



## Original Contribution

# Individual and Neighborhood Socioeconomic Status in Relation to Breast Cancer Incidence in African-American Women

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Socioeconomic status (SES) for both individuals and neighborhoods has been positively associated with incidence of breast cancer, although not consistently. The authors conducted an assessment of these factors among African-American women, based on data from the Black Women's Health Study, a prospective cohort study of 59,000 African-American women from all regions of the United States. Individual SES was defined as the participant's self-reported level of education, and neighborhood SES was measured by a score based on census block group data for 6 indicators of income and education. Analyses included 1,343 incident breast cancer cases identified during follow-up from 1995 through 2009. In age-adjusted analyses, SES for both individuals and neighborhoods was associated with an increased incidence of estrogen receptor-positive breast cancer. The associations were attenuated by control for parity and age at first birth, and there was no association after further control for other breast cancer risk factors. These findings suggest that the observed associations of breast cancer with SES may be largely mediated by reproductive factors that are associated with both estrogen receptor-positive breast cancer and SES.

African Americans; breast neoplasms; female; residence characteristics; social class

Abbreviations: CI, confidence interval; ER+, estrogen receptor positive; ER-, estrogen receptor negative; SES, socioeconomic status.

Breast cancer incidence rates have been shown to be higher in areas of high socioeconomic status (SES) than in more disadvantaged areas (1–6). A number of observational studies have also found breast cancer incidence to be greater among women with higher individual-level SES (7–9), and this relation appears to be due in part to the distribution of predisposing factors such as late age at first birth, low parity, and menopausal female hormone use (8). It is unclear whether the increased incidence of breast cancer in higher SES neighborhoods is due to characteristics of the neighborhoods themselves or to the fact that greater proportions of women in those areas have high personal-level SES.

Only 2 studies, both of white women, have considered individual-level and neighborhood-level SES simultaneously. In a Wisconsin case-control study of 7,179 cases of

breast cancer and 7,488 controls (10), the odds of having breast cancer were 20% greater in the highest quintile of neighborhood SES relative to the lowest after control for individual-level SES and breast cancer risk factors. In a Massachusetts case-control study of 548 cases and 490 controls, the odds of breast cancer were 30% greater for those living in the wealthiest areas relative to the poorest areas and about 20% greater for those with the highest level of education relative to those with the lowest (11).

At the same levels of education and income, African-American women are more likely than their white counterparts to live in neighborhoods of low SES (12–14). Thus, it may be more feasible to disentangle the individual effects of personal and neighborhood-level SES on breast cancer incidence by studying African-American women. We have

done so based on data from the Black Women's Health Study, a follow-up study of women from across the United States. In addition to assessing overall breast cancer incidence, we assessed estrogen receptor-positive (ER+) and estrogen receptor-negative (ER-) breast cancer separately, because their associations with breast cancer risk factors may differ (15).

## MATERIALS AND METHODS

### Study population

The Black Women's Health Study has been in progress since 1995, when 59,000 African-American women aged 21–69 years from 17 states across the United States enrolled by completing health questionnaires. The median age was 38 years, and more than 80% of the participants were residents of New York, California, Illinois, Georgia, New Jersey, Virginia, Maryland, Louisiana, South Carolina, Indiana, Massachusetts, and the District of Columbia. Follow-up by biennial health questionnaires and by searches of the National Death Index was achieved for 80% of the baseline cohort in the most recent completed round of follow-up. The Boston University Institutional Review Board approved the protocol and reviews the study annually.

### Data

At baseline in 1995, participants provided information on many factors, including medical history, height and current weight, weight at age 18 years, age at menarche, parity, age at first birth, lactation, breast cancer in a first-degree relative, hours per week of vigorous physical activity, alcohol consumption, cigarette smoking, menopausal status, age at menopause, oral contraceptive use, supplemental female hormone use, mammography use, and years of education. Information on risk factors and incident disease was updated through the follow-up questionnaires. In 2003, participants were asked about family income, with categorical choices. Participants' addresses from 1995 through 2007 were linked through geocoding to 2000 US Census block group data on 29 variables representing wealth (e.g., median housing value) and education (e.g., percentage of adults older than 25 who have completed college) by a commercial firm shown to geocode accurately (16).

From a factor analysis of all 29 variables, we selected the 6 variables with the highest factor loadings to represent neighborhood SES. The variables selected (with their factor loading values) were as follows: median household income, 0.84; median housing value, 0.60; percentage of households receiving interest, dividend, or net rental income, 0.89; percentage of adults 25 years or older that have completed college, 0.91; percentage of employed persons aged 16 years or older that are in occupations classified as managerial, executive, or professional specialty, 0.85; and percentage of families with children that are not headed by a single female, 0.79. The factor loadings were used to weight the variables and sum them for an overall neighborhood SES score, with higher scores signifying higher neighborhood SES (17).

### Analytical sample and breast cancer cases

The present analyses are based on follow-up from 1995 through 2009. We excluded 1,462 women who at baseline reported a history of any cancer (except nonmelanoma of the skin), 112 women with a missing value for years of education, and 1,531 women whose addresses could not be geocoded, leaving 55,896 women in the analytical cohort. Diagnoses of women who reported breast cancer were validated through hospital pathology data and state cancer registry data. To date, records have been obtained for 85% of reported cases, of which 99% have been confirmed. Of the 1,406 confirmed cases of breast cancer (including both invasive and ductal carcinoma in situ), we were successful in geocoding 1,343 and linking them to year 2000 census data. Information on estrogen receptor status was available for 1,006 cases; the cases with data on estrogen receptor status were similar to cases without such data with respect to prevalence of breast cancer risk factors (18).

### Statistical analysis

Each participant contributed person-time from March 1995 until the diagnosis of breast cancer, death, loss to follow-up, or the end of observation (March 2009), whichever came first. The neighborhood SES variable was updated for each 2-year questionnaire cycle so that, if a participant moved, her SES score would reflect the new neighborhood. We estimated incidence rate ratios with 95% confidence intervals using generalized estimating equations that take into account possible clustering within neighborhoods (19). Model 1 controlled for age (1-year intervals) and time period (2-year intervals) only. Model 2 additionally controlled for parity (0, 1, 2,  $\geq 3$  births) and age at first birth (<20, 20–24,  $\geq 25$  years); these are the reproductive variables most strongly associated with breast cancer risk and also associated with SES. We hypothesized that they might be mediators of an association of SES with breast cancer risk. Model 3 additionally controlled for other factors that might explain any remaining association: the alternate SES variable (neighborhood SES for analyses of individual SES and vice versa) and lactation (never/ever); age at menarche (<12, 12–13,  $\geq 14$  years); history of breast cancer in a mother or sister; oral contraceptive use (never, use in previous 5 years, use  $\geq 5$  years previously); age at menopause (premenopausal, <45, 45–49,  $\geq 50$  years); menopausal female hormone use (never, <5 years of use,  $\geq 5$  years of use); body mass index (<25, 25–29,  $\geq 30$  kg/m<sup>2</sup>); vigorous exercise (none, <5,  $\geq 5$  hours/week); alcohol consumption (<1, 1–6,  $\geq 7$  drinks/week); geographic region (Northeast, South, Midwest, West); and mammography use within the previous 2 years (yes/no). Women who reported a hysterectomy but retained one or both ovaries were classified as premenopausal if their current age was less than the 10th percentile of age at natural menopause in the Black Women's Health Study (<43 years), as postmenopausal if their age was greater than the 90th percentile of age at natural menopause in the cohort ( $\geq 57$  years), and as having unknown age at menopause if their age was 43–56 years. The Anderson–Gill data structure was used to update all time-varying covariates.

**Table 1.** Age-standardized Baseline Characteristics According to Individual Educational Level and Neighborhood Socioeconomic Status Score, Black Women's Health Study, 1995

Characteristic	Education				Socioeconomic Status Score			
	≤12 Years		≥16 Years		Quintile 1 (Low)		Quintile 5 (High)	
	Mean	%	Mean	%	Mean	%	Mean	%
Age, years	41.9		38.5		39.1		39.4	
Age at menarche, years	12.4		12.3		12.4		12.3	
Body mass index at age 18 years <sup>a</sup>	21.7		21.3		22.1		20.9	
Body mass index at baseline	29.0		27.2		29.4		26.5	
Geographic region <sup>b</sup>								
Northeast		30.6		27.8		26.7		25.7
South		31.6		31.3		30.1		25.6
Midwest		22.7		23.1		32.8		21.0
West		15.1		17.8		10.5		27.6
Mammogram within previous 2 years		78.5		84.1		76.7		84.8
Family history of breast cancer		6.5		6.5		6.7		6.4
Nulliparous		20.4		46.6		27.3		43.6
Parity ≥3		31.2		12.6		27.6		13.8
Age at first birth ≤20 years among parous		53.2		18.9		45.0		22.9
Ever breastfed among parous		27.1		50.7		32.0		51.5
Ever oral contraceptive use		70.5		78.0		72.1		78.7
Ever menopausal female hormone use		15.6		14.8		15.5		15.6
Vigorous exercise ≥5 hours/week		10.8		14.5		11.3		16.0
Alcohol consumption ≥4 drinks/week		15.9		10.3		13.8		12.6
Education ≤12 years						32.4		8.1
Education ≥16 years						27.1		64.9

<sup>a</sup> Body mass index: weight (kg)/height (m)<sup>2</sup>.

<sup>b</sup> All percents are column percents.

Tests for trend were carried out by inclusion of an ordinal variable for increasing categories of the SES variable.

## RESULTS

Table 1 shows breast cancer risk factors and other covariates according to individual level of education and neighborhood SES score. A high level of education was associated with a high neighborhood SES score; however, even among women in the lowest quintile of neighborhood SES, an appreciable proportion, 27.1%, had ≥16 years of education. The SES for both individuals and neighborhoods was inversely associated with high parity and positively associated with later age at first birth and having breastfed. In addition, women with higher SES were more likely to have a lower body mass index, to have used oral contraceptives, to exercise more, and to have had a recent mammogram. There was little clustering within census block groups in the present study: The median number of individuals per census block was 1.

Table 2 presents the relation of years of education to the incidence of breast cancer overall and by estrogen receptor status. Educational level was positively associated with the overall incidence of breast cancer when only age and time

period were controlled (model 1): incidence rate ratio = 1.17 (95% confidence interval (CI): 0.99, 1.37) for ≥17 relative to ≤12 years of education ( $P_{\text{trend}} = 0.03$ ). The association with overall incidence was largely accounted for by a positive association with ER+ breast cancer: the incidence rate ratio (model 1) for ER+ breast cancer was 1.44 (95% CI: 1.14, 1.82) for ≥17 years of education relative to ≤12 years ( $P_{\text{trend}} < 0.002$ ). After additional control for parity and age at first birth (model 2), the incidence rate ratio for the association with ER+ breast cancer was attenuated to 1.25 (95% CI: 0.97, 1.60) ( $P_{\text{trend}} = 0.10$ ), and it was attenuated further to 1.14 (95% CI: 0.88, 1.48) ( $P_{\text{trend}} = 0.37$ ) after control for other breast cancer risk factors and neighborhood SES score (model 3). There was little association of educational level with incidence of ER- cancer: The incidence rate ratio for ≥17 years of education relative to ≤12 years was 1.02 (95% CI: 0.73, 1.41) ( $P_{\text{trend}} = 0.93$ ) after control for age and time period only. Control for breast cancer risk factors resulted in an incidence rate ratio of 1.00. Results were similar among premenopausal and postmenopausal women (data not shown).

Table 3 shows the relation of quintile of neighborhood SES score to the incidence of breast cancer overall and by

**Table 2.** Educational Level in Relation to Breast Cancer Incidence Overall and by Estrogen Receptor Status, Black Women's Health Study, 1995–2009

Breast Cancer by Years of Education	No. of Cases	Person-Years	IRR <sup>a</sup>	95% CI	IRR <sup>b</sup>	95% CI	IRR <sup>c</sup>	95% CI
All								
≤12	272	123,622	1.00	Referent	1.00	Referent	1.00	Referent
13–15	431	240,715	1.03	0.89, 1.20	1.01	0.86, 1.18	1.00	0.85, 1.17
16	286	163,691	1.10	0.93, 1.30	1.02	0.86, 1.21	0.99	0.83, 1.18
≥17	354	146,462	1.17	0.99, 1.37	1.06	0.90, 1.25	1.02	0.86, 1.21
<i>P</i> <sub>trend</sub>				0.03		0.45		0.85
ER+								
≤12	112	123,356	1.00	Referent	1.00	Referent	1.00	Referent
13–15	197	240,334	1.17	0.92, 1.48	1.13	0.89, 1.43	1.08	0.85, 1.38
16	132	163,437	1.26	0.98, 1.63	1.13	0.87, 1.47	1.05	0.81, 1.38
≥17	180	146,169	1.44	1.14, 1.82	1.25	0.97, 1.60	1.14	0.88, 1.48
<i>P</i> <sub>trend</sub>				0.002		0.10		0.37
ER–								
≤12	65	123,276	1.00	Referent	1.00	Referent	1.00	Referent
13–15	124	240,213	1.15	0.85, 1.55	1.14	0.84, 1.55	1.13	0.83, 1.54
16	77	163,340	1.12	0.81, 1.54	1.11	0.79, 1.57	1.09	0.77, 1.54
≥17	77	146,005	1.02	0.73, 1.41	1.02	0.72, 1.44	1.00	0.70, 1.43
<i>P</i> <sub>trend</sub>				0.93		0.93		0.84

Abbreviations: CI, confidence interval; ER+, estrogen receptor positive; ER–, estrogen receptor negative; IRR, incident rate ratio.

<sup>a</sup> Control for age and time period.

<sup>b</sup> Control for age, time period, parity, and age at first birth.

<sup>c</sup> Control for age, time period, parity, age at first birth, lactation, age at menarche, family history of breast cancer, age at menopause, oral contraceptive use, menopausal female hormone use, body mass index, vigorous exercise, alcohol consumption, region, mammography use, and neighborhood socioeconomic status score.

estrogen receptor status. Neighborhood SES score was not associated with overall breast cancer incidence ( $P_{\text{trend}} = 0.49$ ) (model 1) but was associated with ER+ breast cancer: The incidence rate ratio was 1.33 (95% CI: 1.03, 1.71) for quintile 5 (highest SES score) relative to quintile 1 (lowest SES score) with control for age and time period ( $P_{\text{trend}} = 0.02$ ). Additional control for age at first birth and parity (model 2) reduced the estimate to 1.20 (95% CI: 0.93, 1.55) ( $P_{\text{trend}} = 0.14$ ), and control for other breast cancer risk factors and level of education (model 3) further weakened the association: Incidence rate ratio = 1.08 (95% CI: 0.82, 1.41) ( $P_{\text{trend}} = 0.59$ ). In an analysis in which we controlled for household income in 2003, the results were closely similar. For ER– breast cancer, the incidence rate ratio for the highest quintile of neighborhood SES score relative to the lowest was 0.81 (95% CI: 0.58, 1.13) in the age-adjusted model. After control for all risk factors, the estimate was 0.76 (95% CI: 0.53, 1.08) ( $P_{\text{trend}} = 0.15$ ).

## DISCUSSION

The present study is the first to consider both individual and neighborhood level of SES in relation to breast cancer

incidence in African-American women. Both measures of SES were positively associated with ER+ breast cancer in age-adjusted models. After control for the 2 risk factors that were most strongly associated with both SES and breast cancer in the Black Women's Health Study, parity and age at first birth, the associations of SES with ER+ cancer incidence were weaker and not statistically significant. Further control for additional breast cancer risk factors brought the incidence rate ratios even closer to the null.

Previous reports focusing on the relation of SES to breast cancer incidence have not stratified by estrogen receptor status. The ER+ breast cancer subtype is less common among African-American women than among women from any other race/ethnicity group (20). This difference may explain why stronger positive associations of SES with overall breast cancer incidence were observed in previous studies of white women than in the present study of African-American women.

With regard to neighborhood SES, the 2 previous studies that examined both individual and neighborhood SES in relation to breast cancer incidence found a positive association of neighborhood SES with breast cancer risk after control for individual-level SES and other risk factors (10, 11).

**Table 3.** Neighborhood socioeconomic status score in relation to breast cancer incidence overall and by estrogen receptor status, Black Women's Health Study, 1995–2009

Breast Cancer by Quintile of Score	No. of Cases	Person-Years	IRR <sup>a</sup>	95% CI	IRR <sup>b</sup>	95% CI	IRR <sup>c</sup>	95% CI
All								
1	259	131,454	1.00	Referent	1.00	Referent	1.00	Referent
2	268	133,685	1.04	0.88, 1.24	1.02	0.86, 1.21	1.01	0.85, 1.19
3	266	136,144	1.07	0.90, 1.26	1.03	0.87, 1.22	1.01	0.85, 1.21
4	282	136,906	1.13	0.95, 1.33	1.08	0.91, 1.28	1.05	0.88, 1.24
5	268	136,300	1.03	0.87, 1.22	0.96	0.81, 1.14	0.92	0.77, 1.10
<i>P</i> <sub>trend</sub>				0.49		0.87		0.54
ER+								
1	106	131,205	1.00	Referent	1.00	Referent	1.00	Referent
2	123	133,447	1.17	0.90, 1.52	1.13	0.87, 1.47	1.10	0.85, 1.43
3	120	135,900	1.17	0.90, 1.52	1.11	0.85, 1.45	1.06	0.81, 1.39
4	131	136,658	1.29	1.00, 1.67	1.21	0.94, 1.56	1.13	0.87, 1.46
5	141	136,086	1.33	1.03, 1.71	1.20	0.93, 1.55	1.08	0.82, 1.41
<i>P</i> <sub>trend</sub>				0.02		0.14		0.59
ER–								
1	73	131,152	1.00	Referent	1.00	Referent	1.00	Referent
2	70	133,361	0.95	0.69, 1.32	0.96	0.69, 1.32	0.92	0.67, 1.28
3	69	135,814	0.95	0.69, 1.32	0.96	0.69, 1.33	0.91	0.66, 1.27
4	70	136,557	0.95	0.69, 1.33	0.95	0.67, 1.33	0.90	0.64, 1.26
5	61	135,950	0.81	0.58, 1.13	0.79	0.56, 1.11	0.76	0.53, 1.08
<i>P</i> <sub>trend</sub>				0.27		0.22		0.15

Abbreviations: CI, confidence interval; ER+, estrogen receptor positive; ER–, estrogen receptor negative; IRR, incident rate ratio.

<sup>a</sup> Control for age and time period.

<sup>b</sup> Control for age, time period, parity, and age at first birth.

<sup>c</sup> Control for age, time period, parity, age at first birth, lactation, age at menarche, family history of breast cancer, age at menopause, oral contraceptive use, menopausal female hormone use, body mass index, vigorous exercise, alcohol consumption, region, mammography use, and years of education.

Their methods were similar to the methods used in the present study: Level of education was used to measure individual SES, and a composite variable was used to measure neighborhood SES (10, 11). However, although the larger of the 2 studies included detailed terms for parity and age at first birth, the smaller study controlled for these factors with a combined variable that had only 3 levels: nulliparous; parous and first birth before age 30; and parous with first birth at age 30 years or older. Over 80% of the parous women had their first birth before age 30 years. Thus, there may have been residual confounding from age at first birth and parity. In addition, the correlation of individual SES with neighborhood SES differs between white and black Americans. As a result of the legacy of racial segregation, black Americans tend to live in poorer neighborhoods than white Americans regardless of their own level of education and wealth (12–14). The stronger correlation of individual SES with neighborhood SES among whites may have made adequate control for confounding by factors related

to individual SES (e.g., parity and age at first birth) difficult in the previous studies.

In contrast to the findings for ER+ cancer, there was little evidence in the present study of a positive association of ER– cancer incidence with individual or neighborhood SES. Specifically, there were a weak positive association of ER– cancer with level of education and a weak inverse association with neighborhood SES, neither of which was statistically significant.

Strengths of the present study include the large sample size, the prospective design that minimized reporting bias, control for important breast cancer risk factors, and the assessment of breast cancer by hormone receptor status. There is no “gold standard” for characterization of neighborhood SES (21). Of note, neighborhood SES as characterized in the present study has been significantly associated with 2 other outcomes in the Black Women's Health Study, weight gain (22) and type 2 diabetes (23), in the expected directions. Educational attainment was used as

a marker of individual SES in our study; previous research indicates that level of education is a strong correlate of individual level of SES in African Americans (24). Nevertheless, it is possible that different findings could result if individual SES were better characterized.

In sum, in the present study of African-American women, individual educational level and neighborhood SES were positively associated with incidence of ER+ breast cancer but not ER- breast cancer. Parity and age at first birth were the primary factors mediating the association.

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Conflict of interest: none declared.

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