Research Article

Cancer Epidemiology, Biomarkers & Prevention

Impact of Neighborhood and Individual Socioeconomic Status on Survival after Breast Cancer Varies by Race/Ethnicity: The Neighborhood and Breast Cancer Study

Salma Shariff-Marco[1,2], Juan Yang[1], Esther M. John[1,2], Meera Sangaramoorthy[1], Andrew Hertz[1], Jocelyn Koo[1], David O. Nelson[1,2], Clayton W. Schupp[1], Sarah J. Shema[1], Myles Cockburn[3], William A. Satariano[4], Irene H. Yen[5], Ninez A. Ponce[6], Marilyn Winkleby[2], Theresa H.M. Keegan[1,2], and Scarlett L. Gomez[1,2]

Abstract

Background: Research is limited on the independent and joint effects of individual- and neighborhood-level socioeconomic status (SES) on breast cancer survival across different racial/ethnic groups.

Methods: We studied individual-level SES, measured by self-reported education, and a composite neighborhood SES (nSES) measure in females (1,068 non-Hispanic whites, 1,670 Hispanics, 993 African-Americans, and 674 Asian-Americans), ages 18 to 79 years and diagnosed 1995 to 2008, in the San Francisco Bay Area. We evaluated all-cause and breast cancer–specific survival using stage-stratified Cox proportional hazards models with cluster adjustment for census block groups.

Results: In models adjusting for education and nSES, lower nSES was associated with worse all-cause survival among African-Americans ($P_{trend} = 0.03$), Hispanics ($P_{trend} = 0.01$), and Asian-Americans ($P_{trend} = 0.01$). Education was not associated with all-cause survival. For breast cancer–specific survival, lower nSES was associated with poorer survival only among Asian-Americans ($P_{trend} = 0.01$). When nSES and education were jointly considered, women with low education and low nSES had 1.4 to 2.7 times worse all-cause survival than women with high education and high nSES across all races/ethnicities. Among African-Americans and Asian-Americans, women with high education and low nSES had 1.6 to 1.9 times worse survival, respectively. For breast cancer–specific survival, joint associations were found only among Asian-Americans with worse survival for those with low nSES regardless of education.

Conclusions: Both neighborhood and individual SES are associated with survival after breast cancer diagnosis, but these relationships vary by race/ethnicity.

Impact: A better understanding of the relative contributions and interactions of SES with other factors will inform targeted interventions toward reducing long-standing disparities in breast cancer survival. *Cancer Epidemiol Biomarkers Prev; 23(5); 793–811. ©2014 AACR.*

Introduction

Breast cancer is the second leading cancer cause of death in the United States (1). Despite significant improvements in breast cancer survival over the past few decades, racial/ethnic and socioeconomic disparities persist, with African-American, American Indian/Alaska Native, and low-income women having worse survival after diagnosis (1–5). An individual's socioeconomic status (SES) may influence survival through material and social resources, including access to and quality of health care, and lifestyle risk factors (3, 5). Neighborhood SES (nSES) may influence survival through features of the physical (e.g., goods, services, pollutants) and social (e.g., cohesion, collective efficacy, support, stress, coping) environment (6–8). Understanding individual-level and neighborhood-level SES associations with survival can identify potential explanatory pathways for informing strategies to reduce these disparities.

Lower nSES (9–13) and lower individual-level SES (e.g., education, income, wealth; refs. 14 and 15) have each been associated with worse survival after breast cancer diagnosis. Studies that have examined both individual-level and neighborhood-level SES have found either only nSES (16, 17), only individual-level SES (8), both measures (18), or the interactions between the 2 measures (19) to be

Authors' Affiliations: [1]Cancer Prevention Institute of California, Fremont; [2]Stanford University, School of Medicine, Stanford; [3]University of Southern California, School of Medicine, Los Angeles; [4]University of California, Berkeley School of Public Health, Berkeley; [5]University of California, San Francisco School of Medicine, San Francisco; and [6]University of California, Los Angeles School of Public Health and Center for Health Policy Research, Los Angeles, California

Corresponding Author: Salma Shariff-Marco, Research Scientist, Cancer Prevention Institute of California, 2201 Walnut Avenue, Suite 300, Fremont, CA 94538. Phone: 510-608-5276; Fax: 510-608-5085; E-mail: salma.shariff-marco@cpic.org

doi: 10.1158/1055-9965.EPI-13-0924

associated with survival. These mixed findings may partly be because of the variation across studies in racial/ethnic composition of the samples, geographic regions, geographic levels used to assess nSES, and measures of SES, or residual confounding and selection bias. Furthermore, prior studies have had limited racial/ethnic diversity, often including non-Hispanic whites and/or African-Americans only (8, 17, 18), and used larger and more heterogeneous geographic units as proxies for residential neighborhoods. The emerging literature on the differential effects of SES on health across population subgroups also may contribute to the mixed results (20–22).

We examined race/ethnicity-specific independent and joint associations of individual education and nSES with survival after breast cancer diagnosis using data from the Neighborhood and Breast Cancer (NABC) study which pooled neighborhood and cancer registry data with interview data from 2 multiethnic population-based studies in the San Francisco Bay Area.

Materials and Methods

Study population

NABC includes female patients with breast cancer from 2 epidemiologic studies, the San Francisco Bay Area Breast Cancer Study (SFBCS) and the Northern California Breast Cancer Family Registry (NC-BCFR). Both studies included patients identified through the Greater Bay Area Cancer Registry (GBACR), which participates in the NCI Surveillance, Epidemiology, and End Results (SEER) Program and the California Cancer Registry (CCR). Interview data from the 2 studies were harmonized and merged with CCR data and neighborhood data from the California Neighborhoods Data System (23). The protocols for the 2 parent studies and the NABC study were approved by the Cancer Prevention Institute of California Institutional Review Board.

The SFBCS is a population-based case–control study among women ages 35 to 79 years and residing in Alameda, Contra Costa, San Mateo, San Francisco, or Santa Clara counties at the time of diagnosis (24, 25). Eligible cases newly diagnosed with a first primary invasive breast cancer included all Hispanics diagnosed between April 1, 1995 and April 30, 2002, and all African-Americans and a random 10% sample of non-Hispanic whites diagnosed between April 1, 1995 and April 30, 1999.

The NC-BCFR is a family study that is part of the NCI-funded Breast Cancer Family Registry (26, 27), and included newly diagnosed invasive breast cancer cases ages 18 to 64 years who lived in Alameda, Contra Costa, Marin, San Mateo, San Francisco, Santa Clara, Santa Cruz, and Monterey counties at the time of diagnosis. The study included cases of any race/ethnicity diagnosed from January 1, 1995 to September 30, 1998; Hispanic, African-American, Chinese, Filipina, and Japanese diagnosed from October 1, 1998 to April 30, 2002; and Hispanic and African-American diagnosed from May 1, 2002 to December 31, 2009. Cases were eligible for the NC-BCFR if they had indicators of increased genetic susceptibility (i.e., diagnosis before age 35 years, personal history of ovarian or childhood cancer, bilateral breast cancer with a first diagnosis before age 50 years, or a first-degree family history of breast, ovarian, or childhood cancer). Cases not meeting these criteria (sporadics) were randomly sampled (2.5% of non-Hispanic whites and 33% of other racial/ethnic groups because NC-BCFR focused on minority breast cancer families).

Both studies screened cases by telephone to assess study eligibility, with 84% participation among those contacted. In the SFBCS, 2,571 cases were eligible, and 2,258 (88%) completed the in-person interview, with similar response rates in Hispanics (88%), African-Americans (87%), and non-Hispanic whites (86%). In the NC-BCFR, 4,708 eligible cases were selected for the family study that involved an in-person interview, assistance with recruiting family members, and annual follow-up. Of these, 3,631 (77%) enrolled in the study and completed the interview, with similar response rates in African-Americans (82%), non-Hispanic whites (80%), Hispanics (78%), and Asian-Americans (73%).

For 339 participants that were in both studies, we used data from the SFBCS interview. Our analytic sample included participants with a first primary invasive breast cancer, who completed the questionnaire themselves, had a geocodeable address and follow-up information from the CCR. We excluded participants of American Indian/Alaska Native or mixed race/ethnicity ($n = 11$), or unknown education ($n = 36$). The 4,369 breast cancer cases were interviewed on average 21.0 months (SD = 11.1) after diagnosis.

Data collection and follow-up

In-person interviews were conducted in English, Spanish, Mandarin, or Cantonese using similar structured questionnaires on breast cancer risk factors (24–26). CCR data included age and year at diagnosis, American Joint Committee on Cancer (AJCC) stage, histology, grade, tumor size, nodal status, estrogen receptor (ER), and progesterone receptor (PR) status, first course of treatment (surgery, radiation, chemotherapy), subsequent tumors, and marital status. The CCR obtains vital status and underlying cause of death through hospital follow-up and linkages to vital statistics, death records, and other databases. CCR data were used to create hospital-level indicators of percent of patients with cancer in highest nSES quintile and percent of patients with cancer by race/ethnicity.

Participants' addresses at time of diagnosis were geocoded to a latitude/longitude coordinate and then assigned a census block group (average of 1,500 residents with range of 600 to 3,000) for 98% of our sample, and address at interview were used for the remaining. Addresses were standardized to conform to U.S. Postal Service specifications using ZP4 software (ZP4; Semaphore Corp., 2011). Batch geocoding was performed using ArcGIS 10.0 (ArcGIS, Version 10; Environmental Systems

Research Institute, Inc., 2011). Extensive efforts were made to review addresses that did not batch geocode, resulting in assigning 97% of residences to a latitude and longitude.

Analytic variables

Individual-level SES was measured using self-reported education categorized into 4 levels: less than high school, high school degree or equivalent, vocational/technical degree or some college, college degree, or graduate school. NSES was based on a composite SES measure created by principal component analysis and comprising Census 2000 indicator variables at the block group level: education index (among individuals age $\geq$25 years: proportion with college, high school, or less than high school weighted by 16, 12, or 9 respectively; ref. 28), proportion with a blue collar job, proportion older than age 16 years without a job, median household income, proportion below 200% of the poverty line, median rent, median house value (29). This nSES index was categorized into statewide quintiles. Because of small numbers, the 2 lowest SES quintiles were combined for non-Hispanic whites and Asian-Americans. We also created a combination variable using binary indicators for education and nSES. Low education was defined as having a high school degree or less, and high education as having at least a vocational/technical degree or some college; low nSES included quintiles 1 to 3 and high nSES, quintiles 4 to 5.

Breast cancer deaths were identified from the underlying cause of death listed on the death certificate [ICD-9 (30) or ICD-10 (31) codes 174–175 and C50, respectively]. Survival time was calculated in days from the date of diagnosis to date of death from breast cancer or from any cause, date of last known contact, or December 31, 2009 (the end of the study period), whichever occurred first. Of the 3,463 patients alive at the end of the study period, 97% had a follow-up date in the last year of the study. On average, patients were followed for 7.4 years (SD = 3.8) after diagnosis.

Analysis

To assess associations of education and nSES variables with survival, we used multivariate stage-stratified Cox proportional hazards regression models, with cluster adjustment for block groups, to compute relative rates (HR) of dying from any cause or from breast cancer. The sandwich estimator of the covariance structure, applied to Cox proportional hazards regression models by Lin and Wei and utilized here in the SAS PHREG procedure, accounts for the intracluster dependence and yields robust standard error estimates even under model misspecification (32). Over 70% of block groups in this study had only one participant across the racial/ethnic strata. The assumption of proportional hazards was checked by including interactions with time and assessing their significance using likelihood ratio tests and confirmed, except for AJCC stage, for which the proportionality did not hold. All Cox models were thus stratified on stage allowing the baseline hazards within each model to vary by stage. We checked for and did not detect any effect modification by study type (SFBCS, high-risk NC-BCFR, sporadic NC-BCFR); all models were adjusted for study type. Analyses were conducted using SAS (version 9.3). We also tested for spatial autocorrelation with Moran I and found no evidence of it.

Base models were adjusted for age at diagnosis, year of diagnosis, study, tumor characteristics, treatment, and subsequent tumors. We considered modeling year of diagnosis using categorical intervals and found a consistent gradient of lower mortality over time, which suggests that year of diagnosis has a linear effect on both all-cause and breast cancer–specific mortality in our study; therefore, we have modeled year of diagnosis linearly. Linear trends for education and nSES in these models were assessed using the P-values associated with the significance of these ordinal variables (33). We are cautious in our interpretation of P-values for linear trends and only report on significant P_{trend}s in the absence of significant main associations when we see a consistent trend with increasing or decreasing HRs across the levels of our ordinal variables. We consider these suggestive of a dose–response relationship between the SES measure and survival.

To assess their relative impact on the associations between SES and survival, additional sets of prognostic factors that may be important mediators were added to the base model if they were independently associated with survival: (i) personal and reproductive risk factors, including history of benign breast disease, years since last full-term pregnancy, use of hormonal contraception, use of menopausal hormone therapy; (ii) marital status; (iii) behavioral factors, including alcohol consumption in the year before diagnosis, prediagnostic body mass index [BMI, calculated as self-reported weight (in kg) in the year before diagnosis divided by height (in m) squared based on measured height for SFBCS participants or self-reported height for NC-BCFR participants], recent recreational physical activity (hours per week during the 3 years before diagnosis; ref. 34); and (iv) hospital characteristics.

Results

Non-Hispanic white women were more likely than other groups to be diagnosed with stage I disease, or ER/PR–positive tumors, be nulliparous, or have a history of benign breast disease, or hormone therapy use (Table 1). They were also more likely to be seen in hospitals with proportionally more white or higher SES patients. African-American women were more likely to have had a lumpectomy, ER- and PR-negative tumors, be overweight or obese, and less likely to have been married. Hispanic women were more likely to be overweight or obese and report no recent recreational physical activity, and less likely to be nulliparous. Asian-American women were

Table 1. Characteristics of NABC patients with breast cancer ($N = 4,639$), San Francisco Bay Area, 1995 to 2008

	Non-Hispanic white *n* (%)	African-American *n* (%)	Hispanic *n* (%)	Asian-American *n* (%)	Chi-square *P*-value	Total *n* (%)
Total patients	1,067	988	1,642	672		4,369
Number of deaths						
All-cause	277	280	257	92		906
Breast cancer–specific	157 (57)	173 (62)	162 (63)	75 (82)		567 (63)
Study					<0.01	
NC-BCFR high risk	448 (42)	241 (24)	337 (21)	259 (39)		1,285 (29)
NC-BCFR sporadic	99 (9)	293 (30)	365 (22)	413 (62)		1,170 (27)
SFBCS	520 (49)	454 (46)	940 (57)	0 (0)		1,914 (44)
Age at diagnosis (years)					<0.01	
<30	19 (2)	11 (1)	29 (2)	14 (2)		73 (2)
30–34	79 (7)	32 (3)	69 (4)	48 (7)		228 (5)
35–39	52 (5)	53 (5)	139 (9)	55 (8)		299 (7)
40–44	100 (9)	121 (12)	229 (14)	115 (17)		565 (13)
45–49	153 (14)	162 (16)	297 (18)	127 (19)		739 (17)
50–54	171 (16)	180 (18)	238 (15)	119 (18)		708 (16)
55–59	157 (15)	142 (14)	241 (14)	106 (16)		646 (15)
60–64	149 (14)	152 (15)	193 (12)	88 (13)		582 (13)
65+	187 (18)	135 (14)	207 (13)	0 (0)		529 (12)
AJCC stage					<0.01	
I	535 (50)	398 (40)	685 (42)	291 (43)		1,909 (44)
II	429 (40)	449 (45)	742 (45)	319 (48)		1,939 (44)
III	53 (5)	80 (8)	143 (9)	32 (5)		308 (7)
IV	17 (2)	25 (3)	24 (2)	13 (2)		79 (2)
Unknown	33 (3)	36 (4)	48 (3)	17 (3)		134 (3)
Nodal involvement					<0.01	
No	694 (65)	576 (58)	968 (59)	397 (59)		2,635 (60)
Yes	323 (30)	363 (37)	627 (38)	255 (38)		1,568 (36)
Unknown	50 (5)	49 (5)	47 (3)	20 (3)		166 (4)
Histology					0.19	
Ductal	839 (79)	786 (80)	1299 (79)	551 (82)		3,475 (80)
Lobular	151 (14)	112 (11)	212 (13)	72 (11)		547 (12)
Other	77 (7)	90 (9)	131 (8)	49 (7)		347 (8)
Histologic grade					<0.01	
1	192 (18)	125 (13)	243 (15)	85 (13)		645 (15)
2	423 (40)	314 (32)	592 (36)	278 (41)		1,607 (37)
3 and 4	324 (30)	437 (44)	654 (40)	252 (38)		1,667 (38)
Unknown	128 (12)	112 (11)	153 (9)	57 (9)		450 (10)
Estrogen and progesterone receptor status					<0.01	
ER and/or PR negative	160 (15)	261 (26)	378 (23)	127 (19)		926 (21)
ER/PR positive	796 (75)	627 (64)	1,122 (68)	476 (71)		3,021 (69)
Unknown	111 (10)	100 (10)	142 (9)	69 (10)		422 (10)
Surgery[a]					<0.01	
None	10 (1)	40 (4)	29 (2)	12 (2)		91 (2)
Lumpectomy	581 (55)	592 (60)	899 (55)	317 (47)		2,389 (55)
Mastectomy	475 (45)	356 (36)	714 (44)	343 (51)		1,888 (43)
Radiation					<0.01	
No	421 (40)	398 (40)	656 (40)	322 (48)		1,797 (41)
Yes	646 (61)	590 (60)	986 (60)	350 (52)		2,572 (59)

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Table 1. Characteristics of NABC patients with breast cancer ($N = 4,639$), San Francisco Bay Area, 1995 to 2008 (Cont'd)

	Non-Hispanic white *n* (%)	African-American *n* (%)	Hispanic *n* (%)	Asian-American *n* (%)	Chi-square *P*-value	Total *n* (%)
Chemotherapy					<0.01	
No	545 (51)	453 (46)	660 (40)	248 (37)		1,906 (44)
Yes	505 (47)	519 (53)	968 (59)	417 (62)		2,409 (55)
Unknown	17 (2)	16 (2)	14 (1)	7 (1)		54 (1)
Education					<0.01	
<High school	45 (4)	143 (15)	606 (40)	51 (8)		845 (19)
High school degree or equivalent	175 (16)	194 (20)	349 (21)	64 (10)		782 (18)
Vocational/technical degree or some college	374 (35)	430 (44)	436 (27)	176 (26)		1,416 (32)
College degree/graduate school	473 (44)	221 (22)	251 (15)	381 (57)		1,326 (30)
Neighborhood (block group) SES[b]					<0.01	
Quintile 1-low SES	9 (1)	132 (13)	98 (6)	9 (1)		248 (6)
Quintile 2	30 (3)	282 (29)	240 (15)	31 (5)		583 (13)
Quintile 3	100 (9)	207 (21)	363 (22)	101 (15)		771 (18)
Quintile 4	257 (24)	216 (22)	434 (26)	164 (24)		1,071 (25)
Quintile 5-high SES	671 (63)	151 (15)	507 (31)	367 (55)		1,696 (39)
% Poverty (block group)					<0.01	
0–0.049, high SES	627 (59)	202 (20)	591 (36)	350 (52)		1,770 (41)
0.05–0.09	279 (26)	191 (19)	429 (26)	199 (30)		1,098 (25)
0.1–0.19	135 (13)	317 (32)	438 (27)	94 (14)		984 (23)
≥0.2, low SES	26 (2)	278 (28)	184 (11)	29 (4)		517 (12)
Marital status					<0.01	
Single/never married	164 (15)	282 (29)	258 (16)	98 (15)		802 (18)
Married	681 (64)	397 (40)	1,018 (62)	522 (78)		2,618 (60)
Separated/divorced	114 (11)	197 (20)	207 (12)	34 (5)		552 (13)
Widowed	78 (7)	86 (9)	119 (7)	10 (2)		293 (7)
Unknown	30 (3)	26 (3)	40 (2)	8 (1)		104 (2)
History of benign breast disease					<0.01	
No	817 (77)	794 (80)	1,405 (86)	576 (86)		3,592 (82)
Yes	250 (23)	192 (19)	234 (14)	96 (14)		772 (18)
Unknown	0 (0)	2 (0)	3 (0)	0 (0)		5 (0)
Years since last full-term pregnancy					<0.01	
Nulliparous	272 (26)	180 (18)	234 (14)	173 (26)		859 (20)
<2	25 (2)	14 (1)	21 (1)	17 (3)		77 (2)
2–4	40 (4)	26 (3)	82 (5)	47 (7)		195 (5)
5+	726 (68)	767 (78)	1,303 (79)	435 (65)		3,231 (74)
Unknown	4 (0)	1 (0)	2 (0)	0 (0)		7 (0)
History of oral contraceptive use					<0.01	
No	285 (27)	271 (27)	535 (33)	365 (54)		1,456 (33)
Yes	730 (68)	679 (69)	1,052 (64)	306 (46)		2,767 (63)
Unknown	52 (5)	38 (4)	55 (3)	1 (0)		146 (3)
History of menopausal hormone therapy use[c]					<0.01	
No	540 (51)	686 (70)	1,126 (69)	514 (77)		2,866 (66)
Past	197 (19)	201 (20)	232 (14)	90 (13)		720 (17)
Recent	330 (31)	101 (10)	284 (17)	68 (10)		783 (18)

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Table 1. Characteristics of NABC patients with breast cancer ($N = 4,639$), San Francisco Bay Area, 1995 to 2008 (Cont'd)

	Non-Hispanic white *n* (%)	African-American *n* (%)	Hispanic *n* (%)	Asian-American *n* (%)	Chi-square *P*-value	Total *n* (%)
Alcohol consumption (g/day) in the year before diagnosis					<0.01	
0	380 (36)	614 (62)	1,045 (64)	617 (92)		2,656 (61)
<5	240 (23)	125 (13)	263 (16)	21 (3)		649 (15)
5–9	135 (13)	97 (10)	107 (7)	12 (2)		351 (8)
10–14	109 (10)	48 (5)	99 (6)	9 (1)		265 (6)
≥15	196 (18)	101 (10)	124 (8)	10 (2)		431 (10)
Unknown	7 (1)	3 (0)	4 (0)	3 (0)		17 (0)
BMI (kg/m^2) in year before diagnosis					<0.01	
<25.0	604 (57)	262 (27)	529 (32)	471 (70)		1,866 (43)
25.0–29.9	257 (24)	312 (32)	543 (33)	146 (22)		1,258 (29)
≥30.0	197 (19)	400 (41)	549 (33)	48 (7)		1,194 (27)
Unknown	9 (1)	14 (1)	21 (1)	7 (1)		51 (1)
Recent recreational physical activity (hours/week)					<0.01	
0, None	260 (24)	288 (29)	686 (42)	211 (31)		1,445 (33)
Quartiles 1 & 2	330 (31)	460 (47)	476 (29)	241 (36)		1,507 (35)
Quartile 3 & 4	476 (45)	240 (24)	479 (29)	218 (32)		1,413 (32)
Unknown	1 (0)	0 (0)	1 (0)	2 (0)		4 (0)
Percent of race/ethnic-concordant patients with cancer in reporting hospital (%)					<0.01	
<25	1 (0)	646 (65)	1456 (89)	562 (84)		2,665 (61)
25–49	70 (7)	342 (35)	186 (11)	86 (13)		684 (16)
50–74	472 (44)	0 (0)	0 (0)	10 (2)		482 (11)
≥75	524 (49)	0 (0)	0 (0)	14 (2)		538 (12)
Percent of patients with cancer in highest SES quintile in reporting hospital (%)					<0.01	
<25	169 (16)	317 (32)	420 (26)	124 (19)		1,030 (24)
25–49	286 (27)	491 (50)	492 (30)	249 (37)		1,518 (35)
50–74	521 (49)	163 (17)	659 (40)	251 (37)		1,594 (37)
≥75	91 (9)	17 (2)	71 (4)	48 (7)		227 (5)

[a]Distributions are based on known status.

[b]Neighborhood SES was measured using a composite measure of 7 Census indicator measures known as the Yost SES Index (29).

[c]Past = stopped before diagnosis; recent = stopped or continued to use at diagnosis.

more likely to have had a mastectomy, be younger at diagnosis, be nulliparous, and without a history of hormonal contraceptive use or alcohol consumption.

The distributions of both SES measures varied substantially by race/ethnicity. The percent with less than a high school degree ranged from 4% among non-Hispanic whites to 37% among Hispanics. Proportions of cases living in the highest SES neighborhoods ranged from 63% among non-Hispanic whites to 15% among African-Americans.

Education was correlated with nSES and varied by race/ethnicity (correlation coefficients ranged from 0.25 to 0.39). Lower proportions of Hispanic and African-American women with higher education lived in higher SES neighborhoods than non-Hispanic white and Asian-American women (Table 2). Conversely, higher proportions of non-Hispanic white and Asian-American women with lower education lived in higher SES neighborhoods than Hispanic and African-American women.

All-cause survival

Lower education was associated with worse survival after breast cancer diagnosis among Asian-Americans and African-Americans (marginally significant) in

Table 2. Distributions of education and neighborhood SES by race/ethnicity for NABC patients with breast cancer, San Francisco Bay Area, 1995 to 2008

	Education				
Neighborhood SES[b]	<High school graduation *N* (%)	High school graduation *N* (%)	Vocational school/some college *N* (%)	College+ *N* (%)	Total[a] *N* (%)
Non-Hispanic white					
Neighborhood SES					
Q1-low SES	1 (11.1)	3 (33.3)	3 (33.3)	2 (22.2)	9 (0.8)
Q2	3 (10.0)	8 (26.7)	14 (46.7)	5 (16.7)	30 (2.8)
Q3	12 (12.0)	24 (24.0)	41 (41.0)	23 (23.0)	100 (9.4)
Q4	21 (8.1)	52 (20.2)	86 (33.3)	98 (38.0)	258 (24.2)
Q5-high SES	8 (1.2)	88 (13.1)	230 (34.3)	345 (51.4)	671 (62.8)
Total	45 (4.2)	175 (16.4)	374 (35.0)	473 (44.3)	1,068 (100.0)
African-American					
Neighborhood SES					
Q1-low SES	38 (28.6)	34 (25.6)	51 (38.3)	9 (6.8)	133 (13.4)
Q2	55 (19.4)	59 (20.8)	133 (46.8)	35 (12.3)	284 (28.6)
Q3	23 (11.0)	46 (22.0)	93 (44.5)	45 (21.5)	209 (21.0)
Q4	19 (8.8)	39 (18.1)	103 (47.7)	55 (25.5)	216 (21.8)
Q5-high SES	8 (5.3)	16 (10.6)	50 (33.1)	77 (51.0)	151 (15.2)
Total	143 (14.4)	194 (19.5)	430 (43.3)	221 (22.3)	993 (100.0)
Hispanic					
Neighborhood SES					
Q1-low SES	64 (64.6)	13 (13.1)	16 (16.2)	5 (5.1)	99 (5.9)
Q2	146 (58.9)	42 (16.9)	41 (16.5)	11 (4.4)	248 (14.9)
Q3	184 (49.2)	75 (20.1)	75 (20.1)	29 (7.8)	374 (22.4)
Q4	123 (28.0)	115 (26.1)	126 (28.6)	70 (15.9)	440 (26.3)
Q5-high SES	89 (17.5)	104 (20.4)	178 (35.0)	136 (26.7)	509 (30.5)
Total	606 (36.3)	349 (20.9)	436 (26.1)	251 (15.0)	1,670 (100.0)
Asian-American					
Neighborhood SES					
Q1-low SES	3 (33.3)	2 (22.2)	1 (11.1)	3 (33.3)	9 (1.3)
Q2	7 (22.6)	8 (25.8)	8 (25.8)	8 (25.8)	31 (4.6)
Q3	14 (13.9)	16 (15.8)	22 (21.8)	49 (48.5)	101 (15.0)
Q4	14 (8.5)	19 (11.6)	57 (34.8)	74 (45.1)	164 (24.3)
Q5-high SES	13 (3.5)	19 (5.1)	88 (23.8)	247 (66.9)	369 (54.7)
Total	51 (7.6)	64 (9.5)	176 (26.1)	381 (56.5)	674 (100.0)

[a]Totals include patients with unknown education, and therefore row numbers may not add up to the total. Note that those with unknown education were excluded from the analytic sample.

[b]Neighborhood SES was measured using a composite measure of 7 Census indicator measures known as the YOST SES Index (29).

base models, but these associations were attenuated and became nonsignificant after adjusting for nSES (Table 3). NSES was associated with worse survival among Hispanics and Asian-Americans and a statistically significant trend was found for African-Americans ($P = 0.01$) and a marginally significant trend for non-Hispanic whites ($P = 0.05$); for all groups, HRs were increasing from high-to-low quintiles of nSES. The trends for nSES remained significant after adjusting for education among African-Americans, Hispanics, and Asian-Americans.

Education and nSES was jointly associated with survival and this association varied by race/ethnicity. Compared with women of high education and high nSES, survival was worse for those with low education and low nSES, both among non-Hispanic whites [HR = 1.62, 95% CI: 1.02–2.56] and Hispanics [HR = 1.39 (1.01–1.91)]. Among African-Americans, survival was worse for those living in low SES neighborhoods regardless of education [high education/low nSES HR = 1.61 (1.16–2.25); low education/low nSES HR = 1.67 (1.20–2.32)]. Among Asian-Americans, survival was worse for all other groups

Table 3. Association of individual and neighborhood SES with all-cause mortality by race/ethnicity: HRs with 95% CIs, San Francisco Bay Area, 1995 to 2008 (with follow-up through 2009)

	Non-Hispanic white		African-American		Hispanic		Asian-American	
	Base model[a]	Base + education + nSES model[b]	Base model[a]	Base + education + nSES model[b]	Base model[a]	Base + education + nSES model[b]	Base model[a]	Base + education + nSES model[b]
SES variables	**HR (95% CI)**	**HR (95% CI)**	**HR (95% CI)**	**HR (95% CI)**	**HR (95% CI)**	**HR (95% CI)**	**HR (95% CI)**	**HR (95% CI)**
Education								
College degree+	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Vocational/some college	1.03 (0.78–1.36)	1.01 (0.76–1.34)	0.92 (0.65–1.31)	0.88 (0.62–1.26)	1.31 (0.83–2.06)	1.25 (0.79–1.97)	1.29 (0.74–2.23)	1.11 (0.63–1.97)
= High school degree[c]	1.27 (0.92–1.74)	1.19 (0.86–1.65)	1.03 (0.69–1.54)	0.92 (0.60–1.40)	1.20 (0.75–1. 92)	1.08 (0.66–1.77)	**2.13 (1.28–3.52)**	1.53 (0.89–2.62)
<High school degree			1.40 (0.96–2.06)	1.20 (0.80–1.80)	1.38 (0.90–2.11)	1.15 (0.73–1.81)		
P_{trend}	*0.17*	*0.34*	*0.05*	*0.31*	*0.19*	*0.76*	***0.01***	*0.13*
Neighborhood SES (nSES)[e]								
Q5-high SES	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Q4	1.15 (0.86–1.54)	1.12 (0.84–1.50)	0.65 (0.41–1.02)	0.66 (0.42–1.03)	1.12 (0.77–1.63)	1.12 (0.76–1.64)	**2.14 (1.31–3.51)**	**1.99 (1.19–3.34)**
Q3	1.28 (0.86–1.91)	1.24 (0.83–1.85)	1.03 (0.67–1.59)	1.03 (0.66–1.61)	1.38 (0.96–1.99)	1.37 (0.92–2.02)	**2.29 (1.24–4.23)**	**2.02 (1.07–3.82)**
Q2[d]	1.64 (0.91–2.94)	1.56 (0.86–2.83)	1.17 (0.80–1.71)	1.16 (0.78–1.71)	**1.59 (1.07–2.36)**	**1.57 (1.03–2.38)**	**3.79 (1.89–7.61)**	**3.18 (1.51–6.70)**
Q1-low SES			1.33 (0.86–2.05)	1.29 (0.82–2.03)	1.59 (0.94–2.67)	1.57 (0.92–2.71)		
P_{trend}	*0.05*	*0.08*	***0.01***	***0.03***	***0.01***	***0.01***	***0.01***	***0.01***
Education and nSES[f]								
≥Some college, high nSES	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)	
≥Some college, low nSES	1.22 (0.78–1.91)		**1.61 (1.16–2.25)**		1.41 (0.89–2.23)		**1.89 (1.02–3.50)**	
≤HS degree, high nSES	1.19 (0.86–1.63)		1.44 (0.86–2.42)		0.99 (0.70–1.41)		1.84 (1.00–3.38)	
≤HS degree, low nSES	**1.62 (1.02–2.56)**		**1.67 (1.20–2.32)**		**1.39 (1.01–1.92)**		**2.68 (1.37–5.23)**	

NOTE: Bold font refers to statistically significant associations.

[a]Adjusted for age at diagnosis (continuous), year of diagnosis (continuous), study eligibility [Northern California site of the Breast Cancer Family Registry (NC-BCFR) high risk, NC-BCFR sporadic, SFBCS], nodal involvement (no, yes, unknown), histology (ductal, lobular, other), histologic grade (1–4, unknown), joint ERPR status (ER^-PR^-, ER^+, or PR^+, unknown), type of surgery (none, lumpectomy, mastectomy, not otherwise specified, unknown), radiation (no, yes, unknown), chemotherapy (no, yes, unknown), subsequent primary tumor (yes, no) and clustering by block group, and stratified by AJCC stage (I–IV, unknown).

[b]Adjusted for covariates of model 1 and clustering by block group (individual education and neighborhood SES in the same model), and stratified by AJCC stage (I–IV, unknown).

[c]Education levels <high school graduate and high school graduate collapsed as for non-Hispanic whites and Asian-Americans because of small sample sizes.

[d]Neighborhood SES quintiles 1 and 2 were collapsed for non-Hispanic whites and Asian-Americans because of small sample sizes.

[e]Neighborhood SES was measured using a composite measure of 7 Census indicator measures known as the YOST SES Index (29).

[f]HS, high school. Education levels (<high school graduate and high school graduate) collapsed as ≤ high school graduate. Neighborhood SES levels collapsed as Q1 to Q3: low SES; Q4 to Q5: high SES.

[high education/low nSES HR = 1.89 (1.02–3.50); low education/high nSES HR = 1.84 (1.02–3.37); low education/low nSES HR = 2.67 (1.37–5.23)].

Among African-Americans, nSES associations were attenuated after including hospital factors in the model (Table 4). Among Hispanics, further adjusting for behavioral risk factors and hospital characteristics attenuated the association between nSES and survival. Among Asian-Americans, the nSES and survival association was not attenuated after adjusting for personal and hospital factors.

Among non-Hispanic whites, the joint association of education and nSES with all-cause survival was attenuated after adjustment for behavioral factors [low education/low nSES HR = 1.44 (0.90–2.28)] and hospital characteristics [low education/low nSES HR = 1.60 (0.99–2.60)]. Among African-Americans, the joint association remained mostly unchanged after adjusting for additional prognostic factors, demonstrating slight attenuation with adjustment for personal and reproductive factors. Among Hispanic women, adjusting for reproductive, behavioral, and hospital factors attenuated the worse survival for low education/low nSES. Among Asian-Americans, further adjusting for prognostic factors attenuated the association for women with high education and low nSES and slightly attenuated the association for women with low education and high nSES.

Breast cancer–specific survival

We observed significant associations between education and nSES for breast cancer–specific survival only in Asian-Americans (Table 5). Those with a high school degree or less had worse survival compared with those with at least a college degree. However, this association was no longer statistically significant after adjusting for nSES. Asian-American women living in lower SES neighborhoods had worse breast cancer–specific survival compared with those living in the highest SES neighborhoods. Adjusting for education and other prognostic factors did not attenuate this association (Table 6). Among African-Americans, further adjusting for reproductive factors and for marital status resulted in marginally significant ($P = 0.05$) and significant ($P = 0.04$) trends for nSES, respectively, for breast cancer–specific survival, although no significant HRs were observed.

For the joint association of education and nSES, worse survival was observed for Asian-American women with low nSES regardless of education compared with women with high education/high nSES. Adjusting for reproductive factors, marital status, and hospital factors slightly weakened the association for Asian-American women with low education/low nSES, whereas adjusting for behavioral factors completely attenuated the association. Adjusting for marital status and behavioral factors slightly attenuated the association while adjusting for hospital characteristics completely attenuated the association for Asian-American women with high education/low nSES.

Discussion

Combining data from 2 multiethnic breast cancer studies, we found an independent association between nSES and overall survival that varied by race/ethnicity, and persisted after adjustment for education, and personal and institutional characteristics. Lower nSES was associated with worse all-cause survival among Hispanics and Asian-Americans, with a 3-fold worse survival comparing the lowest to highest nSES groups among Asian-Americans. The nSES associations were not significant among African-Americans, although a significant trend was observed, suggesting that the associations are likely modest and undetectable with our sample size. No significant associations were observed among non-Hispanic whites. We also found that lower nSES was associated with a nearly 4-fold higher breast cancer–specific mortality among Asian-Americans, likely because of the high proportion of breast cancer deaths in this group (82%); HRs for the lower nSES quintiles among African-Americans and Hispanics were in the expected direction showing higher, nonsignificant relative hazards of death. Low education was a significant prognostic factor only in the context of low nSES. Thus, our findings underscore the importance of studying SES and survival associations by race/ethnicity and the need to consider interactions between individual-level and neighborhood-level SES.

Prior studies have shown that lower education (8, 14, 15) and lower nSES (9–13) are associated with worse survival after breast cancer diagnosis. Our findings of null associations for education after adjusting for nSES across all racial/ethnic groups is most likely because education alone may not be a sufficient indicator of individual-level SES among women (15, 19, 20). Education is a single dimension of SES; additional measures such as occupation, household income, wealth and assets, and human capital may more accurately characterize a woman's individual-level SES (35). For example, education may not accurately capture individual-level SES among married women (see Table 1, where marital status varied by race/ethnicity) or groups for whom attained education may not reflect SES, such as immigrant women. Future studies on SES should ensure that individual-level SES measures are multidimensional to better evaluate the associations between SES and health.

In prior studies, findings have been less consistent when both education and nSES were evaluated independently within the same study. In a population-based cohort of primarily non-Hispanic white patients with breast cancer from Wisconsin, only nSES was associated with overall and breast cancer–specific mortality after adjustment for individual-level education and income, and established prognostic factors (17). In a subgroup of the American Cancer Society Cancer Prevention Study II cohort, associations of both individual-level and block-level SES with all-cause mortality were attenuated after adjusting for additional prognostic factors (8). Some of these discrepant results may reflect racial/ethnic and geographical differences in the study populations as well

Table 4. Association of individual and neighborhood SES with all-cause mortality adjusted for reproductive factors, marital status, behavioral factors, and hospital characteristics, by race/ethnicity: HRs with 95% CIs, San Francisco Bay Area, 1995 to 2008 (with follow-up through 2009)

			All-cause mortality			
	Cases	Deaths	Base + SES + reproductive factor model[a]	Base + SES + marital status model[b]	Base + SES + behavioral factors model[c]	Base + SES + hospital characteristics model[d]
SES variables	*n* (%)	*n* (%)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Non-Hispanic whites						
Education						
College+	473 (44.3%)	112 (40.4%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Vocational/some college	374 (35.1%)	95 (34.3%)	1.01 (0.76–1.34)	1.01 (0.76–1.34)	0.96 (0.72–1.28)	1.05 (0.78–1.40)
≤High school graduate[e]	220 (20.6%)	70 (25.3%)	1.18 (0.85–1.63)	1.23 (0.89–1.69)	1.09 (0.78–1.53)	1.25 (0.90–1.73)
P_{trend}			*0.37*	*0.26*	*0.66*	*0.21*
Neighborhood SES (nSES)[f]						
Q5-high SES	671 (62.9%)	161 (58.1%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Q4	257 (24.1%)	70 (25.3%)	1.11 (0.82–1.50)	1.09 (0.81–1.47)	1.08 (0.80–1.45)	1.09 (0.81–1.46)
Q3	100 (9.4%)	32 (11.6%)	1.24 (0.83–1.85)	1.18 (0.78–1.77)	1.17 (0.78–1.79)	1.18 (0.78–1.79)
Q1, Q2-low SES	39 (3.7%)	14 (5.1%)	1.49 (0.82–2.72)	1.51 (0.84–2.72)	1.51 (0.81–2.80)	1.48 (0.79–2.76)
P_{trend}			*0.12*	*0.15*	*0.17*	*0.18*
Education and nSES[g]						
≥ College, high nSES	759 (71.1%)	180 (65.0%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
≥ College, low nSES	88 (8.3%)	27 (9.8%)	1.19 (0.76–1.86)	1.18 (0.75–1.85)	1.18 (0.76–1.85)	1.17 (0.73–1.85)
≤ High school graduate, high nSES	169 (15.8%)	51 (18.4%)	1.16 (0.83–1.61)	1.21 (0.88–1.66)	1.12 (0.81–1.55)	1.20 (0.88–1.65)
≤ High school graduate, low nSES	51 (4.8%)	19 (6.9%)	**1.62 (1.03–2.54)**	**1.59 (1.01–2.51)**	1.44 (0.90–2.28)	1.60 (0.99–2.60)
African-Americans						
Education	(N = 980)	(N = 280)				
College+	221 (22.4%)	49 (17.5%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Vocational/some college	430 (43.5%)	112 (40.0%)	0.90 (0.62–1.31)	0.89 (0.62–1.29)	0.86 (0.60–1.25)	0.91 (0.63–1.31)
High school graduate	194 (19.6%)	59 (21.1%)	0.91 (0.58–1.41)	0.94 (0.62–1.44)	0.87 (0.56–1.35)	0.97 (0.63–1.50)
<High school graduate	143 (14.5%)	60 (21.4%)	1.18 (0.78–1.80)	1.24 (0.82–1.88)	1.17 (0.77–1.77)	1.26 (0.83–1.90)
P_{trend}			*0.38*	*0.24*	*0.40*	*0.20*
Neighborhood SES (nSES)[f]						
Q5-high SES	151 (15.3%)	42 (15.0%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Q4	216 (21.9%)	46 (16.4%)	0.67 (0.42–1.05)	0.64 (0.41–1.01)	0.68 (0.43–1.08)	0.65 (0.41–1.03)
Q3	207 (21.0%)	54 (19.3%)	0.99 (0.62–1.59)	1.02 (0.64–1.61)	0.98 (0.63–1.55)	1.04 (0.65–1.66)
Q2	282 (28.5%)	88 (31.4%)	1.11 (0.75–1.66)	1.14 (0.77–1.69)	1.16 (0.78–1.72)	1.09 (0.72–1.66)
Q1-low SES	132 (13.4%)	50 (17.9%)	1.26 (0.79–2.01)	1.29 (0.81–2.03)	1.29 (0.81–2.04)	1.19 (0.73–1.92)
P_{trend}			***0.04***	***0.02***	***0.03***	*0.06*

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Table 4. Association of individual and neighborhood SES with all-cause mortality adjusted for reproductive factors, marital status, behavioral factors, and hospital characteristics, by race/ethnicity: HRs with 95% CIs, San Francisco Bay Area, 1995 to 2008 (with follow-up through 2009) (Cont'd)

			All-cause mortality			
	Cases	Deaths	Base + SES + reproductive factor model[a]	Base + SES + marital status model[b]	Base + SES + behavioral factors model[c]	Base + SES + hospital characteristics model[d]
SES variables	*n* (%)	*n* (%)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Education and nSES[g]						
≥ College, high nSES	285 (28.9%)	61 (21.8%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
≥ College, low nSES	366 (37.0%)	100 (35.7%)	**1.62 (1.15–2.27)**	**1.62 (1.15–2.27)**	**1.57 (1.12–2.20)**	**1.58 (1.12–2.22)**
≤ High school graduate, high nSES	82 (8.3%)	27 (9.6%)	1.53 (0.91–2.57)	1.44 (0.86–2.42)	1.44 (0.85–2.42)	1.46 (0.87–2.47)
≤ High school graduate, low nSES	255 (25.8%)	92 (32.9%)	**1.58 (1.11–2.23)**	**1.70 (1.22–2.36)**	**1.58 (1.13–2.22)**	**1.68 (1.20–2.35)**
Hispanics						
Education	(*N* = 1,642)	(*N* = 257)				
College+	251 (15.3%)	29 (11.3%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Vocational/some college	436 (26.6%)	58 (22.6%)	1.20 (0.75–1.89)	1.24 (0.78–1.97)	1.24 (0.78–1.95)	1.23 (0.78–1.94)
High school graduate	349 (21.3%)	50 (19.5%)	1.06 (0.64–1.74)	1.11 (0.67–1.83)	1.06 (0.64–1.74)	1.07 (0.65–1.75)
<High school graduate	606 (36.9%)	120 (46.7%)	1.04 (0.65–1.64)	1.17 (0.74–1.86)	1.06 (0.66–1.71)	1.06 (0.67–1.68)
P_{trend}			*0.79*	*0.72*	*0.82*	*0.85*
Neighborhood SES (nSES)[f]						
Q5-high SES	507 (30.9%)	67 (26.1%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Q4	434 (26.4%)	65 (25.3%)	1.14 (0.77–1.67)	1.13 (0.77–1.66)	1.08 (0.74–1.59)	1.07 (0.73–1.57)
Q3	363 (22.1%)	62 (24.1%)	1.33 (0.89–1.97)	1.35 (0.91–2.00)	1.29 (0.86–1.92)	1.27 (0.86–1.88)
Q2	240 (14.6%)	48 (18.7%)	**1.65 (1.08–2.50)**	**1.61 (1.07–2.43)**	1.50 (0.99–2.27)	1.41 (0.91–2.17)
Q1-low SES	98 (6.0%)	15 (5.8%)	1.51 (0.87–2.61)	1.65 (0.97–2.82)	1.55 (0.91–2.64)	1.36 (0.78–2.39)
P_{trend}			***0.01***	***<0.01***	***0.02***	*0.08*
Education and nSES[g]						
≥ College, high nSES	510 (31.1%)	64 (24.9%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
≥ College, low nSES	177 (10.8%)	23 (9.0%)	1.34 (0.86–2.10)	1.40 (0.89–2.23)	1.34 (0.84–2.13)	1.26 (0.79–2.03)
≤ High school graduate, high nSES	431 (26.3%)	68 (26.5%)	0.94 (0.65–1.35)	1.02 (0.71–1.45)	0.93 (0.64–1.34)	0.93 (0.65–1.33)
≤ High school graduate, low nSES	524 (31.9%)	102 (39.7%)	1.29 (0.93–1.80)	**1.43 (1.04–1.98)**	1.25 (0.87–1.78)	1.20 (0.85–1.71)
Asian-Americans						
Education	(N = 672)	(N = 92)				
College+	381 (56.7%)	41 (44.6%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Vocational/some college	176 (26.2%)	24 (26.1%)	1.19 (0.66–2.15)	1.18 (0.65–2.15)	1.03 (0.58–1.85)	1.08 (0.61–1.90)
≤ High school graduate[e]	115 (17.1%)	27 (29.4%)	1.45 (0.83–2.53)	1.57 (0.90–2.73)	1.31 (0.69–2.47)	1.46 (0.84–2.53)
P_{trend}			*0.20*	*0.12*	*0.45*	*0.21*
Neighborhood SES (nSES)[f]						
Q5-high SES	367 (54.6%)	38 (41.3%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Q4	164 (24.4%)	27 (29.4%)	**1.85 (1.09–3.11)**	**1.91 (1.13–3.23)**	**2.01 (1.17–3.47)**	**1.93 (1.15–3.25)**

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Table 4. Association of individual and neighborhood SES with all-cause mortality adjusted for reproductive factors, marital status, behavioral factors, and hospital characteristics, by race/ethnicity: HRs with 95% CIs, San Francisco Bay Area, 1995 to 2008 (with follow-up through 2009) (Cont'd)

			All-cause mortality			
SES variables	Cases *n* (%)	Deaths *n* (%)	Base + SES + reproductive factor model[a] HR (95% CI)	Base + SES + marital status model[b] HR (95% CI)	Base + SES + behavioral factors model[c] HR (95% CI)	Base + SES + hospital characteristics model[d] HR (95% CI)
Q3	101 (15.0%)	18 (19.6%)	1.79 (0.91–3.54)	**1.93 (1.00–3.69)**	**1.89 (1.00–3.54)**	1.86 (0.95–3.62)
Q1, Q2-low SES	40 (6.0%)	9 (9.8%)	**3.20 (1.52–6.73)**	**2.68 (1.17–6.13)**	**3.11 (1.42–6.78)**	**3.05 (1.39–6.70)**
P_{trend}			***<0.01***	***<0.01***	***<0.01***	***<0.01***
Education and nSES[g]						
≥College, high nSES	466 (69.4%)	50 (54.4%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
≥College, low nSES	91 (13.5%)	15 (16.3%)	1.85 (0.99–3.47)	1.72 (0.91–3.27)	1.78 (0.96–3.29)	1.62 (0.80–3.27)
≤High school graduate, high nSES	65 (9.7%)	15 (16.3%)	1.79 (0.94–3.42)	1.82 (0.97–3.40)	1.67 (0.82–3.43)	1.64 (0.88–3.05)
≤High school graduate, low nSES	50 (7.4%)	12 (13.0%)	**2.32 (1.13–4.78)**	**2.54 (1.26–5.10)**	**2.21 (1.06–4.60)**	**2.43 (1.20–4.92)**

NOTE: Bold font refers to statistically significant associations.

[a]Adjusted for age at diagnosis (continuous), year of diagnosis (continuous), study eligibility (NC-BCFR high risk, NC-BCFR sporadic, SFBCS), histology (ductal, lobular, other), histologic grade (1–4, unknown), joint ERPR status (ER^-PR^-, ER^+, or PR^+, unknown), nodal involvement (none, positive, unknown), type of surgery (none, lumpectomy, mastectomy, NOS, unknown), radiation (no, yes, unknown), chemotherapy (no, yes, unknown), first subsequent primary tumor (yes, no), second subsequent primary tumor (yes, no), days between the dates of diagnosis of study qualifying tumor and the first subsequent tumor (continuous), days between the dates of diagnosis of the first and second subsequent tumor (continuous), benign breast disease (no, yes, unknown), years since last full-term pregnancy (≤2, 2–4, 5±, unknown), prediagnosis hormonal contraception use (never, ever, unknown), prediagnosis hormone therapy use (never, past, recent, unknown) and clustering by block group, and stratified by AJCC stage (I– IV, unknown).

[b]Adjusted for age at diagnosis (continuous), study eligibility (NC-BCFR high risk, NC-BCFR sporadic, SFBCS), histology (ductal, lobular, other), histologic grade (1–4, unknown), joint ERPR status (ER^-PR^-, ER^+, or PR^+, unknown), nodal involvement (none, positive, unknown), type of surgery (none, lumpectomy, mastectomy, NOS, unknown), radiation (no, yes, unknown), chemotherapy (no, yes, unknown), first subsequent primary tumor (yes, no), second subsequent primary tumor (yes, no), days between the dates of diagnosis of study qualifying tumor and the first subsequent tumor (continuous), days between the dates of diagnosis of the first and second subsequent tumor (continuous), marital status (single/never married, married, separated/divorced, widowed, unknown) and clustering by block group, and stratified by AJCC stage (I–IV, unknown).

[c]Adjusted for age at diagnosis (continuous), study eligibility (NC-BCFR high risk, NC-BCFR sporadic, SFBCS), histology (ductal, lobular, other), histologic grade (1–4, unknown), joint ERPR status (ER^-PR^-, ER^+, or PR^+, unknown), nodal involvement (none, positive, unknown), type of surgery (none, lumpectomy, mastectomy, NOS, unknown), radiation (no, yes, unknown), chemotherapy (no, yes, unknown), first subsequent primary tumor (yes, no), second subsequent primary tumor (yes, no), days between the dates of diagnosis of study qualifying tumor and the first subsequent tumor (continuous), days between the dates of diagnosis of the first and second subsequent tumor (continuous), grams per day of alcohol in reference year (0, ≤5, 5–9, 10–14, 15±, unknown), prediagnosis BMI (≤25, 25–29, 30±, unknown), recent recreational physical activity (0, Q1/Q2, Q3/Q4, unknown) and clustering by block group, and stratified by AJCC stage (I–IV, unknown).

[d]Adjusted for age at diagnosis (continuous), study eligibility (NC-BCFR high risk, NC-BCFR sporadic, SFBCS), histology (ductal, lobular, other), histologic grade (1–4, unknown), joint ERPR status (ER^-PR^-, ER^+, or PR^+, unknown), nodal involvement (none, positive, unknown), type of surgery (none, lumpectomy, mastectomy, NOS, unknown), radiation (no, yes, unknown), chemotherapy (no, yes, unknown), first subsequent primary tumor (yes, no), second subsequent primary tumor (yes, no), days between the dates of diagnosis of study qualifying tumor and the first subsequent tumor (continuous), days between the dates of diagnosis of the first and second subsequent tumor (continuous), percent of white patients with cancer in reporting hospital (≤25%, 25–49%, 50–74%, ≥75%, unknown), percent of patients with cancer in highest SES quintile in reporting hospital (≤25%, 25–49%, 50–74%, ≥75%, unknown) and clustering by block group, and stratified by AJCC stage (I–IV, unknown).

[e]Education levels (<high school graduate and high school graduate) collapsed as ≤ high school graduate.

[f]Neighborhood SES was measured using a composite measure of 7 Census indicator measures known as the Yost SES Index (29).

[g]SES levels collapsed as Q1 to Q3: low SES; Q4 to Q5: high SES.

Table 5. Association of individual and neighborhood SES with breast cancer–specific mortality by race/ethnicity: HRs with 95% CIs, San Francisco Bay Area, 1995 to 2008 (with follow-up through 2009)

	Non-Hispanic white		African-American		Hispanic		Asian-American	
	Base model[a]	Base + education + SES model[b]	Base model[a]	Base + education + SES model[b]	Base model[a]	Base + education + SES model[b]	Base model[a]	Base + education + SES model[b]
SES variables	**HR (95% CI)**	**HR (95% CI)**	**HR (95% CI)**	**HR (95% CI)**	**HR (95% CI)**	**HR (95% CI)**	**HR (95% CI)**	**HR (95% CI)**
Education								
College degree+	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Vocational/some college	0.87 (0.59–1.29)	0.87 (0.59–1.29)	0.74 (0.49–1.14)	0.70 (0.45–1.09)	1.41 (0.83–2.37)	1.36 (0.80–2.32)	1.11 (0.59–2.09)	0.93 (0.49–1.76)
= High school degree[c]	1.15 (0.75–1.77)	1.14 (0.73–1.77)	0.65 (0.39–1.10)	0.56 (0.32–1.00)	1.17 (0.66–2.08)	1.09 (0.60–2.00)	**1.93 (1.09–3.43)**	1.23 (0.66–2.31)
<High school degree			0.97 (0.59–1.60)	0.83 (0.49–1.40)	1.37 (0.82–2.27)	1.22 (0.70–2.13)		
P_{trend}	*0.70*	*0.74*	*0.61*	*0.31*	*0.43*	*0.86*	***0.04***	*0.51*
Neighborhood SES[e]								
Q5-high SES	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Q4	1.12 (0.76–1.65)	1.09 (0.73–1.62)	0.63 (0.37–1.09)	0.67 (0.39–1.15)	0.85 (0.54–1.35)	0.84 (0.53–1.36)	**2.63 (1.51–4.60)**	**2.55 (1.42–4.58)**
Q3	1.02 (0.61–1.70)	1.00 (0.59–1.68)	0.78 (0.45–1.37)	0.88 (0.50–1.57)	1.05 (0.67–1.66)	1.03 (0.63–1.69)	**2.97 (1.47–5.98)**	**2.78 (1.36–5.71)**
Q2[d]	1.08 (0.41–2.87)	1.05 (0.40–2.75)	0.95 (0.60–1.52)	1.08 (0.67–1.74)	1.41 (0.87–2.30)	1.38 (0.83–2.30)	**4.25 (1.99–9.08)**	**3.91 (1.72–8.91)**
Q1-low SES			1.20 (0.71–2.02)	1.42 (0.81–2.47)	1.48 (0.78–2.84)	1.47 (0.74–2.91)		
P_{trend}	*0.75*	*0.80*	*0.17*	*0.10*	*0.10*	*0.14*	***0.01***	***0.01***
Education and nSES[f]								
≥Some college, high nSES	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)	
≥Some college, low nSES	0.78 (0.41–1.50)		1.45 (0.99–2.14)		1.08 (0.59–1.97)		**2.26 (1.14–4.49)**	
≤HS degree, high nSES	1.09 (0.69–1.73)		1.25 (0.65–2.43)		0.84 (0.52–1.34)		1.74 (0.88–3.44)	
≤HS degree, low nSES	1.52 (0.82–2.82)		1.11 (0.72–1.70)		1.24 (0.83–1.86)		**2.82 (1.29–6.14)**	

NOTE: Bold font refers to statistically significant associations.

[a]Adjusted for age at diagnosis (continuous), year of diagnosis (continuous), study eligibility (FRBC high risk, case–control, FRBC sporadic), nodal involvement (no, yes, unknown), histology (ductal, lobular, other), histologic grade (1–4, unknown), joint ERPR status (ER^-PR^-, ER^+, or PR^+, unknown), type of surgery (none, lumpectomy, mastectomy, NOS, unknown), radiation (no, yes, unknown), chemotherapy (no, yes, unknown), subsequent primary tumor (yes, no) and clustering by block group, and stratified by AJCC stage (I–IV, unknown).

[b]Adjusted for covariates of model 1 and clustering by block group (individual education and neighborhood SES in the same model), and stratified by AJCC stage (I–IV, unknown).

[c]Education levels (<high school graduate and high school graduate) collapsed as ≤ high school graduate for non-Hispanic whites and Asian-Americans because of small sample sizes.

[d]Neighborhood SES quintiles 1 and 2 were collapsed for non-Hispanic whites and Asian-Americans because of small sample sizes.

[e]Neighborhood SES was measured using a composite measure of 7 Census indicator measures known as the YOST SES Index (29).

[f]HS, high school. Education levels (<high school graduate and high school graduate) collapsed as ≤ high school graduate. Neighborhood SES levels collapsed as Q1 to Q3: low SES; Q4 to Q5: high SES.

Table 6. Association of individual and neighborhood SES with breast cancer–specific mortality adjusted for reproductive factors, marital status, behavioral factors, and hospital characteristics, by race/ethnicity: HRs with 95% CIs, San Francisco Bay Area, 1995 to 2008 (with follow-up through 2009)

			Breast cancer mortality			
	Cases	Deaths	Base + SES + reproductive factor model[a]	Base + SES + marital status model[b]	Base + SES + behavioral factors model[c]	Base + SES + hospital characteristics model[d]
SES variables	*n* (%)	*n* (%)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Non-Hispanic whites						
Education	(*N* = 1,067)	(*N* = 157)				
College+	473 (44.3%)	74 (47.1%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Vocational/some college	374 (35.1%)	49 (31.2%)	0.89 (0.60–1.31)	0.90 (0.61–1.33)	0.89 (0.59–1.33)	0.91 (0.60–1.38)
≤ High school graduate[e]	220 (20.6%)	34 (21.7%)	1.13 (0.72–1.76)	1.17 (0.76–1.82)	1.12 (0.71–1.76)	1.16 (0.74–1.82)
P_{trend}			*0.75*	*0.63*	*0.76*	*0.64*
Neighborhood SES (nSES)[f]						
Q5-high SES	671 (62.9%)	93 (59.2%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Q4	257 (24.1%)	42 (26.8%)	1.07 (0.71–1.60)	1.06 (0.71–1.60)	1.07 (0.71–1.61)	0.97 (0.64–1.46)
Q3	100 (9.4%)	16 (10.2%)	0.95 (0.55–1.64)	0.91 (0.53–1.58)	0.94 (0.56–1.57)	0.81 (0.46–1.43)
Q1, Q2-low SES	39 (3.7%)	6 (3.8%)	1.01 (0.38–2.70)	1.02 (0.40–2.61)	1.12 (0.44–2.86)	0.84 (0.30–2.34)
P_{trend}			*1.00*	*0.94*	*0.92*	*0.52*
Education and nSES[g]						
≥ College, high nSES	759 (71.1%)	111 (70.7%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
≥ College, low nSES	88 (8.3%)	12 (7.6%)	0.74 (0.38–1.43)	0.74 (0.39–1.42)	0.78 (0.41–1.46)	0.64 (0.33–1.27)
≤ High school graduate, high nSES	169 (15.8%)	24 (15.3%)	1.06 (0.66–1.69)	1.11 (0.71–1.76)	1.07 (0.67–1.72)	1.06 (0.67–1.68)
≤ High school graduate, low nSES	51 (4.8%)	10 (6.4%)	1.48 (0.80–2.75)	1.43 (0.75–2.70)	1.44 (0.78–2.68)	1.33 (0.69–2.53)
African-Americans						
Education	(*N* = 980)	(*N* = 173)				
College+	221 (22.4%)	38 (22.0%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Vocational/some college	430 (43.5%)	78 (45.1%)	0.67 (0.42–1.07)	0.70 (0.45–1.10)	0.68 (0.42–1.08)	0.72 (0.46–1.13)
High school graduate	194 (19.6%)	31 (17.9%)	**0.52 (0.29–0.95)**	0.58 (0.33–1.03)	0.55 (0.30–1.00)	0.58 (0.33–1.04)
<High school graduate	143 (14.5%)	26 (15.0%)	0.79 (0.46–1.36)	0.92 (0.53–1.58)	0.84 (0.49–1.45)	0.87 (0.51–1.46)
P_{trend}			*0.25*	*0.48*	*0.36*	*0.39*
Neighborhood SES (nSES)[f]						
Q5-high SES	151 (15.3%)	29 (16.8%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Q4	216 (21.9%)	33 (19.1%)	0.69 (0.40–1.20)	0.68 (0.39–1.18)	0.67 (0.39–1.16)	0.66 (0.38–1.14)
Q3	207 (21.0%)	29 (16.8%)	0.85 (0.47–1.56)	0.91 (0.50–1.67)	0.81 (0.45–1.45)	0.89 (0.50–1.58)
Q2	282 (28.5%)	53 (30.6%)	1.11 (0.68–1.81)	1.12 (0.68–1.83)	1.02 (0.62–1.67)	1.04 (0.63–1.72)
Q1-low SES	132 (13.4%)	29 (16.8%)	1.45 (0.82–2.54)	1.50 (0.85–2.62)	1.36 (0.78–2.37)	1.34 (0.75–2.40)
P_{trend}			*0.05*	***0.04***	*0.10*	*0.09*

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Table 6. Association of individual and neighborhood SES with breast cancer–specific mortality adjusted for reproductive factors, marital status, behavioral factors, and hospital characteristics, by race/ethnicity: HRs with 95% CIs, San Francisco Bay Area, 1995 to 2008 (with follow-up through 2009) (Cont'd)

			Breast cancer mortality			
SES variables	Cases *n* (%)	Deaths *n* (%)	Base + SES + reproductive factor model[a] HR (95% CI)	Base + SES + marital status model[b] HR (95% CI)	Base + SES + behavioral factors model[c] HR (95% CI)	Base + SES + hospital characteristics model[d] HR (95% CI)
Education and nSES[g]						
≥ College, high nSES	285 (28.9%)	46 (26.6%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
≥ College, low nSES	366 (37.0%)	70 (40.5%)	1.48 (0.99–2.21)	1.48 (1.00–2.20)	1.40 (0.94–2.09)	1.45 (0.97–2.15)
≤ High school graduate, high nSES	82 (8.3%)	16 (9.3%)	1.30 (0.67–2.54)	1.23 (0.63–2.41)	1.36 (0.70–2.65)	1.27 (0.65–2.46)
≤ High school graduate, low nSES	255 (25.8%)	41 (23.7%)	1.05 (0.66–1.65)	1.18 (0.76–1.83)	1.07 (0.70–1.64)	1.12 (0.73–1.73)
Hispanics						
Education	(N = 1,642)	(N = 162)				
College+	251 (15.3%)	20 (12.4%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Vocational/some college	436 (26.6%)	42 (25.9%)	1.29 (0.76–2.21)	1.34 (0.79–2.29)	1.35 (0.78–2.31)	1.31 (0.77–2.23)
High school graduate	349 (21.3%)	32 (19.8%)	1.07 (0.58–1.98)	1.09 (0.59–2.01)	1.12 (0.61–2.06)	1.05 (0.57–1.92)
<High school graduate	606 (36.9%)	68 (42.0%)	1.10 (0.62–1.97)	1.23 (0.70–2.15)	1.23 (0.68–2.24)	1.08 (0.61–1.91)
P_{trend}			*0.93*	*0.76*	*0.78*	*0.82*
Neighborhood SES (nSES)[f]						
Q5-high SES	507 (30.9%)	47 (29.0%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Q4	434 (26.4%)	39 (24.1%)	0.86 (0.53–1.41)	0.84 (0.52–1.35)	0.86 (0.53–1.41)	0.82 (0.51–1.33)
Q3	363 (22.1%)	36 (22.2%)	1.07 (0.64–1.78)	1.02 (0.62–1.67)	1.02 (0.60–1.71)	0.93 (0.57–1.52)
Q2	240 (14.6%)	30 (18.5%)	1.48 (0.88–2.48)	1.43 (0.86–2.37)	1.38 (0.82–2.33)	1.20 (0.70–2.08)
Q1-low SES	98 (6.0%)	10 (6.2%)	1.53 (0.77–3.02)	1.50 (0.76–2.97)	1.56 (0.79–3.09)	1.14 (0.57–2.28)
P_{trend}			*0.09*	*0.11*	*0.13*	*0.47*
Education and nSES[g]						
≥ College, high nSES	510 (31.1%)	48 (29.6%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
≥ College, low nSES	177 (10.8%)	14 (8.6%)	1.05 (0.58–1.89)	1.09 (0.60–1.98)	1.08 (0.58–2.02)	0.93 (0.50–1.73)
≤ High school graduate, high nSES	431 (26.3%)	38 (23.5%)	0.78 (0.48–1.28)	0.85 (0.53–1.37)	0.86 (0.53–1.41)	0.77 (0.48–1.25)
≤ High school graduate, low nSES	524 (31.9%)	62 (38.3%)	1.23 (0.81–1.87)	1.27 (0.85–1.89)	1.26 (0.80–1.97)	1.01 (0.65–1.55)
Asian-Americans						
Education	(N = 672)	(N = 75)				
College+	381 (56.7%)	35 (46.7%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Vocational/some college	176 (26.2%)	18 (24.0%)	1.00 (0.51–1.94)	1.01 (0.52–1.98)	0.86 (0.45–1.64)	0.90 (0.48–1.68)
≤ High school graduate[e]	115 (17.1%)	22 (29.3%)	1.14 (0.59–2.20)	1.31 (0.69–2.48)	0.98 (0.47–2.03)	1.13 (0.59–2.15)
P_{trend}			*0.71*	*0.46*	*0.87*	*0.80*
Neighborhood SES (nSES)[f]						
Q5-high SES	367 (54.6%)	29 (38.7%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Q4	164 (24.4%)	22 (29.3%)	**2.44 (1.36–4.39)**	**2.41 (1.33–4.37)**	**2.51 (1.37–4.61)**	**2.51 (1.40–4.49)**

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Table 6. Association of individual and neighborhood SES with breast cancer–specific mortality adjusted for reproductive factors, marital status, behavioral factors, and hospital characteristics, by race/ethnicity: HRs with 95% CIs, San Francisco Bay Area, 1995 to 2008 (with follow-up through 2009) (Cont'd)

		Breast cancer mortality				
SES variables	Cases *n* (%)	Deaths *n* (%)	Base + SES + reproductive factor model[a] HR (95% CI)	Base + SES + marital status model[b] HR (95% CI)	Base + SES + behavioral factors model[c] HR (95% CI)	Base + SES + hospital characteristics model[d] HR (95% CI)
Q3	101 (15.0%)	16 (21.3%)	**2.58 (1.19–5.56)**	**2.64 (1.27–5.49)**	**2.59 (1.28–5.22)**	**2.51 (1.13–5.58)**
Q1, Q2-low SES	40 (6.0%)	8 (10.7%)	**3.98 (1.78–8.92)**	**3.21 (1.20–8.63)**	**4.07 (1.76–9.41)**	**3.76 (1.52–9.30)**
P_{trend}			***<0.01***	***<0.01***	***<0.01***	***<0.01***
Education and nSES[g]						
≥ College, high nSES	466 (69.4%)	39 (52.0%)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
≥ College, low nSES	91 (13.5%)	14 (18.7%)	**2.27 (1.15–4.49)**	**2.05 (1.01–4.16)**	**2.09 (1.05–4.14)**	1.92 (0.82–4.52)
≤ High school graduate, high nSES	65 (9.7%)	12 (16.0%)	1.67 (0.80–3.46)	1.72 (0.85–3.46)	1.38 (0.58–3.28)	1.50 (0.75–3.01)
≤ High school graduate, low nSES	50 (7.4%)	10 (13.3%)	**2.46 (1.05–5.75)**	**2. 74 (1.21–6.23)**	2.29 (0.99–5.32)	**2.42 (1.03–5.69)**

NOTE: Bold font refers to statistically significant associations.

[a]Adjusted for age at diagnosis (continuous), year of diagnosis (continuous), study eligibility (NC-BCFR high risk, NC-BCFR sporadic, SFBCS), histology (ductal, lobular, other), histologic grade (1–4, unknown), joint ERPR status (ER^-PR^-, ER^+, or PR^+, unknown), nodal involvement (none, positive, unknown), type of surgery (none, lumpectomy, mastectomy, NOS, unknown), radiation (no, yes, unknown), chemotherapy (no, yes, unknown), first subsequent primary tumor (yes, no), second subsequent primary tumor (yes, no), days between the dates of diagnosis of study qualifying tumor and the first subsequent tumor (continuous), days between the dates of diagnosis of the first and second subsequent tumor (continuous), benign breast disease (no, yes, unknown), years since last full-term pregnancy (≤2, 2–4, 5±, unknown), prediagnosis hormonal contraception use (never, ever, unknown), prediagnosis hormone therapy use (never, past, recent, unknown) and clustering by block group, and stratified by AJCC stage (I–IV, unknown).

[b]Adjusted for age at diagnosis (continuous), study eligibility (NC-BCFR high risk, NC-BCFR sporadic, SFBCS), histology (ductal, lobular, other), histologic grade (1–4, unknown), joint ERPR status (ER^-PR^-, ER^+, or PR^+, unknown), nodal involvement (none, positive, unknown), type of surgery (none, lumpectomy, mastectomy, NOS, unknown), radiation (no, yes, unknown), chemotherapy (no, yes, unknown), first subsequent primary tumor (yes, no), second subsequent primary tumor (yes, no), days between the dates of diagnosis of study qualifying tumor and the first subsequent tumor (continuous), days between the dates of diagnosis of the first and second subsequent tumor (continuous), marital status (single/never married, married, separated/divorced, widowed, unknown) and clustering by block group, and stratified by AJCC stage (I–IV, unknown).

[c]Adjusted for age at diagnosis (continuous), study eligibility (NC-BCFR high risk, NC-BCFR sporadic, SFBCS), histology (ductal, lobular, other), histologic grade (1–4, unknown), joint ERPR status (ER^-PR^-, ER^+, or PR^+, unknown), nodal involvement (none, positive, unknown), type of surgery (none, lumpectomy, mastectomy, NOS, unknown), radiation (no, yes, unknown), chemotherapy (no, yes, unknown), first subsequent primary tumor (yes, no), second subsequent primary tumor (yes, no), days between the dates of diagnosis of study qualifying tumor and the first subsequent tumor (continuous), days between the dates of diagnosis of the first and second subsequent tumor (continuous), grams per day of alcohol in reference year (0,≤5, 5–9, 10–14, 15±, unknown), prediagnosis BMI (≤25, 25–29, 30±, unknown), recent recreational physical activity (0, Q1/Q2, Q3/Q4, unknown) and clustering by block group, and stratified by AJCC stage (I–IV, unknown).

[d]Adjusted for age at diagnosis (continuous), study eligibility (NC-BCFR high risk, NC-BCFR sporadic, SFBCS), histology (ductal, lobular, other), histologic grade (1–4, unknown), joint ERPR status (ER^-PR^-, ER^+, or PR^+, unknown), nodal involvement (none, positive, unknown), type of surgery (none, lumpectomy, mastectomy, NOS, unknown), radiation (no, yes, unknown), chemotherapy (no, yes, unknown), first subsequent primary tumor (yes, no), second subsequent primary tumor (yes, no), days between the dates of diagnosis of study qualifying tumor and the first subsequent tumor (continuous), days between the dates of diagnosis of the first and second subsequent tumor (continuous), percent of white patients with cancer in reporting hospital (≤25%, 25–49%, 50–74%, ≥75%, unknown), percent of patients with cancer in highest SES quintile in reporting hospital (≤25%, 25–49%, 50–74%, ≥75%, unknown), and clustering by block group, and stratified by AJCC stage (I–IV, unknown).

[e]Education levels (<high school graduate and high school graduate) collapsed as ≤ high school graduate.

[f]Neighborhood SES was measured using a composite measure of 7 Census indicator measures known as the Yost SES Index (29).

[g]SES levels collapsed as Q1 to Q3: low SES; Q4 to Q5: high SES.

as use of different SES measures. In our study, although the nSES gradient for all-cause mortality was evident for most racial/ethnic groups (suggestive for African-Americans), except non-Hispanic whites, the magnitude of the associations varied by race/ethnicity, with Asian-Americans having the largest relative hazard of death as nSES decreased. Sample size and statistical power are likely explanations for significant nSES associations observed for all-cause, but not breast cancer specific, mortality, except among Asian-Americans. We had adequate power to detect associations between nSES and all-cause mortality because of the larger number of events within each race/ethnicity and magnitude of the effects. For breast cancer–specific mortality, Asian-Americans had a high number of events and large effect magnitude (HRs above 2) allowing us to detect the significance. The other races/ethnicities did not have strong associations (HRs all close to 1), so even though there were more events, we had inadequate power to detect them as significant. For both all cause and breast cancer–specific mortality the HR estimates have trends in similar directions, but the confidence intervals are wide for breast cancer–specific mortality.

To our knowledge, no prior study has examined the joint association of individual-level and neighborhood-level SES on survival after breast cancer diagnosis. In the general population, all-cause mortality has been found to be highest among those who had low individual-level SES but resided in high SES neighborhoods (36–39). It is hypothesized that discordant individual-level and neighborhood-level SES measures may result in worse health through relative deprivation (i.e., those with low education having fewer resources to navigate their high SES neighborhoods, which may include higher living costs) or relative standing (i.e., those with low education may have fewer social resources and higher stress compared with their counterparts in high SES neighborhoods and therefore different levels of stress and coping mechanisms; ref. 36). Although we observed worse survival for Asian-Americans with low education in high SES neighborhoods, Asian-American women of low education in low SES neighborhoods had the worst survival, 2.7-fold relative to Asian-Americans of high education in high SES neighborhoods. Similarly, women of other race/ethnicities with low education in low SES neighborhoods had lower survival relative to women with high education in high SES neighborhoods. In addition, among African-Americans, living in a low SES neighborhood was associated with worse survival, regardless of education. The varying interactions between education and nSES across racial/ethnic groups may be because of variations in how well education alone captures individual-level SES as discussed above and whether this association is moderated by race/ethnicity. Furthermore, the range of influence that a specified geographic area has could vary by individual-level SES, in that people who are higher SES may experience a diluted influence by their immediate neighborhoods, as they have access to more resources or people beyond a census block group. However, lower SES people may be more constrained and experience stronger or more concentrated influence of their more immediate surroundings. Nevertheless, our findings support the hypothesis that SES measures do not afford the same protection from death across racial/ethnic groups and the need to consider joint effects between individual-level and neighborhood-level SES (20–22).

The variation in the attenuation of our findings from further adjusting for potential mediating factors across racial/ethnic groups also suggest that nSES may be operating through multiple pathways that vary across racial/ethnic groups. Prior studies have shown that associations between education and breast cancer–specific mortality were attenuated after adjustment for behavioral factors and hormone therapy use (17) or after adjustment for marital status (8). Similarly for nSES measures, prior studies found that associations with all-cause and all-cancer mortality were attenuated after adjustment for marital status, behavioral factors and hormone therapy use (8, 16). Given our focus on examining the independent and joint associations of education and nSES on survival across racial/ethnic groups, we have been able to identify factors, including marital status, behavioral factors, hormone therapy use, and hospital characteristics, that are potentially important mediators and should be further studied using mediation analyses, as they may offer opportunities for intervention in reducing socioeconomic inequalities in breast cancer survival.

There are several limitations to our study. First, we defined neighborhoods using administrative boundaries of census block groups. However, we used the smallest level of geography for which rich SES data are available and that has been shown to be a useful approach for defining neighborhoods for health studies as census block groups are more homogenous and better represents neighborhoods where individuals practice healthy behaviors, access services, and receive health care (10). Second, we were not able to measure individual-level SES in multiple dimensions. We were also unable to include 2 important prognostic factors that were not measured by the study surveys, including smoking status and comorbid health conditions. Including these in our models would have most likely further attenuated the SES effects, although we already observed attenuation from the other behavioral factors in our study for the joint SES variable among Hispanic, Asian-American, and non-Hispanic whites. Third, for heterogeneous racial/ethnic groups such as Asian-Americans and Hispanics, subgroup differences may confound or modify associations; unfortunately, our sample did not have sufficient statistical power to examine ethnic subgroups. Fourth, we used 2000 Census data for our nSES measure. We carried out sensitivity analyses using 1990 Census data for the 9.5% of our cases diagnosed in 1995 and saw no differences in the results. We are also missing data on length of residency and whether they moved between date of diagnosis and death or censoring date, which may result in some misclassification of nSES. Fifth, CCR data on treatment are limited to

first course of treatment and may lack meaningful detail, yet, the data are relatively complete and missing rates do not vary greatly by race/ethnicity (40, 41). Finally, our racial/ethnic-specific analyses were limited by sample size. Although the patterns of associations with nSES seemed to differ by race/ethnicity, tests for interactions between race/ethnicity, and the 2 SES variables were not statistically significant. Future studies with larger samples sizes are needed to sufficiently test such interactions and ensure that such models with adjustment for a variety of factors are not sensitive to issues of model extrapolation because of sparse data.

We have identified several important next steps to further our understanding of socioeconomic disparities in survival after breast cancer diagnosis. Although we had a relatively large and diverse sample of patients with breast cancer, the associations with individual-level and neighborhood-level SES should be further studied in other populations and geographic locations to extend the generalizaibilty of our findings. Future studies will need to comprehensively measure individual-level SES (e.g., education, wealth, assets) as well as multilevel measures of SES in additional groups (e.g., American Indian/Alaska Native, multiracial patients). It is also important to better understand how living in low SES neighborhoods are more directly contributing to survival and/or interacting with individual-level SES to influence survival. Most importantly, future studies need to work on identifying features of these neighborhoods and the pathways through which they produce better or worse survival. A better understanding of the relative contributions and interactions of SES with other factors will inform targeted interventions toward reducing long-standing disparities in breast cancer survival.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

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Authors' Contributions

Conception and design: S. Shariff-Marco, M. Cockburn, W.A. Satariano, N.A. Ponce, T.H.M. Keegan, S.L. Gomez
Development of methodology: S. Shariff-Marco, D.O. Nelson, M. Cockburn, N.A. Ponce, S.L. Gomez
Acquisition of data (provided animals, acquired and managed patients, provided facilities, etc.): E.M. John, J. Koo, M. Cockburn, S.L. Gomez
Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): S. Shariff-Marco, J. Yang, M. Sangaramoorthy, A. Hertz, J. Koo, D.O. Nelson, C.W. Schupp, S.J. Shema, T.H.M. Keegan, S.L. Gomez
Writing, review, and/or revision of the manuscript: S. Shariff-Marco, J. Yang, E.M. John, M. Sangaramoorthy, D.O. Nelson, M. Cockburn, W.A. Satariano, I.H. Yen, N.A. Ponce, M. Winkleby, S.L. Gomez
Administrative, technical, or material support (i.e., reporting or organizing data, constructing databases): S. Shariff-Marco, J. Yang, A. Hertz, S.L. Gomez
Study supervision: S. Shariff-Marco, M. Sangaramoorthy, S.L. Gomez

Acknowledgments

The authors thank J.K. Winters and R. Leung for their help in preparing the neighborhood and cancer registry datasets for this study.

Grant Support

This work was supported by National Cancer Institute funds from R21CA133255 (T.H.M. Keegan) and R01CA140058 (S.L. Gomez). The Breast Cancer Family Registry (BCFR) was supported by grant UM1 CA164920 from the National Cancer Institute. The San Francisco Bay Area Breast Cancer Study was supported by National Cancer Institute grants R01 CA63446 and R01 CA77305; by the U.S. Department of Defense (DOD) grant DAMD17-96-1-6071; and by the California Breast Cancer Research Program (CBCRP) grants 4JB-1106 and 7PB-0068. The collection of cancer incidence data used in this study was supported by the California Department of Public Health as part of the statewide cancer reporting program mandated by California Health and Safety Code Section 103885; the National Cancer Institute's Surveillance, Epidemiology, and End Results Program under contract HHSN261201000140C awarded to the Cancer Prevention Institute of California, contract HHSN261201000035C awarded to the University of Southern California, and contract HHSN261201000034C awarded to the Public Health Institute; and the Centers for Disease Control and Prevention's National Program of Cancer Registries, under agreement U58DP003862-01 awarded to the California Department of Public Health.

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Received September 6, 2013; revised January 3, 2014; accepted February 3, 2014; published OnlineFirst March 11, 2014.

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