Residential Racial Composition, Spatial Access to Care, and Breast Cancer Mortality among Women in Georgia

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ABSTRACT *We explored the association between neighborhood residential racial composition and breast cancer mortality among Black and White breast cancer patients in Georgia and whether spatial access to cancer care mediates this association. Participants included 15,256 women living in 15 metropolitan statistical areas in Georgia who were diagnosed with breast cancer between 1999 and 2003. Residential racial composition was operationalized as the percent of Black residents in the census tract. We used gravity-based modeling methods to ascertain spatial access to oncology care. Multilevel Cox proportional hazards models and mediation analyses were used to test associations. Black women were 1.5 times more likely to die from breast cancer than White women. Residential racial composition had a small but significant association with breast cancer mortality (hazard ratios [HRs]=1.04–1.08 per 10% increase in the percent of Black tract residents). Individual race did not moderate this relationship, and spatial access to care did not mediate it. Residential racial composition may be part of the socioenvironmental milieu that produces increased breast cancer mortality among Black women. However, there is a lack of evidence that spatial access to oncology care mediates these processes.*

KEYWORDS *Breast cancer, Spatial access to health care, Race, Ethnicity, Disparities*

INTRODUCTION

Black–White disparities in breast cancer survival are well-documented and substantial. Although White women have the highest breast cancer incidence among all racial groups in the US, Black women have the highest rates of breast cancer mortality.¹ A growing body of research has explored whether these disparities are produced by biological and other individual-level factors, including racial differences in tumor characteristics, screening rates, timeliness of diagnostic follow-up for breast abnormalities, stage of diagnosis, and receipt of breast cancer treatment.^{2–6}

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These individual-level factors occur in broader socioenvironmental contexts, contexts that may shape patterns of screening, diagnosis, and treatment as well as whether and how cancer progresses. To date, existing research on exogenous environmental risk factors for breast cancer has focused on exposure to pollutants and other toxins,⁷⁻⁹ urban vs. rural differences in risk,¹⁰ and US regional differences in risk.¹⁰⁻¹² Virtually nothing, however, is known about how the *social* environment creates and perpetuates disparities in breast cancer survival and mortality.

It has been hypothesized that residential racial segregation in general and local racial composition in particular produces these disparities.¹³⁻¹⁶ These dimensions of the social environment have well-established relationships to a range of health outcomes,¹⁷⁻¹⁹ including cancer-related outcomes.²⁰ Recent evidence suggests that segregation and local racial composition may also affect disparities in breast cancer outcomes. There are several mechanisms through which residential segregation and local racial composition may affect disparities in breast cancer outcomes, including greater exposure to stressors that promote cancer’s progression and local norms concerning treatment seeking and adherence.^{15,18,21} Health care-related factors are also posited to powerfully mediate this relationship,^{15,16,22} though related evidence is sparse. In a study exploring the role of health care quality, Haas et al. found that residential racial segregation explained some of the Black/White disparity in the adequacy of breast cancer care among seniors, but not mortality.¹⁵ Spatial access to care may also mediate the relationship between residential segregation and local racial composition and breast cancer outcomes.^{15,22} Predominately Black/African-American neighborhoods tend to have poorer spatial access to health care services,²³⁻²⁷ and increased distance and travel time to healthcare providers may be associated with less cancer treatment uptake and poorer cancer outcomes.²⁸⁻³¹

Here, we advance this line of inquiry by exploring the relationships between residential racial composition (RRC) and disparities in breast cancer survival in 15 metropolitan areas in Georgia. As depicted in our conceptual model (see Figure 1), we also investigate whether spatial access to cancer care mediates this relationship and whether individual race moderates it.

METHODS

This multilevel study has two units of analysis: individual women diagnosed with breast cancer and the census tracts where they lived at the time of diagnosis.

FIGURE 1. Conceptual model of the relationship of residential racial composition to Black/White disparities in breast cancer mortality.

Individual-level data were drawn from the Georgia Comprehensive Cancer Registry (GCCR), which is a statewide population-based cancer registry of all cases of cancer diagnosed among residents of Georgia since January 1, 1995. To be eligible for these analyses, women within this database had to have been diagnosed with a primary malignant neoplasm of the breast between January 1, 1999 and December 31, 2003; have at least one racial designation as Black or White regardless of Hispanic/Latino ethnicity (those who identified as multiracial including Black were categorized as Black);¹ have a valid census tract identifier; be 40–85 years of age; and live in one of Georgia's 15 metropolitan statistical areas (MSAs) at the time of diagnosis. From 1999 to 2006, there were only 474 incidence female breast cancer cases among Asians (1.1%) and 692 among Hispanics (Black and White combined; 1.7%). Due to the low incidence in these groups, Asian and Hispanic women were excluded from our analysis. Fifteen thousand two hundred fifty-six women in the GCCR database met these eligibility criteria. All census tracts where these 15,256 women lived were included in the analysis ($N=1,159$).

MEASURES

Our primary dependent variable was postdiagnosis breast-cancer-specific survival time for residents of the 15 MSAs in Georgia. Survival was defined as the interval from the date of diagnosis to the date of death from breast cancer or censoring as of December 31, 2007, the end of the study period. Breast cancer mortality was ascertained using Vital Statistics Records (ICD-9, codes C50.0–50.9), which are linked to the GCCR; death for other reasons were censored at the date of death. Residents of MSA's rather than the state overall were chosen because issues of spatial access to medical care can vary dramatically for rural as compared to metropolitan areas. However, 80% of Black and 76% of White Georgians reside in the studied MSAs.³²

The GCCR database was also the source of all individual-level control variables, including age at diagnosis, marital status, cancer stage at diagnosis (in situ, local, regional, distant, or unstaged) and course of treatment (surgery, no surgery, and unknown).

We used census tracts to approximate the residential environment of each participant.³³ Two tract-level variables were abstracted from the 2000 Decennial Census data: the percent of residents who identified as Black/African American (either alone or in combination with other racial groups, regardless of Hispanic/Latino ethnicity) and the percent of households with residents living below the federal poverty line. The tract-level RRC is the neighborhood component used to measure the metropolitan isolation index, which assesses the residential exposure or isolation of minority communities to other groups across metropolitan space.^{34–36}

We defined “spatial access to cancer care” as the local availability of cancer treatment and care. We focused on *potential* spatial access, which concerns reasonable possible use, rather than *revealed* access, which refers to actual service use because the GCCR does not provide information on the physical address of the specific treatment facilities in which participants received care. Cancer care could be delivered by oncologists in private practice or at academic medical centers and we considered both types of service provision. Medical Marketing Services Inc. (MMS) was used to identify all board-certified oncologists in the state of Georgia in year 2000 and their primary practice address. The MMS list is based on the national database of the American Medical Association and is the most complete list of

physicians available in the USA. A list of academic medical centers was developed through a comprehensive internet search. Each facility and practice location was geocoded to its latitude and longitude from street addresses. While the comprehensive list of oncology practices was available for year 2000 only, we found little difference in practice distribution across the state when more current lists were evaluated. We applied gravity-based modeling (GBM) methods to ascertain spatial access to these facilities for each census tract in our sample. Health geographers commonly use GBM to assess spatial access to health services.^{37–39} This approach models spatial access as a function of service opportunities (number of oncologists at a given location), the road-network drive-time distance from the race-specific population-weighted centroid of each participant's census tract to each potential service opportunity, and a friction parameter which serves as a distance decay impedance factor, providing the greatest access for closest service opportunities.^{40,41} Following Apparicio et al., we compared results using three friction parameters (1, 1.5, and 2) to determine sensitivity of our findings to assumptions of distance decay. Larger friction parameters suggest an assumption of increasing importance of travel distance in determining potential access to oncology care.⁴² The resulting value for each participant represents a *relative* measure of potential spatial access with larger numbers indicating increased access. All geospatial analyses were conducted using ArcGIS 9.3 (Environmental Systems Research Institute, Redlands, CA, USA).

DATA ANALYSIS

We used descriptive statistics to explore the central tendency and dispersion of each individual-level and tract-level variable; chi-square tests were used to quantify Black/White differences in study variables. We applied multilevel Cox proportional hazards models to examine the association of tract-level RRC and breast cancer mortality while accounting for clustering of individuals within tracts using robust standard errors. Survival analysis was appropriate in this context because our goal was to explore the risk of death in women exposed to environments where a higher proportion of residents were Black as compared to those exposed to environments with a lower proportion of Black residents, while accounting for the fact that women may contribute different lengths of time at risk for death (e.g., women diagnosed in 1999 had 8 years of follow-up, whereas women diagnosed in 2002 had only 5).⁴³ Tracts are nested within the 15 MSAs included in our sample. We thus ran models with and without indicator variables for the MSAs. Because effect sizes and confidence intervals (CIs) were similar across these sets of models, we present results of models that excluded these indicators.

We used Baron and Kenny methods to investigate whether spatial access to board-certified oncologists mediated the relationship between percent of tract residents who are Black and breast cancer mortality. We first explored the relationship between percent of tract residents who were Black and mortality; then we explored the relationship between percent of tract residents who were Black and spatial access to oncologists; and finally, we explored the relationship between spatial access to oncologists and mortality. Evidence of mediation is demonstrated by significant findings for all three pathways.⁴⁴ Data were analyzed using R 2.10 software and the survival package.⁴⁵

Finally, we calculated “pseudo” population attributable risk percents (PAR%), which are an estimate of the population-level importance of an exposure. It incorporates both the magnitude of an association (e.g., the hazard ratio) and the

prevalence of that exposure in groups to describe the proportion of overall mortality which could be attributable to exposure. In the current study, PAR% was used to estimate the percent of deaths that would have been prevented in the 15 MSAs during our study period if Black residents had been evenly distributed across tracts within each MSA. Specifically, we classified each participant as residing in a tract that had a lower proportion of Black residents than the MSA overall versus a higher proportion of Black residents. We call these “pseudo” PAR% because true PAR% assume a causal relationship between the exposure and the outcome, and we cannot yet make that assumption.

RESULTS

Table 1 shows the characteristics of the study cohort. Black women tended to have higher breast cancer mortality than White women. They also had a younger mean age at diagnosis and were less likely to be married at diagnosis than White women. They were less likely to be diagnosed with localized tumors and more likely to be diagnosed with regional and distant tumors. Finally, Black women were more likely

TABLE 1 Cohort demographic characteristics and exposures

	Total	White	Black	
Cohort <i>N</i>	15,256	11,775	3,481	<i>P</i> value
Breast cancer deaths/person years	1,737/97,468	1,125/76,837	612/20,631	
Breast cancer mortality rate/1,000 person years	17.8	14.6	29.7	
Mean years of follow-up	6.4	6.5	5.9	
Age at diagnosis (mean)	59.3	60.0	57.1	<0.001
Marital status at diagnosis (%)				
Single	9.6	6.8	19.0	<0.001
Married	58.3	64.1	38.7	
Separated/Divorced/Widowed	32.1	29.1	42.3	
Stage at diagnosis (%)				
In situ	18.5	18.5	18.4	<0.001
Local	49.3	51.7	41.3	
Regional	26.4	24.9	31.4	
Distant	3.6	2.9	6.1	
Unstaged	2.2	2.1	2.7	
Surgery				
None	4.4	3.4	7.5	<0.001
Some surgery	94.2	95.3	90.5	
Unknown	1.5	1.3	2.0	
Tract% Black (mean)	26.8	16.4	61.9	<0.001
Tract% below poverty (mean)	10.5	8.3	17.8	<0.001
Tract per capita income (mean)	\$24,957	\$26,960	\$18,179	<0.001
Gravity access to oncologists (median of log-transformed value) ^a				
Friction parameter=1	−10.1	−10.3	−9.4	<0.001
Friction parameter=1.5	−10.3	−10.5	−9.6	<0.001
Friction parameter=2	−10.7	−10.9	−9.9	<0.001

^aLog-median gravity access is a relative measure of potential spatial access to board-certified oncologists, with larger numbers indicating greater relative access. Friction parameter is user-specified indicator of distance decay rate

to have not had surgery for the treatment of their tumor than White women. Regarding area-level measures, Black compared to White women tended to reside in more impoverished census tracts and to have lower per capita income at the tract level, but to have greater spatial access to oncologists (see Table 1).

Figure 2 depicts spatial access to oncologists and density of Whites and Blacks per square mile in Georgia. The spatial access is greatest in the metropolitan areas with academic medical centers: Atlanta (Emory and Morehouse), Macon (Mercer University), and Augusta (Medical College of Georgia). The density of Whites is relatively homogenous across all metropolitan areas, but the density of Blacks is concentrated in the central portion of each MSA, including Atlanta, Macon, and Augusta. This spatial concentration of Blacks in the urban centers of Georgia cities, combined with the central location of academic medical providers and oncology care, results in apparent increased spatial access of Blacks to oncology care.

Table 2 shows the results of the multilevel Cox proportional hazards model for the association of census tract RRC, participant race, and breast-cancer-specific mortality. From the baseline model, results indicate that census tract RRC has a small but significant relationship with breast cancer mortality such that for each 10% increase in tract percent Black residents, women experience a 7% increased risk of mortality (hazard ratio (HR) 1.07, 95% CI 1.05, and 1.08). As evidenced by the full model, this relationship remains even after controlling for race of the participant and was not moderated by individual race (data not shown). Black women consistently had higher breast cancer mortality even after controlling for stage, surgery status, age at diagnosis, and percent of census tract residents living in poverty (see Table 2).

FIGURE 2. Maps depicting spatial access to oncologists, density of Whites per square mile and density of Blacks per square mile in Georgia MSAs.

TABLE 2 Multilevel cox proportional hazards model for the associations of census tract residential racial composition, participant race, and breast cancer specific mortality

	Baseline/crude ^a			Partially adjusted ^b			Full model ^c		
	HR	95% CI		HR	95% CI		HR	95% CI	
Percent Black ^d	1.07	1.05	1.08				1.03	1.00	1.05
Race (1=Black, 0=White)	1.51	1.35	1.69	1.35	1.20	1.53	1.22	1.06	1.42
Log (poverty rate)	1.23	1.15	1.32	1.15	1.07	1.24	1.10	1.01	1.20

HR hazard ratio, CI confidence interval

^aBaseline/crude models for each predictor are the independent association with mortality controlling only for age, age-squared, cancer stage at diagnosis, and surgery status

^bThe partially adjusted model includes both race and the log of tract poverty rate as well as age, age-squared, cancer stage at diagnosis, and surgery status

^cThe full model adds tract percent Black to the partially adjusted model

^dTract percent Black is transformed such that a one-unit change is equivalent to a 10% change in tract proportion Black

Results from the mediation analysis indicate that tracts with a higher percentage of Black residents have *higher* spatial access to oncology care, as indicated by the positive slope coefficient (Table 3). Correspondingly, Black women on average reside in tracts with higher spatial access, as indicated by larger model intercepts for Black as compared with White women. The patterns were similar regardless of choice of friction parameter. We found no relationship between spatial access to oncology care and breast cancer mortality, after adjusting for age, surgery, stage at diagnosis, and tract poverty. All adjusted hazard ratios ranged from .94 to 1.23 and were nonsignificant (data not shown).

To calculate the pseudo-PAR%, we re-ran the full model (presented in Table 2), and dichotomized the tract-level percent Black as described above. In this revised model, women living in tracts that had “high” percentages of Black residents had higher mortality rates (HR=1.30; 95% CI 1.14, 1.48). We used the HR of 1.30 to calculate the pseudo-PAR%s for Black and White women

TABLE 3 Linear regression of participant potential spatial access to oncology care on census tract percent Black among female patients diagnosed with breast cancer in Georgia from 1999 to 2003

	Intercept	Coefficient	SE	P value
Less distance decay (friction parameter=1)				
All women	−10.29	0.0920	0.0013	<0.0001
White women	−10.26	0.0290	0.0022	<0.0001
Black women	−9.73	0.0437	0.0022	<0.0001
More distance decay (friction parameter=2)				
All women	−11.00	0.1403	0.0031	<0.0001
White women	−11.03	0.1160	0.0056	<0.0001
Black women	−10.43	0.0786	0.0055	<0.0001

Potential spatial access is measured with gravity-based modeling of oncology supply, potential demand (population density), distance from patient to oncology services, and a distance decay function (‘friction parameter’). Resulting values were small and skewed, and thus log-transformed for modeling. Friction of 1 indicates less influence of travel distance on access; friction of 2 is greater influence of travel distance on potential access

separately. These analyses indicate that 5.0% of excess mortality among White women is attributable to living in a tract that has a higher percentage of Black residents than would be expected by the racial distribution in the MSA overall; however, for Black women the excess mortality attributable to residence in such a tract is 18.9%.

DISCUSSION

The goal of this study was to explore the association between RRC and breast cancer mortality among Black and White breast cancer patients in Georgia. Furthermore, we explored whether this association was moderated by individual race and mediated by spatial access to oncology care. Consistent with past research,⁴⁶ our data indicate that Black women diagnosed with breast cancer have higher breast cancer mortality rates than White women. Our results indicate that this disparity may be produced in part by the differing racial compositions of the places where Black and White women live. Controlling for local poverty rates, we found a small but significant positive association between tract-level RRC and breast cancer mortality for both Black and White women who had been diagnosed with breast cancer. Because Black women diagnosed with breast cancer are more likely than their White counterparts to live in tracts with higher percentages of other Black residents, this tract-level characteristic accounted for substantially more excess mortality among Black women than among White women (pseudo-PAR%*s* were 19% and 5%, respectively).

While our findings are consistent with a large body of literature documenting the association of poorer health outcomes with increasing percent of local residents who are Black, and with racial segregation,^{47–56} they run counter to findings from the emerging literature that focuses exclusively on these exposures' relationship to breast cancer mortality. Haas et al.¹⁵ found no relationship between racial segregation (operationalized as isolation) and breast cancer mortality, and Warner and Gomez¹⁶ found an *inverse* relationship between Black neighborhood racial composition and breast cancer mortality among Black women and a positive relationship for White women, controlling for metropolitan segregation. Each study employed a different measure of the distribution of racial groups across space and these measurement differences may account for our diverging findings. Collectively, these three analyses testify to the importance of expanding research into the relationships of local racial composition and segregation to breast cancer mortality, and of carefully considering possible mediators and moderators of these relationships.

To explore the pathways through which neighborhood composition and mortality might be associated, we tested the hypothesis that spatial access to care serves as a mediator. The data failed to support this hypothesis. Black neighborhood composition was associated with increased access to care (not *decreased* access as might be expected), and spatial access to care was not associated with mortality at all. These findings indicate the need to examine spatial access to care in more nuanced and sophisticated ways. We note that most past research on RRC and spatial access to care has not focused on specialized services, like oncology clinics. In post hoc analyses, we investigated the locations of specialized cancer care sites and found that they tended cluster in the MSAs' urban core. This clustering may be produced in part by the presence of academic medical centers in urban core areas where Black metropolitan residents tend to live. Thus,

residents of the urban core may have good spatial access to specialized care and poor spatial access to primary care.

The lack of a relationship between spatial access to cancer care and mortality may speak to the fact that spatial access to care is but one dimension of “health care access.” Even when oncology care is physically close to a patient, distrust of medical providers,⁵⁷ lack of health insurance,^{58,59} poor communication with healthcare providers,⁶⁰ and racial bias in referral patterns or treatment recommendations^{56,61} may serve as insurmountable barriers that prevent spatial access from translating into actual utilization. These findings highlight the need to critically evaluate the role that these other factors play in explaining the relationship between tract-level RRC and breast cancer mortality.

While few studies focus on breast cancer mortality, there is an ongoing debate about the impact of geographic access to breast cancer mammography screenings on access to cancer treatment and care and cancer-related outcomes. This is particularly important because breast cancer outcomes are best when the disease is detected at an early stage.⁴⁸ Our work is consistent with recent studies that have found that spatial access to mammography screening did not significantly affect stage at breast cancer diagnosis in multivariate analyses.^{22,28} In another study, risk of death was associated with an increased travel time to a general practitioner for prostate cancer but not for breast cancer.³⁰ However, findings have been inconclusive. Other studies have found that people who had a greater distance from their residence to mammography facility were diagnosed at a more advanced cancer stage.^{49,50} Other possible mediators include (1) poorer quality of care at facilities that were located near predominately Black areas,⁵¹ and (2) governmental and corporate disinvestment from predominately Black areas that produces increased exposure to hazards and stressors, and diminished access to treatment opportunities.

The issue of quality of care at facilities is of particular concern. There is a growing body of research dedicated to examining whether racial minorities receive treatment or care from the same medical facilities that other racial groups do. Several studies found evidence that racial minorities are more likely to receive care from lower quality facilities than their White counterparts.^{52–54,62} For example, hospital and physician “volume” is thought to be connected to quality of care.⁵⁵ In a recent study where there was an established association between volume and mortality, Black patients in New York City were at a double disadvantage because they were less likely than their White counterparts to use high-volume hospitals and surgeons for breast cancer surgery.⁵² So while our findings indicate that Black women had greater spatial access to oncologists, we were unable to examine the quality of care received from these facilities in relation to breast cancer mortality.

There are several limitations to this study that warrant attention. Some researchers suggest that census tracts may be too arbitrary in terms of their scale and boundaries to explain the mechanism through which local racial composition and segregation impact health outcomes.^{36,63–65} While census tracts are unlikely the ideal measure of experienced residential environment, the high correlation of tract-level exposures and health outcomes⁶⁶ supports their use as neighborhood proxies. Second, our study relied on the GCCR, a pre-existing database, and as such our analyses were subject to the limitations of the original dataset. These limitations included not having actual addresses where participants underwent care or information on whether participants changed their residence or treatment facilities while receiving care. Relatedly, it is likely that individual-level socioeconomic status and health insurance status impact the interrelationships under study as well;

however, we were not able to measure either of these variables because the GCCR did not contain these data for the desired study period.

Despite these limitations, the current study represents an important step towards improving understanding of how the social environment shapes disparities in breast cancer mortality. Clearly, the pathways are complicated. Thus, more multilevel research is needed. Future research should focus on how the quality of healthcare and different dimensions of health care access (i.e., distrust of medical practitioners and health insurance status) impact the relationship between RRC and segregation to breast cancer mortality. Findings from this and future studies can be used to influence the context in which breast cancer treatment and care is delivered.

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