HHS Public Access

Author manuscript

J Community Health. Author manuscript; available in PMC 2016 December 01.

Published in final edited form as:

J Community Health. 2015 December ; 40(6): 1287–1299. doi:10.1007/s10900-015-0052-y.

Intersection of Race/Ethnicity and Socioeconomic Status in Mortality After Breast Cancer

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Abstract

We investigated social disparities in breast cancer (BC) mortality, leveraging data from the California Breast Cancer Survivorship Consortium. The associations of race/ethnicity, education, and neighborhood SES (nSES) with all-cause and BC-specific mortality were assessed among 9372 women with BC (diagnosed 1993–2007 in California with follow-up through 2010) from

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Conflict of interest Dr. Scarlett Gomez reports receiving funding support from Genentech unrelated to this manuscript. All other authors declare that they have no conflict of interest.

Electronic supplementary material The online version of this article (doi:10.1007/s10900-015-0052-y) contains supplementary material, which is available to authorized users.

Compliance with Ethical Standards The protocols for the CBCSC study were approved by the institutional review boards (IRBs) at all participating institutions and the California state IRB (Committee for the Protection of Human Subjects). Informed consent was obtained from all individual participants included in the study.

four racial/ ethnic groups [African American, Asian American, Latina, and non-Latina (NL) White] using Cox proportional hazards models. Compared to NL White women with high-education/high-nSES, higher all-cause mortality was observed among NL White women with high-education/ low-nSES [hazard ratio (HR) (95 % confidence interval) 1.24 (1.08–1.43)], and African American women with low-nSES, regardless of education [high education HR 1.24 (1.03–1.49); low-education HR 1.19 (0.99–1.44)]. Latina women with low-education/high-nSES had lower all-cause mortality [HR 0.70 (0.54–0.90)] and non-significant lower mortality was observed for Asian American women, regardless of their education and nSES. Similar patterns were seen for BC-specific mortality. Individual- and neighborhood-level measures of SES interact with race/ethnicity to impact mortality after BC diagnosis. Considering the joint impacts of these social factors may offer insights to understanding inequalities by multiple social determinants of health.

Keywords

Breast cancer survival; Racial/ethnic disparities; Socioeconomic disparities; Education; Neighborhood socioeconomic status

Introduction

Racial/ethnic and socioeconomic disparities in mortality after breast cancer (BC) diagnosis are persistent in the United States (U.S.). These disparities remain even after accounting for differences in important prognostic factors including clinical factors (e.g., tumor characteristics, treatment), personal risk factors (e.g., reproductive factors and lifestyle behaviors), sociodemographic characteristics, and health care access [1–3]. Race/ethnicity and socioeconomic status (SES) are highly correlated; however, their complex relations with mortality after BC have been difficult to disentangle given that prior studies have used different individual measures (e.g., education, income) and neighborhood levels (e.g., census block, block group, tract, zip code, county) to represent SES [4, 5]. While some studies have evaluated both individual SES and neighborhood SES (nSES) measures [6–11], only one has included diverse racial/ethnic populations [12].

Measuring SES at multiple levels is important because individual-level SES (e.g., education, income, wealth) may influence survival through material and social resources, including access to and quality of health care, and lifestyle risk factors [13, 14], whereas 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 [7, 15, 16]. A few studies of BC and other health outcomes suggest that the type and level of SES measure can contribute differentially to health, and that these effects may further differ by race/ethnicity [12, 17–19]. This work supports an emerging perspective for evaluating social inequalities, known as the ‘‘intersectional approach’’ [19], which emphasizes the interactions among multiple social determinants of health and the analytic approach to consider their joint effects. Such studies, however, require large numbers of population subgroups [1, 20, 21].

We aimed to assess the joint associations of race/ethnicity, education, and nSES with all-cause and BC-specific mortality, leveraging data from the large and diverse cohort of women with BC assembled in the California Breast Cancer Survivorship Consortium (CBCSC) [2].

Methods

Study Population

This analysis included five studies from the CBCSC, which was established in 2011 to better understand racial/ethnic disparities in survival among women with BC, who were diagnosed from 1993 through 2007 [2]. The studies included three case–control studies [Asian American Breast Cancer Study (AABCS), the Women's Contraceptive and Reproductive Experiences Study (CARE), the San Francisco Bay Area Breast Cancer Study (SFBCS)], and two prospective cohort studies [the California Teachers' Study (CTS), the Multiethnic Cohort (MEC)]. For the three case–control studies, the mean (standard deviation) years from diagnosis to data collection were 1.6 (0.8) years for AABCS, 0.4 (0.3) years for CARE, and 1.4 (0.6) years for SFBCS. In brief, interview data on prognostic factors were harmonized across the five studies and merged with California Cancer Registry (CCR) data on clinical and tumor characteristics, treatment, vital status, hospital characteristics, and nSES. The protocols for the CBCSC study were approved by the institutional review boards (IRBs) at all participating institutions and the California state IRB (Committee for the Protection of Human Subjects).

A total of 10,521 women with BC were potentially eligible for analysis. We further excluded, in sequence, women with in situ BC (n = 22), women with cancers diagnosed before their invasive BC (n = 779), and women with<30 days of follow-up (n = 19). Finally, we excluded 63 women of races/ethnicities other than non-Latina (NL) White, Latina, African American, and Asian American, and 266 with missing education or nSES, yielding a final study population of 9372 women with BC.

Analytic Variables

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 pro-gesterone receptor (PR) status, first course of treatment (surgery, radiation, chemotherapy), subsequent tumors (including time between diagnoses), CCR region, and marital status. CCR data were used to create an indicator of hospital-level SES using percent of cancer cases in the highest nSES quintile based on the distribution of nSES (defined below) among registry cases diagnosed from 1993 through 2007. For each hospital, percent of cases residing in high SES neighborhoods (quintile 5) at the time of diagnosis was calculated and then categorized into statewide quintiles.

Geocoding of case addresses at the time of diagnosis was centralized at the CCR using commercial geocoding vendors. Cases' addresses were assigned latitude and longitude coordinates and then assigned to a U.S. Census block group and merged with a block group-level SES measure (see detailed description below). We included 97.5 % of the cases with complete addresses or zip codes (zip code plus four digit format) that were accurately matched to unique, valid census block groups. For cases diagnosed prior to 1996, 1990 U.S.

Census block group and nSES were assigned. For cases diagnosed from 1996 through 2007, 2000 U.S. Census block groups and nSES were assigned. Of the 8225 unique census block groups that were included in our study, 74 % of the block groups had only one case and 92 % had two or fewer cases.

Questionnaire data were collected via in-person interviews (in case–control studies) or self-administered mail surveys (in cohort studies) using structured questionnaires administered in English, Spanish, Tagalog and/or Chinese (Mandarin and Cantonese). Questionnaire data were harmonized according to common definitions for the following variables: number of full-term pregnancies (0, 1, 2, 3, ≥4), smoking status (never, past, current), alcoholic drinks per week (0, ≤2, >2), pre-diagnosis body mass index (BMI) (<25, 25–29.9, ≥30 kg/m^2), and personal history of high blood pressure or diabetes [2, 22]. Race/ethnicity was classified (NL White, African American, Latina, Asian American) according to self-report on the study surveys.

As one dimension of individual-level SES, we used self-reported education, categorized into four levels: less than high school, high school degree or equivalent, vocational/ technical degree or some college, college degree or graduate school. No other individual-level SES indicators were available in the CBCSC.

For nSES, we used a composite SES measure created by principal component analysis of Census 1990 or 2000 SES indicator variables at the block group-level that includes an education index (among individuals age ≥25 years: proportion with college, high school, or less than high school weighted by 16, 12 or 9, respectively) [23], 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, and median house value [24]. We were interested in a general indicator of SES for neighborhoods, rather than specific components of SES such as education or poverty, which may have different effects on health outcomes across the diverse population and geographic subgroups in California [17, 25]. This composite nSES index has shown consistent associations with a variety of cancer outcomes and also enables us to compare our results to those of other studies that have used the same index [12, 26–32]. We categorized this nSES index into quintiles based on the statewide distribution.

To implement the intersectional approach, we accounted for race/ethnicity, individual- and neighborhood-level SES in a single, 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 after high school or some college education; low nSES included quintiles 1–3 and high nSES, quintiles 4–5. These binary cut-points were selected to achieve balanced samples.

The CCR obtains vital status and underlying cause of death through hospital follow-up and linkages to vital statistics, death records, and other databases. BC deaths were identified from the underlying cause of death listed on the death certificate [International Classification of Diseases (ICD)-9 or ICD-10 codes 174–175 and C50, respectively] [33, 34]. Follow-up time was defined as the time from date of diagnosis to study end date

(December 31, 2010), last known contact, or death, whichever came first. We had a median follow-up time of 9.4 years (interquartile range 6.3–12.5 years).

Analysis

To assess the joint association of race/ethnicity, education, and nSES with mortality, we fitted Cox proportional hazards multiple regression models, with cluster adjustment for block groups, to compute hazard rate ratios (HR) of dying from any cause or from BC. The sandwich estimator of the covariance structure, applied to Cox proportional hazards regression models, was utilized to account for the intracluster dependence and yields robust standard error estimates even under model misspecification [35]. All Cox models used attained age (in days) as the time scale, and were stratified on stage and study to allow the baseline hazards within each model to vary by stage and study. Women in the case–control studies (AABCS, CARE, SFBCS) survived after diagnosis until the time of interview; thus, their follow-up was left censored since women who died or were lost to follow-up before data collection by the parent study were not included in this study. The assumption of proportional hazards was checked by including interaction terms with time and assessing their significance using likelihood ratio tests, and confirming proportionality for each of the covariates included in the models. Analyses were conducted using SAS (version 9.3, Cary, NC). We also tested for spatial autocorrelation using Moran’s I, and found no evidence of this correlation.

First, we assessed associations between our race/ethnicity, education and nSES variables and mortality in base models that were adjusted for age at diagnosis, year of diagnosis, CCR region, tumor characteristics (histology, grade, ER/PR status, nodal involvement, tumor size), and subsequent tumors. Next, models were further adjusted sequentially for various sets of prognostic factors—treatment including chemotherapy, radiation and surgery (model 1); parity, marital status, smoking status, alcohol intake, BMI (model 2); comorbidities including hypertension and diabetes (model 3); and hospital SES (model 4).

Results

Personal and social characteristics of the 9372 women with BC included in the analysis are presented in Table 1. Relative to other racial/ethnic groups, NL White women were more likely to be past smokers or drink more than two servings of alcohol per week. African American women were more likely than other groups to be divorced or separated, current smokers, or obese. Latina women were more likely than other groups to have four or more children, or be overweight. Asian American women were more likely than other groups to be married, never smokers, non-drinkers, or normal/underweight.

Clinical and tumor characteristics for the sample are presented in Table 2. Relative to the other racial/ethnic groups, NL White women were more likely to be older at diagnosis, have tumors that were<1 cm, stage 1, grade I or lobular, and treated with radiation and lumpectomy. African American women were more likely than other groups to be seen in a low-SES hospital and have higher grade or ER−/PR− tumors. Latina women were more likely than other groups to be seen in a high-SES hospital and treated with chemotherapy.

Asian American women were more likely than other groups to be younger at diagnosis, seen in a low-SES hospital, have a mastectomy, and were less likely to have radiation treatment.

Education and nSES distributions varied by race/ethnicity (Tables 1, 3). Among NL White women, 80 % had a college degree and 70 % lived in high SES (quintiles 4 and 5) neighborhoods, compared to 24 and 25 %, respectively, among African American women; 16 and 45 %, respectively, among Latina women; and 57 and 53 %, respectively, among Asian American women (Table 1). Table 3 shows the distributions of education by nSES for each racial/ethnic group. While individual-level education and nSES are correlated in all racial/ ethnic groups, the extent of correlation differed substantially across the groups, with similar degrees of correlation among Latina and Asian American women, but more clustering in the higher SES neighborhoods regardless of education among NL White women, and more clustering in the lower SES neighborhoods regardless of education among African American women. Notably, African American women with some college/ technical school, high school, and less than high school education had relatively small differences in terms of their nSES.

Table 4 shows the hazard ratios for the three-way combination variables between race/ ethnicity, education, and nSES. For all-cause mortality, compared to NL White women with high education/high-nSES, the following groups had higher mortality in the base models: NL White women with low-nSES, regardless of education (high-education HR 1.34, 95 % CI 1.16–1.54; low-education HR 1.38, 95 % CI 1.06–1.79), African American women with low-nSES, regardless of education (high-education HR 1.56, 95 % CI 1.32–1.85; low-education HR 1.56, 95 % CI 1.31–1.86), and African American women with low-education/ high-nSES (HR 1.48, 95 % CI 1.04–2.09). Only one group had statistically significant lower mortality compared to NL White women with high-education/high-nSES: Latina women with low-education/high-nSES (HR 0.75, 95 % CI 0.58–0.95). After adjusting for treatment, individual-level risk factors, comorbidities and hospital SES, associations for NL White women with low-education/low-nSES and African American women with low-education/ high-nSES were no longer observed (see model 2 in Table 4 which shows associations were not observed after adjusting for individual-level factors). Among African American women with low-education/low-nSES, only a marginal association remained after adjustment for hospital SES. In the fully adjusted models, compared to NL White women with high-education/high-nSES, NL White and African American women with high-education/low-nSES had slightly attenuated associations of higher mortality (HR 1.24, 95 % CI 1.08–1.43 and HR 1.24, 95 % CI 1.03–1.49, respectively), while Latina women with low-education/ high-nSES had a stronger association of lower mortality (HR 0.70, 95 % CI 0.54–0.90). Lower mortality was observed for Asian American women, regardless of their education and nSES; however, none of the estimates were statistically significant.

We observed similar patterns for BC-specific mortality. Compared to NL White women with high-education/high-nSES, nearly all groups of African American women (except for those with high-education/high-nSES) had higher BC mortality in base models; Latina women with low-education/high-nSES (HR 0.62, 95 % CI 0.44–0.89) had lower BC mortality; and no statistically significant associations were observed for Asian American women. For African American women with low-education/low-nSES, the association was no longer observed in the fully adjusted model (see model 3 in Table 4 which shows the association was not observed after adjusting for comorbidities). Compared to NL White women with high-education/high-nSES, African American women with high-education/low-nSES and African American women with low-education/high-nSES had slightly attenuated associations of higher mortality (HR 1.37, 95 % CI 1.07–1.75 and HR 1.55, 95 % CI 1.01–2.37, respectively), and Latina women with low-education/high-nSES had a slightly attenuated association of lower mortality (HR 0.68, 95 % CI 0.47–0.98) in fully adjusted models.

Discussion

With data on 9372 BC cases, we documented disparities in all-cause and BC-specific mortality accounting for the complex interplay between race/ethnicity, education, and nSES. To our knowledge, no prior study has examined these associations with mortality after BC diagnosis in such a large, diverse group of women with BC.

When simultaneously measuring multiple levels of SES (education, nSES), and race/ethnicity within a single social status variable, we found that disparities existed within and across racial/ethnic groups. One strength of this approach, rather than the stratified approaches, is that comparisons can be made across racial/ethnic and SES groups. We also observed that prognostic factors explained some of the observed disparities in race/ethnicity and SES; however, after adjusting for the full set of prognostic factors, we continued to observe disparities in mortality by race/ethnicity and SES. For all-cause mortality, compared with NL White women with high education and high nSES, NL White and African American women with high education and low nSES had higher mortality, while Latina women with low education and high nSES was the only group to have lower mortality.

Our findings in NL White and African American women for all-cause mortality and in African American women for BC-specific mortality are consistent with prior studies that found higher mortality among women residing in lower SES neighborhoods [9–11, 13, 14]. Furthermore, we observed mortality disparities among groups discordant on their individual- and neighborhood-level SES: NL White and African American women of high education in low SES neighborhoods for all-cause mortality, and African American women of high education in low SES neighborhoods for BC mortality. It has been suggested that discordant individual- 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, higher stress, and different coping mechanisms compared to their counterparts in high SES neighborhoods) [36].

In contrast, Latina women with low education in high SES neighborhoods had lower mortality than NL White women with high education and high nSES for both all-cause and BC-specific mortality and reduced mortality did not disappear with adjustment for other prognostic factors. To our knowledge this finding has not been reported previously and was unexpected and warrants confirmation. In our study, the proportion of women who were lost to follow-up differed somewhat across racial/ethnic groups. However, this is unlikely to explain the lower mortality among Latina women as the percentages of women whose date of last follow-up was more than 2 years ago were 1.2 % among NL White women, 2.5 % among African American women, 3.0 % among Latina women, and 4.1 % among Asian American women.

While we did not observe statistically significant associations for Asian American women in our study, prior work has shown significant associations with heterogeneous associations across specific Asian American subgroups [27, 37]. Aggregating Asian American women into a single group may mask these associations.

Applying the intersectional approach, to jointly examine the impact of race/ethnicity, education and nSES, yielded more informative results than the traditional race/ethnicity-stratified approach that assesses independent effects of these SES factors (see Supplemental Table 1). With stratified analyses, we observed no associations for education and mortality after BC diagnosis, and we observed opposite nSES associations for White and African American women.

Studies that have examined the impact of both individual- and neighborhood-level SES on BC survival have found only nSES [8, 9], only individual-level SES [7], both measures [10], or the interactions between the two measures [11, 12] to be associated with mortality. These mixed findings may be due, in part, to the variation across studies in racial/ethnic composition of the study population, as prior studies had limited racial/ethnic diversity, often including NL White and/or African American women only [7, 9, 10]. For example, in a population-based cohort of primarily NL White women from Wisconsin, no associations were observed for individual-level education and income; nSES (census tract-level education) was associated with overall and BC-specific mortality after adjustment for individual-level education and income, and established prognostic factors [9].

Our finding that African American women have higher mortality in low SES neighborhoods regardless of their education warrants further investigation of specific neighborhood factors: these include social, built, and environmental attributes, and how residents within those neighborhoods use and are impacted by their neighborhoods. This line of research can better inform strategies to effectively reduce social inequalities in mortality after BC diagnosis.

While this study has several strengths, there are a few limitations. First, we only had one measure of individual SES, education. Second, we defined neighborhoods using administrative boundaries of census block groups (representing on average 1500 residents) which may not reflect how participants define their neighborhoods. However, this is the smallest level of geography for which rich SES data are available, and census block groups are more homogeneous and better represent neighborhoods where individuals reside and practice healthy behaviors, access services and receive health care than larger geographic areas (e.g., census tracts, zip codes, counties) [25]. Second, for heterogeneous racial/ethnic groups such as the Asian American and Latina groups, subgroup differences may confound or modify associations; unfortunately, our sample did not have sufficient statistical power to examine more refined subgroups. We did not have data on length of residency and whether women moved between date of diagnosis and death or censoring date, which may result in some misclassification of nSES. While we had clinical characteristics, we did not have data on BC subtypes beyond ER/PR status, however, this literature has predominantly shown that black-white disparities in BC persist even after accounting for subtype [38, 39]. Lastly, CCR data on treatment are limited to first course of treatment and may lack meaningful detail, yet, our recent work comparing Medicare claims to registry treatment data shows that registry treatment data are relatively complete and percentages of missing data are similar across racial/ ethnic groups [40, 41].

In conclusion, our analysis demonstrates that associations between two different measures of SES—education and nSES—and mortality after BC diagnosis vary across racial/ethnic groups. In addition, we found that the intersectional approach offers insight to understanding inequalities by multiple social determinants of health, including the adverse outcomes experienced by NL White and African American women with discordant individual-and neighborhood-level SES. Our results point to the need to understand the modifiable features of low SES neighborhoods such as higher crime, low walkability, poor food environment, low collective efficacy and low social cohesion that contribute to worse survival, especially for African American women who continue to have higher all-cause and BC-specific mortality.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

We are grateful to all the study participants for their contributions in the five California-based studies. The Asian American Breast Cancer Study was supported by the California Breast Research Program (CBCRP) grants 1RB-0287, 3PB-0120, and 5PB-0018. 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 CBCRP grants 4JB-1106 and 7PB-0068. The Women's CARE Study was funded by the National Institute of Child Health and Human Development (NICHD), through a contract with USC (N01-HD-3-3175); and the California Teachers Study was funded by the California Breast Cancer Act of 1993, National Cancer Institute grants (R01 CA77398 and K05 CA136967 to LB), and the California Breast Cancer Research Fund (contract 97-10500). The Multiethnic Cohort Study was supported by National Cancer Institute grants R01 CA54281, R37CA54281, and UM1 CA164973. Clinical and tumor characteristics and mortality data were obtained from the California Cancer Registry (CCR). The collection of cancer incidence data used in this study was supported by the California Department of Health Services 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 HHSN26120100035C awarded to the University of Southern California, and contract HHSN26120100034C awarded to the Public Health Institute; and the Centers for Disease Control and Prevention's National Program of Cancer Registries, under agreement #1U58 DP000807-01 awarded to the Public Health Institute. The ideas and opinions expressed herein are those of the authors, and endorsement by the State of California, the California Department of Health Services, the National Cancer Institute, or the Centers for Disease Control and Prevention or their contractors and subcontractors is not intended nor should be inferred. This work was supported by grants from the California Breast Cancer Research Program: 16ZB-8001(USC, Wu), 16ZB-8002 (CPIC, Gomez), 16ZB-8003 (COH, Bernstein), 16ZB-8004 (KPNC, Kwan), 16ZB-8005 (USC, Monroe).

References

1. Albano JD, Ward E, Jemal A, et al. Cancer mortality in the United States by education level and race. Journal of the National Cancer Institute. 2007; 99(18):1384–1394. [PubMed: 17848670]

2. Wu AH, Gomez SL, Vigen C, et al. The California Breast Cancer Survivorship Consortium (CBCSC): prognostic factors associated with racial/ethnic differences in breast cancer survival. Cancer Causes and Control. 2013; 24(10):1821–1836. [PubMed: 23864487]
3. McKenzie F, Jeffreys M. Do lifestyle or social factors explain ethnic/racial inequalities in breast cancer survival? Epidemiologic Reviews. 2009; 31:52–66. [PubMed: 19675112]
4. Bassett MT, Krieger N. Social class and black–white differences in breast cancer survival. American Journal of Public Health. 1986; 76(12):1400–1403. [PubMed: 3777285]
5. Byers TE, Wolf HJ, Bauer KR, et al. The impact of socioeconomic status on survival after cancer in the United States: Findings from the National Program of Cancer Registries Patterns of Care Study. Cancer. 2008; 113(3):582–591. [PubMed: 18613122]
6. Yao L, Robert SA. Examining the racial crossover in mortality between African American and white older adults: A multilevel survival analysis of race, individual socioeconomic status, and neighborhood socioeconomic context. Journal of Aging Research. 2011; 2011:132073. [PubMed: 21792390]
7. Steenland K, Henley J, Calle E, Thun M. Individual- and area-level socioeconomic status variables as predictors of mortality in a cohort of 179,383 persons. American Journal of Epidemiology. 2004; 159(11):1047–1056. [PubMed: 15155289]
8. Major JM, Doubeni CA, Freedman ND, et al. Neighborhood socioeconomic deprivation and mortality: NIH-AARP diet and health study. PLoS One. 2010; 5(11):e15538. [PubMed: 21124858]
9. Sprague BL, Trentham-Dietz A, Gangnon RE, et al. Socioeconomic status and survival after an invasive breast cancer diagnosis. Cancer. 2011; 117(7):1542–1551. [PubMed: 21425155]
10. Dasgupta P, Baade PD, Aitken JF, Turrell G. Multilevel determinants of breast cancer survival: Association with geographic remoteness and area-level socioeconomic disadvantage. Breast Cancer Research and Treatment. 2012; 132(2):701–710. [PubMed: 22160639]
11. Bentley R, Kavanagh AM, Subramanian SV, Turrell G. Area disadvantage, individual socio-economic position, and premature cancer mortality in Australia 1998 to 2000: A multilevel analysis. Cancer Causes and Control. 2008; 19(2):183–193. [PubMed: 18027094]
12. Shariff-Marco S, Yang J, John EM, et al. Impact of neighborhood and individual socioeconomic status on survival after breast cancer varies by race/ethnicity: The Neighborhood and Breast Cancer Study. Cancer Epidemiology Biomarkers & Prevention. 2014; 23(5):793–811.
13. Klassen AC, Smith KC. The enduring and evolving relationship between social class and breast cancer burden: a review of the literature. Cancer Epidemiology. 2011; 35(3):217–234. [PubMed: 21470929]
14. Vona-Davis L, Rose DP. The influence of socioeconomic disparities on breast cancer tumor biology and prognosis: A review. Journal of Women's Health (Larchmt). 2009; 18(6):883–893.
15. Robert SA, Strombom I, Trentham-Dietz A, et al. Socioeconomic risk factors for breast cancer: Distinguishing individual- and community-level effects. Epidemiology. 2004; 15(4):442–450. [PubMed: 15232405]
16. Meijer M, Rohl J, Bloomfield K, Grittner U. Do neighborhoods affect individual mortality? A systematic review and meta-analysis of multilevel studies. Social Science and Medicine. 2012; 74(8):1204–1212. [PubMed: 22365939]
17. Braveman PA, Cubbin C, Egerter S, et al. Socioeconomic status in health research: one size does not fit all. JAMA. 2005; 294(22):2879–2888. [PubMed: 16352796]
18. Williams DR, Sternthal M. Understanding racial-ethnic disparities in health: Sociological contributions. Journal of Health and Social Behavior. 2010; 51(Suppl):S15–S27. [PubMed: 20943580]
19. Williams DR, Kontos EZ, Viswanath K, et al. Integrating multiple social statuses in health disparities research: The case of lung cancer. Health Services Research. 2012; 47(3 Pt 2):1255–1277. [PubMed: 22568674]
20. Kawachi I, Daniels N, Robinson DE. Health disparities by race and class: Why both matter. Health Affairs (Millwood). 2005; 24(2):343–352.
21. Harper S, Lynch J, Meersman SC, Breen N, Davis WW, Reichman MC. Trends in area-socioeconomic and race-ethnic disparities in breast cancer incidence, stage at diagnosis, screening,

mortality, and survival among women ages 50 years and over (1987–2005). Cancer Epidemiology Biomarkers & Prevention. 2009; 18(1):121–131.

22. Kwan ML, John EM, Caan BJ, et al. Obesity and mortality after breast cancer by race/ethnicity: The california breast cancer survivorship consortium. American Journal of Epidemiology. 2014; 179(1):95–111. [PubMed: 24107615]
23. Liu L, Cozen W, Bernstein L, Ross RK, Deapen D. Changing relationship between socioeconomic status and prostate cancer incidence. Journal of the National Cancer Institute. 2001; 93(9):705–709. [PubMed: 11333293]
24. Yost K, Perkins C, Cohen R, Morris C, Wright W. Socioeconomic status and breast cancer incidence in California for different race/ethnic groups. Cancer Causes and Control. 2001; 12(8): 703–711. [PubMed: 11562110]
25. Krieger N, Chen JT, Waterman PD, Soobader M, Subramanian SV, Carson R. Geocoding and monitoring of US socioeconomic inequalities in mortality and cancer incidence: Does the choice of area-based measure and geographic level matter? The Public Health Disparities Geocoding Project. American Journal of Epidemiology. 2002; 156(5):471–482. [PubMed: 12196317]
26. Clarke CA, Miller T, Chang ET, Yin D, Cockburn M, Gomez SL. Racial and social class gradients in life expectancy in contemporary California. Social Science and Medicine. 2010; 70(9):1373–1380. [PubMed: 20171001]
27. Gomez SL, Clarke CA, Shema SJ, Chang ET, Keegan TH, Glaser SL. Disparities in breast cancer survival among Asian women by ethnicity and immigrant status: A population-based study. American Journal of Public Health. 2010; 100(5):861–869. [PubMed: 20299648]
28. Gomez SL, Press DJ, Lichtensztajn D, et al. Patient, hospital, and neighborhood factors associated with treatment of early-stage breast cancer among Asian American women in California. Cancer Epidemiology Biomarkers & Prevention. 2012; 21(5):821–834.
29. Keegan TH, John EM, Fish KM, Alfaro-Velcamp T, Clarke CA, Gomez SL. Breast cancer incidence patterns among California Hispanic women: Differences by nativity and residence in an enclave. Cancer Epidemiology Biomarkers & Prevention. 2010; 19(5):1208–1218.
30. Keegan TH, Quach T, Shema S, Glaser SL, Gomez SL. The influence of nativity and neighborhoods on breast cancer stage at diagnosis and survival among California Hispanic women. BMC Cancer. 2010; 10:603. [PubMed: 21050464]
31. Livaudais JC, Hershman DL, Habel L, et al. Racial/ ethnic differences in initiation of adjuvant hormonal therapy among women with hormone receptor-positive breast cancer. Breast Cancer Research and Treatment. 2012; 131(2):607–617. [PubMed: 21922245]
32. Telli ML, Chang ET, Kurian AW, et al. Asian ethnicity and breast cancer subtypes: A study from the California Cancer Registry. Breast Cancer Research and Treatment. 2011; 127(2):471–478. [PubMed: 20957431]
33. International Classification of Diseases. Ninth revision. Geneva, Switzerland: World Health Organization; 1980.
34. International Classification of Diseases. 10th revision. Geneva, Switzerland: World Health Organization; 1992.
35. Lin DY, Wei LJ. The robust inference for the Cox proportional hazards model. Journal of the American Statistical Association. 1989; 84(408):1074–1078.
36. Winkleby M, Cubbin C, Ahn D. Effect of cross-level interaction between individual and neighborhood socioeconomic status on adult mortality rates. American Journal of Public Health. 2006; 96(12):2145–2153. [PubMed: 17077398]
37. Li CI, Malone KE, Daling JR. Differences in breast cancer stage, treatment and survival by race and ethnicity. Archives of Internal Medicine. 2003; 163:49–56. [PubMed: 12523916]
38. Keegan TH, Press DJ, Tao L, et al. Impact of breast cancer subtypes on 3-year survival among adolescent and young adult women. Breast Cancer Research. 2013; 15(5):R95. [PubMed: 24131591]
39. Kroenke CH, Sweeney C, Kwan ML, et al. Race and breast cancer survival by intrinsic subtype based on PAM50 gene expression. Breast Cancer Research and Treatment. 2014; 144(3):689–699. [PubMed: 24604094]

40. Cooper GS, Yuan Z, Stange KC, Dennis LK, Amini SB, Rimm AA. Agreement of Medicare claims and tumor registry data for assessment of cancer-related treatment. Medical Care. 2000; 38(4):411–421. [PubMed: 10752973]

41. Cooper GS, Virnig B, Klabunde CN, Schussler N, Free-man J, Warren JL. Use of SEER-Medicare data for measuring cancer surgery. Medical Care. 2002; 40(8 Suppl):IV-43–8.

Table 1

Distribution of personal and social characteristics, California Breast Cancer Survivorship Consortium (CBCSC), 1993–2007

	Race/ethnicity									
	Non-Latina White (N = 4480)		African American (N = 1790)		Latina (N = 1797)		Asian American (N = 1305)		Total (N = 9372)	
	N	%	N	%	N	%	N	%	N	%
Study[a]										
AABCS	0	0.0	0	0.0	0	0.0	1075	82.4	1075	11.5
CARE	532	11.9	539	30.1	85	4.7	0	0.0	1156	12.3
SFBCS	537	12.0	506	28.3	1048	58.3	0	0.0	2091	22.3
CTS	3062	68.3	70	3.9	86	4.8	92	7.0	3310	35.3
MEC	349	7.8	675	37.7	578	32.2	138	10.6	1740	18.6
Neighborhood SES (nSES)[b]										
Quintile 1-lowest nSES	145	3.2	508	28.4	232	12.9	128	9.8	1013	10.8
Quintile 2	435	9.7	463	25.9	368	20.5	235	18.0	1501	16.0
Quintile 3	760	17.0	371	20.7	391	21.8	254	19.5	1776	19.0
Quintile 4	1215	27.1	289	16.1	401	22.3	333	25.5	2238	23.9
Quintile 5-highest nSES	1925	43.0	159	8.9	405	22.5	355	27.2	2844	30.3
Education										
<High school	82	1.8	255	14.2	683	38.0	104	8.0	1124	12.0
High school	321	7.2	444	24.8	424	23.6	167	12.8	1356	14.5
Some college/technical school	504	11.3	665	37.2	404	22.5	291	22.3	1864	19.9
College graduate or higher degree	3573	79.8	426	23.8	286	15.9	743	56.9	5028	53.6
Marital status										
Single, never married	503	11.2	345	19.3	245	13.6	172	13.2	1265	13.5
Married	2821	63.0	717	40.1	1062	59.1	924	70.8	5524	58.9
Separated/divorced	504	11.3	366	20.4	223	12.4	63	4.8	1156	12.3
Widowed	582	13.0	305	17.0	225	12.5	125	9.6	1237	13.2
Unknown	70	1.6	57	3.2	42	2.3	21	1.6	190	2.0
Parity										
Nulliparous	1017	22.7	273	15.3	233	13.0	308	23.6	1831	19.5
1 Birth	632	14.1	333	18.6	209	11.6	220	16.9	1394	14.9

	Race/ethnicity									
	Non-Latina White (N = 4480)		African American (N = 1790)		Latina (N = 1797)		Asian American (N = 1305)		Total (N = 9372)	
	N	%	N	%	N	%	N	%	N	%
2 Births	1485	33.1	396	22.1	399	22.2	398	30.5	2678	28.6
3 Births	816	18.2	327	18.3	357	19.9	219	16.8	1719	18.3
>4 Births	481	10.7	447	25.0	590	32.8	149	11.4	1667	17.8
Unknown	49	1.1	14	0.8	9	0.5	11	0.8	83	0.9
Smoking										
Never	2195	49.0	617	34.5	785	43.7	1024	78.5	4621	49.3
Past	1417	31.6	429	24.0	277	15.4	191	14.6	2314	24.7
Current	355	7.9	277	15.5	132	7.3	77	5.9	841	9.0
Unknown	513	11.5	467	26.1	603	33.6	13	1.0	1596	17.0
Alcohol intake (drinks/week)										
Non-drinker	1422	31.7	1073	59.9	1042	58.0	1069	81.9	4606	49.1
≤2	842	18.8	316	17.7	362	20.1	82	6.3	1602	17.1
>2	2052	45.8	343	19.2	358	19.9	149	11.4	2902	31.0
Unknown	164	3.7	58	3.2	35	1.9	5	0.4	262	2.8
Pre-diagnosis body mass index (BMI)										
<25 (normal/underweight)	2515	56.1	527	29.4	563	31.3	843	64.6	4448	47.5
25 to < 30 (overweight)	1184	26.4	591	33.0	619	34.4	347	26.6	2741	29.2
30+ (obese)	619	13.8	616	34.4	575	32.0	93	7.1	1903	20.3
Unknown	162	3.6	56	3.1	40	2.2	22	1.7	280	3.0

[a] *AABCS* Asian American Breast Cancer Study, *CARE* Women's Contraceptive and Reproductive Experiences Study, *SFBCS* San Francisco Bay Area Breast Cancer Study, *CTS* California Teachers' Study, *MEC* Multiethnic Cohort

[b] Neighborhood SES is measured using the Yost SES Index which is a composite measure of 7 Census indicator variables

Table 2

Distribution of clinical characteristics, California Breast Cancer Survivorship Consortium (CBCSC), 1993–2007

	Race/ethnicity									
	Non-Latina White (N = 4480)		African American (N = 1790)		Latina (N = 1797)		Asian American (N = 1305)		Total (N = 9372)	
	N	%	N	%	N	%	N	%	N	%
Age at diagnosis										
< 40	171	3.8	107	6.0	114	6.3	98	7.5	490	5.2
40 to < 50	550	12.3	353	19.7	391	21.8	379	29.0	1673	17.9
50 to < 60	1299	29.0	465	26.0	452	25.2	347	26.6	2563	27.3
60 to < 70	1217	27.2	430	24.0	504	28.0	293	22.5	2444	26.1
70+	1243	27.7	435	24.3	336	18.7	188	14.4	2202	23.5
AJCC summary stage										
Stage I	2406	53.7	720	40.2	804	44.7	627	48.0	4557	48.6
Stage II	1592	35.5	804	44.9	764	42.5	539	41.3	3699	39.5
Stage III	243	5.4	122	6.8	136	7.6	86	6.6	587	6.3
Stage IV	91	2.0	50	2.8	31	1.7	19	1.5	191	2.0
Unknown	148	3.3	94	5.3	62	3.5	34	2.6	338	3.6
Grade										
Grade I	1074	24.0	241	13.5	274	15.2	177	13.6	1766	18.8
Grade II	1751	39.1	551	30.8	681	37.9	515	39.5	3498	37.3
Grade III or IV	1194	26.7	763	42.6	643	35.8	505	38.7	3105	33.1
Unknown	461	10.3	235	13.1	199	11.1	108	8.3	1003	10.7
ER/PR status										
ER+/PR−	2683	59.9	825	46.1	960	53.4	702	53.8	5170	55.2
ER+/PR−	499	11.1	152	8.5	184	10.2	102	7.8	937	10.0
ER−/PR+	66	1.5	56	3.1	40	2.2	36	2.8	198	2.1
ER−/PR−	582	13.0	396	22.1	365	20.3	175	13.4	1518	16.2
Unknown	650	14.5	361	20.2	248	13.8	290	22.2	1549	16.5
Histology										
Ductal	107	69.4	1335	74.6	1344	74.8	956	73.3	6742	71.9
Lobular	953	21.3	240	13.4	275	15.3	196	15.0	1664	17.8

	Race/ethnicity									
	Non-Latina White (N = 4480)		African American (N = 1790)		Latina (N = 1797)		Asian American (N = 1305)		Total (N = 9372)	
	N	%	N	%	N	%	N	%	N	%
Other	420	9.4	215	12.0	178	9.9	153	11.7	966	10.3
Nodal involvement										
No nodes	3025	67.5	1055	58.9	1090	60.7	846	64.8	6016	64.2
Positive nodes	1313	29.3	636	35.5	639	35.6	436	33.4	3024	32.3
Unknown	142	3.2	99	5.5	68	3.8	23	1.8	332	3.5
Tumor size (cm)										
< 1	974	21.7	203	11.3	272	15.1	246	18.9	1695	18.1
1 to < 5	3016	67.3	1315	73.5	1310	72.9	916	70.2	6557	70.0
≥5	248	5.5	148	8.3	111	6.2	86	6.6	593	6.3
Unknown	242	5.4	124	6.9	104	5.8	57	4.4	527	5.6
Diagnosis with 1 subsequent primary tumor										
No	3679	82.1	1443	80.6	1531	85.2	1088	83.4	7741	82.6
Yes	801	17.9	347	19.4	266	14.8	217	16.6	1631	17.4
Diagnosis with 2 subsequent primary tumors										
No	4391	98.0	1756	98.1	1768	98.4	1288	98.7	9203	98.2
Yes	89	2.0	34	1.9	29	1.6	17	1.3	169	1.8
Chemotherapy										
No	2855	63.7	1026	57.3	935	52.0	703	53.9	5519	58.9
Yes	1556	34.7	732	40.9	830	46.2	568	43.5	3686	39.3
Unknown	69	1.5	32	1.8	32	1.8	34	2.6	167	1.8
Radiation										
No	2004	44.7	977	54.6	863	48.0	781	59.8	4625	49.3
Yes	2476	55.3	813	45.4	934	52.0	524	40.2	4747	50.7
Surgery										
No surgery	90	2.0	82	4.6	29	1.6	17	1.3	218	2.3
Mastectomy	1638	36.6	734	41.0	826	46.0	698	53.5	3896	41.6
Lumpectomy	2743	61.2	971	54.2	941	52.4	588	45.1	5243	55.9
Other	9	0.2	3	0.2	1	0.1	2	0.2	15	0.2
High blood pressure										

	Race/ethnicity									
	Non-Latina White (N = 4480)		African American (N = 1790)		Latina (N = 1797)		Asian American (N = 1305)		Total (N = 9372)	
	N	%	N	%	N	%	N	%	N	%
Yes	810	18.1	329	18.4	225	12.5	330	25.3	1694	18.1
No	2932	65.4	421	23.5	563	31.3	824	63.1	4740	50.6
Unknown	738	16.5	1040	58.1	1009	56.1	151	11.6	2938	31.3
Diabetes										
Yes	119	2.7	85	4.7	97	5.4	104	8.0	405	4.3
No	3622	80.8	663	37.0	688	38.3	1050	80.5	6023	64.3
Unknown	739	16.5	1042	58.2	1012	56.3	151	11.6	2944	31.4
Hospital patients of high SES (%)										
< 25	2053	45.8	1142	63.8	799	44.5	798	61.2	4792	51.1
25 to < 50	1479	33.0	534	29.8	496	27.6	442	33.9	2951	31.5
50 to < 75	886	19.8	109	6.1	479	26.7	64	4.9	1538	16.4
75+	62	1.4	5	0.3	23	1.3	< 5	0.1	91	1.0
Cancer registry region										
Los Angeles County	1447	32.3	1154	64.5	654	36.4	1236	94.7	4491	47.9
Greater San Francisco Bay Area	1165	26.0	554	30.9	1058	58.9	29	2.2	2806	29.9
Sacramento and Sierra	344	7.7	8	0.4	8	0.4	9	0.7	369	3.9
San Diego, Orange, Imperial	650	14.5	25	1.4	26	1.4	16	1.2	717	7.7
Rest of California	872	19.5	49	2.7	51	2.8	15	1.1	987	10.5
Unknown	< 5	0.0	0	0.0	0	0.0	0	0.0	< 5	0.0
Vital status and cause of death										
Alive	3303	73.7	1053	58.8	1356	75.5	1047	80.2	6759	72.1
Breast cancer	527	11.8	433	24.2	250	13.9	164	12.6	1374	14.7
Other cancer	153	3.4	78	4.4	52	2.9	31	2.4	314	3.4
Cardiovascular diseases	183	4.1	103	5.8	47	2.6	19	1.5	352	3.8
Diabetes or obesity	13	0.3	15	0.8	10	0.6	< 5	0.2	40	0.4
Other causes	289	6.5	103	5.8	69	3.8	30	2.3	491	5.2
Death certificate not available	12	0.3	5	0.3	13	0.7	12	0.9	42	0.4

Table 3

Distributions of education and neighborhood SES by race/ethnicity, California Breast Cancer Survivorship Consortium (CBCSC), 1993–2007

	Neighborhood socioeconomic status (nSES) quintiles[a]										
	Q1-low nSES		Q2		Q3		Q4		Q5-high nSES		Total
	N	%	N	%	N	%	N	%	N	%	N
Non Latina White (n = 4480)											
<High school	10	12.2	13	15.9	20	24.4	28	34.1	11	13.4	82
High school	17	5.3	59	18.4	70	21.8	82	25.5	93	29.0	321
Some college/technical school	25	5.0	58	11.5	86	17.1	130	25.8	205	40.7	504
College graduate or higher degree	93	2.6	305	8.5	584	16.3	975	27.3	1616	45.2	3573
Total	145	3.2	435	9.7	760	17.0	1215	27.1	1925	43.0	4480
African American (n = 1790)											
<High school	119	46.7	73	28.6	35	13.7	18	7.1	10	3.9	255
High school	154	34.7	129	29.1	89	20.0	52	11.7	20	4.5	444
Some college/technical school	169	25.4	180	27.1	146	22.0	120	18.0	50	7.5	665
College graduate or higher degree	66	15.5	81	19.0	101	23.7	99	23.2	79	18.5	426
Total	508	28.4	463	25.9	371	20.7	289	16.1	159	8.9	1790
Latina (n = 1797)											
<High school	137	20.1	186	27.2	168	24.6	118	17.3	74	10.8	683
High school	46	10.8	78	18.4	101	23.8	108	25.5	91	21.5	424
Some college/technical school	33	8.2	66	16.3	74	18.3	102	25.2	129	31.9	404
College graduate or higher degree	16	5.6	38	13.3	48	16.8	73	25.5	111	38.8	286
Total	232	12.9	368	20.5	391	21.8	401	22.3	405	22.5	1797
Asian American (n = 1305)											
<High school	25	24.0	25	24.0	26	25.0	17	16.3	11	10.6	104
High school	21	12.6	30	18.0	44	26.3	46	27.5	26	15.6	167
Some college/technical school	17	5.8	55	18.9	72	24.7	77	26.5	70	24.1	291
College graduate or higher degree	65	8.7	125	16.8	112	15.1	193	26.0	248	33.4	743
Total	128	9.8	235	18.0	254	19.5	333	25.5	355	27.2	1305
All (n = 9372)											
<High school	291	25.9	297	26.4	249	22.2	181	16.1	106	9.4	1124

	Neighborhood socioeconomic status (nSES) quintiles[a]										
	Q1-low nSES		Q2		Q3		Q4		Q5-high nSES		Total
	N	%	N	%	N	%	N	%	N	%	N
High school	238	17.6	296	21.8	304	22.4	288	21.2	230	17.0	1356
Some college/technical school	244	13.1	359	19.3	378	20.3	429	23.0	454	24.4	1864
College graduate or higher degree	240	4.8	549	10.9	845	16.8	1340	26.7	2054	40.9	5028
Total	1013	10.8	1501	16.0	1776	19.0	2238	23.9	2844	30.3	9372

[a]Neighborhood SES is measured using the Yost SES Index which is a composite measure of 7 Census indicator variables

Table 4

Hazard ratios for joint associations of race/ethnicity, education, and neighborhood socioeconomic status with all-cause and breast cancer-specific mortality, California Breast Cancer Survivorship Consortium (CBCSC), 1993–2007

	Cases	**Deaths**	**Base model[a]**	**Model 1: base model + treatment[b]**	**Model 2: model 1 + parity, marital status, and behavioral factors[c]**	**Model 3: model 2 + comorbidity[d]**	**Model 4: model 3 + hospital factors[e]**
	N = 9372 (%)	**N = 2613 (%)**	**HR (95 % CI)**	**HR (95 % CI)**	**HR (95 % CI)**	**HR (95 % CI)**	**HR (95 % CI)**
All-cause mortality							
Race, education and nSES[f]							
NL White, high edu, high nSES	2926 (31.2 %)	679 (26.0 %)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
NL White, high edu, low nSES	1151 (12.3 %)	356 (13.6 %)	**1.34 (1.16–1.54)**	**1.36 (1.18–1.56)**	**1.28 (1.11–1.47)**	**1.27 (1.10–1.46)**	**1.24 (1.08–1.43)**
NL White, low edu, high nSES	214 (2.3 %)	74 (2.8 %)	1.17 (0.90–1.51)	1.18 (0.91–1.52)	1.16 (0.90–1.50)	1.14 (0.88–1.47)	1.12 (0.87–1.45)
NL White, low edu, low nSES	189 (2.0 %)	68 (2.6 %)	**1.38 (1.06–1.79)**	**1.43 (1.10–1.86)**	1.28 (0.99–1.67)	1.26 (0.97–1.64)	1.22 (0.94–1.58)
Afr Am, high edu, high nSES	348 (3.7 %)	121 (4.6 %)	1.23 (0.99–1.54)	1.25 (1.00–1.57)	1.14 (0.90–1.43)	1.11 (0.88–1.41)	1.07 (0.85–1.36)
Afr Am, high edu, low nSES	743 (7.9 %)	295 (11.3 %)	**1.56 (1.32–1.85)**	**1.56 (1.31–1.85)**	**1.34 (1.12–1.60)**	**1.30 (1.09–1.56)**	**1.24 (1.03–1.49)**
Afr Am, low edu, high nSES	100 (1.1 %)	46 (1.8 %)	**1.48 (1.04–2.09)**	**1.50 (1.07–2.11)**	1.34 (0.95–1.88)	1.32 (0.94–1.85)	1.27 (0.90–1.78)
Afr Am, low edu, low nSES	599 (6.4 %)	275 (10.5 %)	**1.56 (1.31–1.86)**	**1.57 (1.32–1.87)**	**1.30 (1.08–1.57)**	**1.26 (1.05–1.51)**	1.19 (0.99–1.44)
Latina, high edu, high nSES	415 (4.4 %)	74 (2.8 %)	0.79 (0.61–1.02)	0.80 (0.62–1.03)	0.81 (0.63–1.04)	0.80 (0.62–1.04)	0.80 (0.62–1.03)
Latina, high edu, low nSES	275 (2.9 %)	64 (2.4 %)	0.97 (0.73–1.29)	1.00 (0.76–1.32)	0.96 (0.72–1.27)	0.92 (0.69–1.22)	0.88 (0.66–1.18)
Latina, low edu, high nSES	391 (4.2 %)	88 (3.4 %)	**0.75 (0.58–0.95)**	**0.77 (0.60–0.98)**	**0.73 (0.57–0.94)**	**0.72 (0.56–0.93)**	**0.70 (0.54–0.90)**
Latina, low edu, low nSES	716 (7.6 %)	215 (8.2 %)	1.12 (0.93–1.35)	1.13 (0.93–1.36)	1.01 (0.83–1.22)	0.98 (0.81–1.20)	0.94 (0.77–1.15)
Asian Am, high edu, high nSES	588 (6.3 %)	95 (3.6 %)	0.79 (0.55–1.14)	0.79 (0.55–1.13)	0.80 (0.55–1.16)	0.77 (0.53–1.11)	0.77 (0.53–1.11)
Asian Am, high edu, low nSES	446 (4.8 %)	94 (3.6 %)	0.91 (0.61–1.37)	0.90 (0.60–1.34)	0.88 (0.58–1.32)	0.82 (0.55–1.23)	0.81 (0.54–1.21)
Asian Am, low edu, high nSES	100 (1.1 %)	20 (0.8 %)	0.84 (0.52–1.35)	0.82 (0.51–1.32)	0.82 (0.50–1.32)	0.84 (0.53–1.35)	0.84 (0.52–1.34)
Asian Am, low edu, low nSES	171 (1.8 %)	49 (1.9 %)	0.93 (0.61–1.44)	0.93 (0.61–1.43)	0.91 (0.59–1.41)	0.88 (0.57–1.36)	0.87 (0.56–1.34)
	N = 9372 (%)	N = 1374 (%)	HR (95 % CI)	HR (95 % CI)	HR (95 % CI)	HR (95 % CI)	HR (95 % CI)
Breast cancer-specific mortality							
Race, education and nSES[f]							
NL White, high edu, high nSES	2926 (31.2 %)	319 (23.2 %)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
NL White, high edu, low nSES	1151 (12.3 %)	147 (10.7 %)	1.14 (0.93–1.40)	1.14 (0.93–1.40)	1.11 (0.90–1.37)	1.10 (0.89–1.35)	1.06 (0.86–1.32)

	Cases	Deaths	Base model[a]	Model 1: base model + treatment[b]	Model 2: model 1 + parity, marital status, and behavioral factors[c]	Model 3: model 2 + comorbidity[d]	Model 4: model 3 + hospital factors[e]
	N = 9372 (%)	N = 2613 (%)	HR (95 % CI)	HR (95 % CI)	HR (95 % CI)	HR (95 % CI)	HR (95 % CI)
NL White, low edu, high nSES	214 (2.3 %)	28 (2.0 %)	0.89 (0.61–1.30)	0.90 (0.61–1.33)	0.88 (0.59–1.30)	0.86 (0.58–1.28)	0.85 (0.57–1.27)
NL White, low edu, low nSES	189 (2.0 %)	33 (2.4 %)	1.22 (0.82–1.82)	1.31 (0.89–1.93)	1.26 (0.85–1.87)	1.25 (0.84–1.85)	1.20 (0.81–1.77)
Afr Am, high edu, high nSES	348 (3.7 %)	77 (5.6 %)	1.27 (0.96–1.69)	1.29 (0.97–1.72)	1.21 (0.90–1.63)	1.21 (0.90–1.64)	1.16 (0.86–1.57)
Afr Am, high edu, low nSES	743 (7.9 %)	186 (13.5 %)	**1.54 (1.24–1.92)**	**1.55 (1.24–1.94)**	**1.46 (1.16–1.85)**	**1.45 (1.15–1.84)**	**1.37 (1.07–1.75)**
Afr Am, low edu, high nSES	100 (1.1 %)	28 (2.0 %)	**1.63 (1.07–2.48)**	**1.69 (1.12–2.55)**	**1.61 (1.06–2.44)**	**1.61 (1.05–2.46)**	**1.55 (1.01–2.37)**
Afr Am, low edu, low nSES	599 (6.4 %)	142 (10.3 %)	**1.37 (1.08–1.75)**	**1.42 (1.11–1.81)**	**1.31 (1.01–1.69)**	1.29 (1.00–1.67)	1.21 (0.92–1.58)
Latina, high edu, high nSES	415 (4.4 %)	54 (3.9 %)	0.86 (0.63–1.18)	0.89 (0.65–1.21)	0.95 (0.69–1.30)	0.94 (0.69–1.29)	0.93 (0.68–1.27)
Latina, high edu, low nSES	275 (2.9 %)	39 (2.8 %)	0.92 (0.64–1.31)	0.94 (0.66–1.34)	1.01 (0.70–1.45)	0.99 (0.69–1.42)	0.94 (0.65–1.35)
Latina, low edu, high nSES	391 (4.2 %)	44 (3.2 %)	**0.62 (0.44–0.89)**	**0.65 (0.45–0.92)**	0.71 (0.50–1.02)	0.70 (0.49–1.01)	**0.68 (0.47–0.98)**
Latina, low edu, low nSES	716 (7.6 %)	113 (8.2 %)	0.98 (0.76–1.27)	1.00 (0.77–1.29)	0.99 (0.76–1.30)	0.98 (0.75–1.29)	0.93 (0.71–1.23)
Asian Am, high edu, high nSES	588 (6.3 %)	70 (5.1 %)	0.81 (0.48–1.39)	0.81 (0.47–1.38)	0.85 (0.50–1.44)	0.84 (0.49–1.43)	0.85 (0.49–1.45)
Asian Am, high edu, low nSES	446 (4.8 %)	59 (4.3 %)	0.81 (0.45–1.44)	0.80 (0.44–1.42)	0.82 (0.46–1.47)	0.82 (0.46–1.47)	0.80 (0.45–1.44)
Asian Am, low edu, high nSES	100 (1.1 %)	8 (0.6 %)	0.59 (0.26–1.36)	0.59 (0.26–1.33)	0.61 (0.27–1.40)	0.64 (0.29–1.43)	0.64 (0.28–1.43)
Asian Am, low edu, low nSES	171 (1.8 %)	27 (2.0 %)	0.74 (0.40–1.39)	0.74 (0.40–1.38)	0.76 (0.41–1.44)	0.77 (0.41–1.44)	0.75 (0.40–1.41)

Statistically significant values ($p < 0.05$) are given in bold

[a] Hazard ratios (HR) and 95 % confidence intervals (CI) were estimated using multivariable Cox proportional hazards regression models with age at diagnosis or interview (which occurred later) and age at last contact (in days) as the fundamental time scale, adjusted for age at diagnosis in years (continuous), logarithm of age at diagnosis in years (continuous), year at diagnosis (continuous), cancer registry region (Region1/8, Region 2/4/5/6, Region 3, Region 7/10, Region 9), race/ethnicity (non-Latino White, African American, Latina, Asian American), histology (ductal, lobular, other), grade (grade I, II, III and IV, unknown), EPPR status (ER+PR+, ER+PR−, ER−PR+, ER−PR−, unknown), nodal involvement (no nodes, positive nodes, unknown), tumor size data availability (available, unavailable), tumor size in centimeters (continuous), had 1+ subsequent tumor (yes, no), had 2+ subsequent tumor (yes, no), days between dates at diagnosis of CBCSC study tumor and the 1st subsequent tumor (continuous), days between dates at diagnosis of 1st and 2nd subsequent tumor (continuous), and clustering by block group, and stratified by study (CTS, MEC or AABCS, CARE, SFBCS—depends on study type) and AJCC stage (stage I, II, III, IV, unknown)

[b] Adjusted for covariates of base model, surgery type (no surgery, mastectomy, lumpectomy, other), chemotherapy (none, treatment, unknown), radiation (none, treatment, unknown), and clustering by block group, and stratified by study (CTS, MEC or AABCS, CARE, SFBCS—depends on study type) and AJCC stage (stage I, II, III, IV, unknown)

[c] Adjusted for covariates of model 1, parity (nulliparous, 1, 2, 3, 4+ births, unknown), marital status (single, married, separated/divorced, widowed, unknown), smoking (never, past, current, unknown), alcohol drinks per week (non-drinker, ≤2,>2 drinks, unknown), pre-diagnosis BMI (<25, 25–29, 30+, unknown), and clustering by block group, and stratified by study (CTS, MEC or AABCS, CARE, SFBCS—depends on study type) and AJCC stage (stage I, II, III, IV, unknown)

[d] Adjusted for covariates of model 2, hypertension (yes, no, unknown), diabetes (yes, no, unknown), and clustering by block group, and stratified by study (CTS, MEC or AABCS, CARE, SFBCS—depends on study type) and AJCC stage (stage I, II, III, IV, unknown)

[e] Adjusted for covariates of model 3, percent of cancer patients in highest SES quintile in reporting hospital (<25, 25–49, 50–74, ≥75 %, unknown), and clustering by block group, and stratified by study (CTS, MEC or AABCS, CARE, SFBCS—depends on study type) and AJCC stage (stage I, II, III, IV, unknown)

[f] Education levels collapsed as low education (≤high school) and high education (college+); nSES levels collapsed as low nSES (Q1–Q3) and high nSES (Q4–Q5)