)	5652 (56.4)
Did not link	28944 (25.4)	1273 (12.7)
Hypersegregation (3 indices)⁷		
Yes	9868 (8.7)	2310 (23.0)
No	75167 (65.9)	6447 (64.3)
Did not link	28944 (25.4)	1273 (12.7)

p <0.05 for all variables (chi-square test)

¹ Greater Bay Area includes the counties of Marin, San Francisco, Contra Costa, Alameda, San Mateo, Santa Clara, Monterey, Santa Cruz, and San Benito.

² Composite SES index = a Census-tract level index derived by principal components analysis and includes the following seven census variables: education level, proportion with a working-class job, proportion unemployed, median household income, proportion below 200 percent of poverty line, median rent, and median home value.

³ Quartiles based on distribution among Black cases

⁴ Unknown category created for those cases that did not link to the segregation data file; distribution presented only once, as values are the same for all segregation indices

⁵ excluding individuals living in areas with unknown % Black; “low segregation” = Q1 and Q2 of segregation index; “medium segregation” = Q3; “high segregation” = Q4; “low % Black” = <10% Black; “high % Black” = ≥ 10% Black

⁶ 4th quartile on 2 or more of the 5 segregation indices

⁷ 4th quartile on 3 of the 5 segregation indices

Table 3

Impact of segregation on mortality rates among women with breast cancer diagnosed 1996-2004, by race/ethnicity

RESIDENTIAL SEGREGATION INDICES ¹	NON-HISPANIC WHITE N=95,672 HR (95% CI)		NON-HISPANIC BLACK N=8482 HR (95% CI)	
	Breast cancer specific mortality ³	All cause mortality ⁴	Breast cancer specific mortality ³	All cause mortality ⁴
% Black in block group				
Overall P-value ²	0.7114	0.0320	0.0345	0.0958
<10%	1.00	1.00	1.00	1.00
10-<20%	1.02 (0.94-1.10)	1.07 (1.02-1.13)	0.87 (0.75-1.00)	0.93 (0.83-1.04)
≥20%	1.04 (0.93-1.17)	1.02 (0.95-1.11)	0.86 (0.76-0.97)	0.90 (0.82-0.99)
Dissimilarity × %Black ⁵				
Overall P-value ²	0.1451	0.0628	0.0768	0.0627
Low seg & low % Black	1.00	1.00	1.00	1.00
Low seg & high % Black	1.01 (0.92-1.10)	1.06 (1.01-1.13)	0.88 (0.75-1.02)	0.94 (0.83-1.06)
Medium seg & low % Black	1.01 (0.92-1.10)	1.02 (0.96-1.08)	0.97 (0.71-1.33)	1.20 (0.94-1.53)
Medium seg & high % Black	1.16 (1.00-1.35)	1.12 (1.02-1.24)	0.79 (0.66-0.95)	0.86 (0.74-0.99)
High seg & low % Black	1.03 (0.94-1.12)	0.99 (0.94-1.05)	0.84 (0.65-1.10)	0.98 (0.80-1.20)
High seg & high % Black	0.75 (0.58-0.98)	0.88 (0.74-1.04)	0.73 (0.60-0.88)	0.85 (0.73-0.98)
Did not link & low % Black	1.00 (0.95-1.05)	1.00 (0.97-1.03)	0.96 (0.76-1.21)	0.88 (0.73-1.07)
Did not link & high % Black	1.13 (0.96-1.32)	1.04 (0.93-1.16)	0.82 (0.66-1.02)	0.91 (0.77-1.07)
Delta × %Black				
Overall P-value	0.6207	0.4694	0.0681	0.1993
Low seg & low % Black	1.00	1.00	1.00	1.00
Low seg & high % Black	1.02 (0.93-1.12)	1.06 (1.00-1.13)	0.83 (0.71-0.97)	0.90 (0.79-1.01)
Medium seg & low % Black	1.07 (0.99-1.16)	0.99 (0.94-1.04)	1.09 (0.84-1.42)	1.08 (0.87-1.35)
Medium seg & high % Black	1.03 (0.86-1.23)	1.05 (0.93-1.18)	0.92 (0.73-1.16)	0.99 (0.83-1.19)
High seg & low % Black	0.99 (0.93-1.06)	0.99 (0.95-1.04)	0.81 (0.64-1.03)	1.01 (0.84-1.21)
High seg & high % Black	0.98 (0.82-1.17)	1.03 (0.92-1.16)	0.75 (0.63-0.90)	0.86 (0.75-1.00)
Did not link & low % Black	1.00 (0.95-1.05)	0.99 (0.96-1.02)	0.95 (0.75-1.20)	0.88 (0.72-1.07)
Did not link & high % Black	1.13 (0.96-1.33)	1.03 (0.92-1.15)	0.83 (0.67-1.04)	0.92 (0.77-1.08)
Isolation × %Black				
Overall P-value	0.1251	0.0695	0.0025	0.0167
Low seg & low % Black	1.00	1.00	1.00	1.00
Low seg & high % Black	1.02 (0.94-1.11)	1.08 (1.02-1.13)	0.93 (0.80-1.08)	0.95 (0.84-1.07)
Medium seg & low % Black	1.01 (0.93-1.10)	0.98 (0.92-1.03)	0.83 (0.63-1.08)	0.93 (0.76-1.15)
Medium seg & high % Black	0.75 (0.58-0.97)	0.87 (0.74-1.02)	0.72 (0.59-0.88)	0.81 (0.70-0.95)
High seg & low % Black	1.12 (0.88-1.41)	1.03 (0.88-1.20)	1.31 (0.88-1.96)	1.25 (0.90-1.74)
High seg & high % Black	1.21 (0.99-1.48)	1.07 (0.93-1.22)	0.74 (0.61-0.89)	0.81 (0.70-0.94)

RESIDENTIAL SEGREGATION INDICES ¹	NON-HISPANIC WHITE N=95,672 HR (95% CI)		NON-HISPANIC BLACK N=8482 HR (95% CI)	
	<u>Breast cancer specific mortality³</u>	<u>All cause mortality⁴</u>	<u>Breast cancer specific mortality³</u>	<u>All cause mortality⁴</u>
Did not link & low % Black	1.00 (0.95-1.05)	0.99 (0.96-1.02)	0.98 (0.78-1.24)	0.87 (0.72-1.06)
Did not link & high % Black	1.12 (0.96-1.32)	1.03 (0.92-1.15)	0.82 (0.66-1.02)	0.89 (0.75-1.05)
Rel Centralization × %Black				
Overall P-value	0.1743	0.2787	0.1242	0.2117
Low seg & low % Black	1.00	1.00	1.00	1.00
Low seg & high % Black	1.04 (0.93-1.15)	1.05 (0.98-1.12)	0.85 (0.71-1.01)	0.91 (0.79-1.05)
Medium seg & low % Black	1.02 (0.95-1.10)	1.01 (0.96-1.06)	0.99 (0.77-1.27)	1.07 (0.88-1.31)
Medium seg & high % Black	0.81 (0.66-0.99)	1.01 (0.89-1.14)	0.75 (0.61-0.92)	0.87 (0.74-1.02)
High seg & low % Black	0.97 (0.92-1.02)	0.99 (0.95-1.02)	0.92 (0.74-1.15)	1.03 (0.86-1.23)
High seg & high % Black	1.03 (0.91-1.16)	1.09 (1.01-1.18)	0.89 (0.73-1.08)	0.96 (0.82-1.12)
Did not link & low % Black	0.99 (0.93-1.04)	0.99 (0.96-1.03)	0.96 (0.75-1.23)	0.89 (0.72-1.09)
Did not link & high % Black	1.11 (0.94-1.31)	1.03 (0.92-1.15)	0.84 (0.66-1.06)	0.93 (0.77-1.11)
Spatial Proximity × %Black				
Overall P-value	0.2015	0.0792	0.1237	0.2350
Low seg & low % Black	1.00	1.00	1.00	1.00
Low seg & high % Black	1.01 (0.93-1.11)	1.06 (1.01-1.13)	0.85 (0.73-0.99)	0.92 (0.81-1.04)
Medium seg & low % Black	0.97 (0.89-1.05)	1.01 (0.96-1.06)	0.88 (0.66-1.18)	1.08 (0.85-1.35)
Medium seg & high % Black	1.10 (0.95-1.27)	1.10 (1.00-1.21)	0.81 (0.68-0.97)	0.88 (0.76-1.01)
High seg & low % Black	1.00 (0.92-1.10)	0.98 (0.92-1.04)	0.86 (0.66-1.12)	0.99 (0.80-1.22)
High seg & high % Black	0.74 (0.57-0.96)	0.88 (0.74-1.04)	0.73 (0.60-0.89)	0.85 (0.73-0.98)
Did not link & low % Black	0.99 (0.95-1.04)	0.99 (0.96-1.03)	0.95 (0.75-1.19)	0.87 (0.72-1.06)
Did not link & high % Black	1.12 (0.95-1.32)	1.03 (0.93-1.15)	0.82 (0.66-1.02)	0.91 (0.77-1.07)
Hypersegregation (2 or more indices) × %Black				
Overall P-value	0.8255	0.2652	0.0366	0.1937
Not hyperseg & low % Black	1.00	1.00	1.00	1.00
Not hyperseg & high % Black	1.01 (0.93-1.10)	1.07 (1.01-1.12)	0.83 (0.72-0.95)	0.89 (0.79-0.99)
Hyperseg & low % Black	1.00 (0.93-1.07)	1.00 (0.96-1.05)	0.80 (0.63-1.01)	0.98 (0.82-1.17)
Hyperseg & high % Black	0.99 (0.84-1.15)	1.04 (0.93-1.15)	0.76 (0.64-0.89)	0.86 (0.76-0.98)
Did not link & low % Black	0.99 (0.95-1.04)	0.99 (0.96-1.03)	0.93 (0.74-1.17)	0.86 (0.71-1.04)
Did not link & high % Black	1.12 (0.95-1.32)	1.03 (0.93-1.16)	0.81 (0.66-1.01)	0.90 (0.76-1.06)

¹ % Black × segregation index = combination variable between % Blacks in block groups and segregation index

² P-value for overall test of significance. Odds ratios for effect difference between each level and the reference. All ORs are adjusted for age at diagnosis, year of diagnosis, marital status, California region of residence, SES index, surgery, ER, and PR.

³ modeling rate of mortality due to breast cancer as underlying cause of death; deaths due to other causes are censored

⁴ modeling rate of mortality due to all causes of death

⁵ excluding individuals living in areas with unknown % Black; “low segregation” = Q1 and Q2 of segregation index; “medium segregation” = Q3; “high segregation” = Q4; “low % Black” = <10% Black; “high % Black” = $\geq$ 10% Black

*
P<.05