Short Communication

Cancer Epidemiology, Biomarkers & Prevention

Contribution of the Neighborhood Environment and Obesity to Breast Cancer Survival: The California Breast Cancer Survivorship Consortium

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Abstract

Little is known about neighborhood attributes that may influence opportunities for healthy eating and physical activity in relation to breast cancer mortality. We used data from the California Breast Cancer Survivorship Consortium and the California Neighborhoods Data System (CNDS) to examine the neighborhood environment, body mass index, and mortality after breast cancer. We studied 8,995 African American, Asian American, Latina, and non-Latina white women with breast cancer. Residential addresses were linked to the CNDS to characterize neighborhoods. We used multinomial logistic regression to evaluate the associations between neighborhood factors and obesity and Cox proportional hazards regression to examine associations between neighborhood factors and mortality. For Latinas, obesity was associated with more neighborhood crowding [quartile 4 (Q4) vs. Q1: OR, 3.24; 95% confidence interval (CI), 1.50–7.00]; breast cancer–specific mortality was inversely associated with neighborhood businesses (Q4 vs. Q1: HR, 0.46; 95% CI, 0.25–0.85) and positively associated with multifamily housing (Q3 vs. Q1: HR, 1.98; 95% CI, 1.20–3.26). For non-Latina whites, lower neighborhood socioeconomic status (SES) was associated with obesity [quintile 1 (Q1) vs. Q5: OR, 2.52; 95% CI, 1.31–4.84], breast cancer–specific (Q1 vs. Q5: HR, 2.75; 95% CI, 1.47–5.12), and all-cause (Q1 vs. Q5: HR, 1.75; 95% CI, 1.17–2.62) mortality. For Asian Americans, no associations were seen. For African Americans, lower neighborhood SES was associated with lower mortality in a nonlinear fashion. Attributes of the neighborhood environment were associated with obesity and mortality following breast cancer diagnosis, but these associations differed across racial/ethnic groups. *Cancer Epidemiol Biomarkers Prev; 24(8); 1282–90. ©2015 AACR.*

Introduction

The obesity epidemic in the United States is a serious health priority for cancer care as an increasing number of patients with cancer are obese at diagnosis. Numerous studies among whites have demonstrated a higher mortality among obese breast cancer patients, compared with normal weight patients (1, 2). In a meta-analysis of more than 213,000 women with breast cancer, those who were obese [body mass index (BMI) >30 kg/m^2] or overweight (BMI, 25–<30 kg/m^2) were at increased risk of all-cause mortality, regardless of when BMI was ascertained (i.e., before or after diagnosis; ref. 2). Within our racially/ethnically diverse California Breast Cancer Survivorship Consortium (CBCSC), we have demonstrated increased risks of all-cause and breast cancer–specific mortality among morbidly obese (BMI > 40 kg/m^2) non-Latina whites and Latinas in comparison to normal weight women (1).

Interest in the relation between the neighborhood environment—social and man-made ("built") physical attributes of an individual's surroundings (3, 4)—and levels of obesity is growing, as these attributes provide opportunities and/or barriers for healthy eating and physical activity, and may influence health outcomes. By using data on the neighborhood environment from the California Neighborhoods Data System (CNDS; ref. 3) and building on our prior work in the CBCSC (1), we investigated the associations of the neighborhood environment with prediagnostic BMI in cross-sectional analyses and breast cancer–specific and all-cause mortalities in prospective analyses among a racial/ethnically diverse cohort of breast cancer cases.

Materials and Methods

Study participants

The CBCSC is composed of 6 California-based epidemiologic studies of breast cancer etiology/prognosis (5). For this analysis, 5 studies contributed data, including 3 case–control studies: the Asian American Breast Cancer Study (AABCS; ref. 6),

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Note: Supplementary data for this article are available at Cancer Epidemiology, Biomarkers & Prevention Online (http://cebp.aacrjournals.org/).

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doi: 10.1158/1055-9965.EPI-15-0055

Women's Contraceptive and Reproductive Experiences study (CARE; ref. 7), and San Francisco Bay Area Breast Cancer Study (SFBCS; ref. 8, 9); and 2 cohort studies: the California Teachers Study (CTS; ref. 10) and Multiethnic Cohort (MEC; ref. 11). Each study collected cases' data on reproductive, lifestyle, sociodemographic, and other breast cancer risk or prognostic factors, which were harmonized according to common definitions (5). Prediagnosis BMI was ascertained closest to the date of breast cancer diagnosis to best coincide with the characterization of the neighborhood environment at the time of diagnosis. Clinicopathologic and treatment factors were obtained from the California Cancer Registry (5). Institutional Review Board approval was received from all participating institutions and from the California Protection for Human Subjects state institutional review board.

We excluded study participants with prior cancer diagnoses ($n = 779$), *in situ* histology ($n = 22$), follow-up time <30 days ($n = 19$), incomplete address ($n = 240$), and those who were underweight (BMI < 18.5 kg/m^2; $n = 183$) or were missing BMI ($n = 283$), leaving 8,995 breast cancer cases for analysis. Vital status and cause of death were ascertained from the California Cancer Registry as of December 31, 2010. Over a median follow-up time of 10.3 years, 1,284 women died of breast cancer among 2,426 total deaths.

California neighborhoods data system

Residential addresses at the time of breast cancer diagnosis were geocoded to latitude and longitude coordinates and linked to census and business data of the California Neighborhoods Data Systems (3). Addresses were assigned to 1990 Census block groups (diagnoses 1994–1995) and 2000 Census block groups (diagnoses 1996–2007) to ascertain neighborhood levels of SES (created by principal component analysis of census data on education, housing, employment, occupation, income, and poverty; refs. 12, 13); population density; urbanicity; commute patterns; household crowding (i.e., housing with >1 occupant per room); proportion of multifamily housing units (i.e., housing structures with 2 or more units, apartment complexes); and were categorized into levels according to the state distribution (Supplementary Tables S1 and S2). Geocodes were also linked to business data to quantify neighborhood attributes of the retail/restaurant food environment; parks; recreational facilities; street connectivity (ref. 14; i.e., gamma index, defined as the ratio of actual number of street segments to maximum possible number of intersections and expressed as the percentage of connectivity); and total businesses within a one-mile pedestrian network distance of participant's residence, reflecting a reasonable distance to walk to a destination. Specifically, information on number of businesses was based on business listings derived from Walls & Associates' National Establishment Time-Series Database from 1990–2008 (15). Traffic density using previously described methods (16) was based on traffic counts from the California Department of Transportation (2004; ref. 17) that were within a residential buffer area of a 500-meter radius based on the assumption that traffic close to a subject's residence influences walking/physical activity behaviors. These neighborhood business and traffic-related attributes were categorized according to the study participant distribution (Supplementary Tables S1 and S2). Study methods of these neighborhood data have been described previously (3, 18, 19). The Census block group (an area of ~1,500 residents) was considered our neighborhood unit.

Statistical analysis

For cross-sectional analysis of the relationship between neighborhood factors and prediagnostic BMI, multivariate multinomial regression was conducted to estimate ORs of being overweight (BMI, 25–29.9) or obese (BMI ≥30) versus normal weight (BMI, 18.5–24.9). All multinomial models were stratified on stage and study and included all neighborhood variables and adjusted for variables listed in Table 1, which showed significant associations with BMI in unadjusted models. For prospective mortality analyses, multivariable Cox proportional hazard regressions were conducted to estimate HRs of breast cancer–specific and all-cause mortalities. All Cox models included all neighborhood factors and were stratified on stage and study and adjusted for variables listed in Tables 2 and 3, which showed significant univariate associations with BMI and/or breast cancer–specific and overall mortalities, respectively. All models were adjusted for clustering within block groups by applying the sandwich estimator of the covariance structure, which has been shown to account for intracluster dependence and has yielded robust SE estimates even under model misspecification (20). Multicollinearity in our models was assessed by examining variation inflation factors (VIF). All models met our criteria of non-multicollinearity with VIF < 10. All P values presented are 2-sided. A P value threshold < 0.05 was used to determine statistical significance, and no correction was applied for multiple hypothesis testing. Analyses were conducted using SAS (version 9.3).

Results

Of the 8,995 breast cancer cases in the CBCSC, 47% were non-Latina white, 20% Latina, 19% African American, and 14% Asian American (Supplementary Table S3). The majority had stage I (49%) or II (40%), 55% had estrogen receptor (ER)- or progesterone (PR)-positive tumors, 56% had breast conserving surgery, 40% received chemotherapy, and 51% received radiation treatment (Supplementary Table S4). Approximately 24% lived in low SES neighborhoods, 60% lived in suburban neighborhoods, and 21% lived in neighborhoods with >3 parks (Supplementary Table S1).

Overall, living in low versus high SES neighborhoods was associated with higher odds of being overweight ($P_{\text{trend}} < 0.01$) or obese ($P_{\text{trend}} = 0.02$; Table 1). Significant SES–BMI associations were seen only among non-Latina whites, although similar patterns were observed in African Americans. Among all breast cancer cases, living in high versus low household crowding (housing with >1 occupant per room) was associated with an increased odds of obesity ($P_{\text{trend}} = 0.02$). Latinas demonstrated the strongest association between obesity and household crowding ($P_{\text{trend}} < 0.01$), with those living in neighborhoods in the highest versus lowest quartile of household crowding having a 3-fold higher odds of obesity (95% CI, 1.50–7.00). In addition, Latinas living in neighborhoods at the highest versus lowest quartile of street connectivity had an increased odds of obesity (OR, 1.77; 95% CI, 1.06–2.95). For non-Latina whites, living in neighborhoods with a higher proportion of multifamily housing units was associated with a lower odds of being overweight (Q4 vs. Q1: OR, 0.72; 95% CI,

Table 1. Association between prediagnosis BMI and the neighborhood environment, California Breast Cancer Survivorship Consortium

	All		African Americans		Asian Americans		Latinas		Non-Latina whites	
	n = 8,995		*n* = 1,719		*n* = 1,234		*n* = 1,754		*n* = 4,234	
	Overweight vs. normal weight OR[a] (95% CI)	Obese vs. normal weight OR[a] (95% CI)	Overweight vs. normal weight OR[a] (95% CI)	Obese vs. normal weight OR[a] (95% CI)	Overweight vs. normal weight OR[a] (95% CI)	Obese vs. normal weight OR[a] (95% CI)	Overweight vs. normal weight OR[a] (95% CI)	Obese vs. normal weight OR[a] (95% CI)	Overweight vs. normal weight OR[a] (95% CI)	Obese vs. normal weight OR[a] (95% CI)
Socioeconomic status[b,c]										
Q5-high	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Q4	**1.34 (1.15–1.55)**	**1.23 (1.01–1.49)**	1.33 (0.78–2.28)	1.25 (0.69–2.27)	0.84 (0.53–1.36)	1.13 (0.48–2.68)	1.44 (0.97–2.14)	1.02 (0.65–1.62)	**1.44 (1.18–1.77)**	**1.43 (1.09–1.88)**
Q3	**1.51 (1.25–1.82)**	**1.36 (1.08–1.71)**	1.53 (0.84–2.79)	1.51 (0.80–2.85)	0.94 (0.51–1.73)	1.91 (0.67–5.40)	1.17 (0.73–1.86)	0.74 (0.44–1.25)	**1.77 (1.36–2.31)**	**1.73 (1.23–2.44)**
Q2	**1.44 (1.15–1.81)**	**1.35 (1.03–1.78)**	1.76 (0.93–3.34)	1.66 (0.84–3.28)	0.95 (0.46–1.97)	1.47 (0.40–5.47)	1.16 (0.66–2.04)	0.97 (0.54–1.76)	**1.49 (1.05–2.13)**	**1.69 (1.08–2.65)**
Q1-low	**1.72 (1.28–2.30)**	**1.43 (1.01–2.02)**	1.93 (0.93–4.02)	1.66 (0.76–3.64)	1.26 (0.52–3.04)	1.88 (0.40–8.82)	1.21 (0.60–2.45)	0.78 (0.37–1.65)	**2.50 (1.49–4.18)**	**2.52 (1.31–4.84)**
P_{trend}	<**0.01**	**0.02**	0.06	0.16	0.68	0.39	0.96	0.69	<**0.01**	<**0.01**
Population density[c]										
Q1-low	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Q2	1.09 (0.91–1.30)	1.04 (0.83–1.30)	1.51 (0.77–2.97)	1.04 (0.52–2.08)	1.32 (0.71–2.44)	1.34 (0.42–4.20)	1.17 (0.70–1.98)	0.87 (0.50–1.51)	1.01 (0.82–1.26)	1.19 (0.88–1.62)
Q3	1.07 (0.88–1.31)	1.08 (0.84–1.39)	1.53 (0.78–2.98)	0.95 (0.47–1.92)	1.48 (0.77–2.85)	2.34 (0.75–7.34)	1.28 (0.75–2.17)	0.89 (0.51–1.56)	0.90 (0.69–1.17)	1.25 (0.88–1.79)
Q4-high	1.09 (0.84–1.40)	1.14 (0.83–1.55)	1.44 (0.70–2.96)	0.83 (0.38–1.79)	1.05 (0.48–2.28)	1.98 (0.52–7.53)	1.25 (0.67–2.35)	0.92 (0.47–1.79)	1.06 (0.69–1.62)	1.59 (0.94–2.67)
P_{trend}	0.53	0.23	0.22	0.84	0.83	0.19	0.55	0.97	0.87	0.06
Urbanicity[c]										
Metropolitan suburb	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Metropolitan urban	0.86 (0.70–1.07)	0.88 (0.69–1.12)	1.02 (0.68–1.53)	1.05 (0.69–1.61)	0.82 (0.46–1.47)	0.53 (0.20–1.42)	0.92 (0.57–1.47)	1.01 (0.62–1.65)	0.86 (0.56–1.32)	0.79 (0.48–1.30)
City	1.00 (0.85–1.17)	1.08 (0.88–1.33)	1.23 (0.59–2.56)	1.26 (0.59–2.73)	0.80 (0.30–2.15)	0.35 (0.03–4.48)	1.03 (0.64–1.66)	1.25 (0.74–2.10)	1.00 (0.82–1.22)	0.99 (0.76–1.28)
Town	1.28 (0.85–1.92)	1.16 (0.65–2.05)	—	0.68 (0.19–2.44)	—	—	—	1.16 (0.37–3.67)	1.27 (0.82–1.98)	1.11 (0.59–2.07)
Rural	0.82 (0.59–1.14)	1.08 (0.70–1.67)	0.18 (0.01–2.84)	—	—	—	0.68 (0.18–2.57)	1.69 (0.56–5.13)	0.87 (0.60–1.27)	0.96 (0.56–1.63)
% Foreign born[c]										
Q1-low %	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Q2	1.07 (0.92–1.24)	1.09 (0.90–1.31)	0.78 (0.53–1.16)	0.95 (0.63–1.45)	1.13 (0.52–2.44)	1.69 (0.34–8.49)	1.11 (0.67–1.86)	**1.88 (1.06–3.34)**	**1.24 (1.03–1.50)**	0.95 (0.74–1.23)
Q3	1.06 (0.89–1.25)	1.05 (0.84–1.30)	0.89 (0.58–1.38)	0.95 (0.59–1.54)	1.90 (0.92–3.93)	1.66 (0.34–8.20)	0.85 (0.49–1.47)	1.46 (0.78–2.75)	1.14 (0.90–1.44)	0.97 (0.70–1.35)
Q4-high %	1.06 (0.86–1.32)	1.05 (0.81–1.37)	0.81 (0.48–1.36)	1.33 (0.78–2.26)	1.60 (0.75–3.39)	1.53 (0.31–7.58)	0.89 (0.48–1.66)	1.10 (0.55–2.19)	1.18 (0.82–1.69)	1.00 (0.63–1.57)
P_{trend}	0.69	0.89	0.78	0.26	0.27	0.98	0.76	0.30	0.26	0.90
% Commuting by public transportation/walk/bike[c]										
Q1-low %	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Q2	1.05 (0.91–1.21)	1.11 (0.92–1.33)	1.27 (0.76–2.11)	1.44 (0.80–2.60)	0.83 (0.55–1.26)	0.89 (0.47–1.70)	1.19 (0.75–1.89)	0.83 (0.52–1.34)	1.04 (0.86–1.25)	1.22 (0.95–1.56)
Q3	0.92 (0.78–1.07)	0.98 (0.81–1.19)	0.99 (0.60–1.63)	1.43 (0.82–2.51)	0.98 (0.62–1.57)	0.52 (0.23–1.19)	0.88 (0.55–1.41)	0.74 (0.46–1.20)	0.91 (0.74–1.13)	0.98 (0.74–1.28)
Q4-high %	0.97 (0.80–1.16)	1.10 (0.89–1.38)	1.22 (0.72–2.05)	1.71 (0.97–3.01)	0.67 (0.37–1.22)	0.74 (0.30–1.82)	1.11 (0.66–1.86)	0.77 (0.45–1.32)	0.89 (0.68–1.17)	1.12 (0.80–1.58)
P_{trend}	0.32	0.69	0.89	0.07	0.33	0.14	0.82	0.42	0.37	0.99
Household crowding[c,d]										
Q1-low	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Q2	1.10 (0.95–1.28)	1.20 (0.98–1.46)	0.72 (0.43–1.21)	0.65 (0.37–1.16)	1.49 (0.87–2.53)	2.98 (0.86–10.35)	**1.81 (1.12–2.92)**	**1.97 (1.13–3.42)**	1.02 (0.84–1.23)	1.14 (0.88–1.48)
Q3	1.06 (0.88–1.29)	**1.35 (1.06–1.72)**	0.61 (0.35–1.07)	0.72 (0.39–1.32)	1.30 (0.70–2.38)	1.98 (0.51–7.66)	1.66 (0.96–2.87)	**1.93 (1.02–3.65)**	1.04 (0.79–1.37)	**1.45 (1.02–2.05)**
Q4-high	1.24 (0.94–1.63)	**1.54 (1.10–2.16)**	0.57 (0.28–1.17)	0.63 (0.29–1.37)	2.17 (0.98–4.80)	3.67 (0.73–18.42)	**2.16 (1.08–4.31)**	**3.24 (1.50–7.00)**	1.07 (0.68–1.67)	1.09 (0.61–1.95)
P_{trend}	0.41	**0.02**	0.07	0.22	0.12	0.16	0.06	<**0.01**	0.70	0.39
% Multifamily housing units[c,e]										
Q1-low %	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Q2	0.95 (0.82–1.10)	0.87 (0.72–1.05)	1.10 (0.69–1.73)	1.02 (0.63–1.66)	0.97 (0.62–1.51)	0.88 (0.41–1.90)	1.16 (0.80–1.69)	1.01 (0.67–1.52)	0.88 (0.72–1.08)	0.86 (0.66–1.12)
Q3	**0.80 (0.68–0.95)**	0.89 (0.73–1.08)	0.89 (0.56–1.42)	1.02 (0.63–1.66)	0.66 (0.41–1.07)	1.14 (0.52–2.50)	1.14 (0.75–1.71)	1.32 (0.86–2.04)	**0.79 (0.63–0.99)**	**0.68 (0.50–0.91)**
Q4-high %	0.89 (0.74–1.07)	0.92 (0.74–1.15)	1.29 (0.78–2.11)	1.35 (0.80–2.26)	0.91 (0.52–1.60)	0.83 (0.31–2.21)	1.14 (0.72–1.79)	1.16 (0.71–1.89)	**0.72 (0.54–0.95)**	0.77 (0.54–1.10)
P_{trend}	**0.04**	0.39	0.64	0.44	0.21	0.47	0.38	0.21	<**0.01**	**0.03**

(Continued on the following page)

Table 1. Association between prediagnosis BMI and the neighborhood environment, California Breast Cancer Survivorship Consortium (Cont'd)

	All		African Americans		Asian Americans		Latinas		Non-Latina whites	
	n = 8,995		*n* = 1,719		*n* = 1,234		*n* = 1,754		*n* = 4,234	
	Overweight vs. normal weight OR[a] (95% CI)	Obese vs. normal weight OR[a] (95% CI)	Overweight vs. normal weight OR[a] (95% CI)	Obese vs. normal weight OR[a] (95% CI)	Overweight vs. normal weight OR[a] (95% CI)	Obese vs. normal weight OR[a] (95% CI)	Overweight vs. normal weight OR[a] (95% CI)	Obese vs. normal weight OR[a] (95% CI)	Overweight vs. normal weight OR[a] (95% CI)	Obese vs. normal weight OR[a] (95% CI)
Street connectivity: Gamma[f,h]										
Q1-low connectivity	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Q2	1.00 (0.86—1.16)	1.04 (0.86–1.27)	0.87 (0.52–1.45)	0.87 (0.49–1.53)	1.03 (0.65–1.62)	1.14 (0.56–2.29)	1.07 (0.73–1.58)	1.30 (0.84–2.00)	0.99 (0.81–1.20)	0.97 (0.74–1.27)
Q3	0.90 (0.77–1.07)	1.11 (0.90–1.37)	0.99 (0.59–1.67)	1.57 (0.88–2.80)	1.03 (0.64–1.65)	0.68 (0.31–1.51)	1.05 (0.70–1.59)	1.33 (0.84–2.11)	0.82 (0.65–1.03)	1.06 (0.79–1.44)
Q4-high connectivity	0.98 (0.81–1.19)	1.19 (0.94–1.50)	1.04 (0.61–1.77)	1.59 (0.88–2.87)	1.36 (0.79–2.33)	0.99 (0.37–2.63)	1.17 (0.72–1.89)	**1.77 (1.06–2.95)**	0.78 (0.59–1.04)	0.86 (0.60–1.25)
P_{trend}	0.66	0.28	0.50	**0.02**	0.17	0.68	0.38	**0.03**	**0.03**	0.17
Number of businesses[h]										
Q1-low	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Q2	0.94 (0.79–1.12)	0.97 (0.78–1.22)	0.74 (0.43–1.29)	0.97 (0.50–1.89)	0.93 (0.53–1.65)	0.79 (0.30–2.10)	0.95 (0.61–1.49)	1.08 (0.66–1.76)	1.01 (0.80–1.28)	0.90 (0.66–1.24)
Q3	1.01 (0.83–1.24)	1.07 (0.83–1.38)	0.87 (0.48–1.55)	1.08 (0.54–2.16)	0.95 (0.51–1.78)	0.99 (0.33–2.92)	0.88 (0.54–1.45)	0.97 (0.56–1.69)	1.12 (0.84–1.49)	1.10 (0.76–1.58)
Q4-high	0.86 (0.68–1.08)	**0.74 (0.56–0.99)**	0.66 (0.35–1.27)	0.68 (0.32–1.45)	1.01 (0.50–2.04)	0.61 (0.17–2.19)	0.69 (0.38–1.25)	0.79 (0.42–1.49)	0.94 (0.67–1.32)	**0.61 (0.39–0.96)**
P_{trend}	0.55	0.07	0.37	0.13	0.91	0.31	0.51	0.31	0.90	0.44
Restaurant environment index[g,h]										
Only non–fast food restaurants	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<Median	1.11 (0.94–1.32)	1.05 (0.85–1.29)	1.13 (0.67–1.89)	0.96 (0.55–1.67)	0.85 (0.52–1.42)	0.95 (0.36–2.51)	**1.71 (1.12–2.60)**	1.21 (0.77–1.89)	1.07 (0.84–1.37)	1.17 (0.85–1.60)
>Median	1.07 (0.92–1.25)	1.07 (0.88–1.30)	1.27 (0.79–2.06)	0.97 (0.58–1.63)	0.90 (0.55–1.46)	1.38 (0.58–3.28)	1.28 (0.85–1.91)	1.24 (0.81–1.91)	1.02 (0.82–1.26)	1.01 (0.76–1.33)
No business	0.97 (0.78–1.21)	0.99 (0.74–1.32)	1.45 (0.60–3.49)	1.26 (0.51–3.14)	0.77 (0.34–1.72)	0.63 (0.13–3.02)	1.43 (0.71–2.89)	1.02 (0.48–2.18)	0.88 (0.68–1.14)	1.06 (0.73–1.54)
P_{trend}	0.42	0.15	0.28	0.92	0.55	0.10	0.57	0.20	0.81	0.59
Number of parks[h]										
0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1	**0.86 (0.75–0.99)**	0.97 (0.82–1.15)	1.00 (0.69–1.47)	0.89 (0.60–1.33)	0.84 (0.57–1.24)	1.67 (0.76–3.67)	0.98 (0.67–1.42)	1.05 (0.70–1.56)	**0.81 (0.66–0.99)**	0.98 (0.75–1.27)
2	0.98 (0.84–1.14)	0.99 (0.82–1.19)	1.19 (0.79–1.80)	0.85 (0.55–1.32)	0.91 (0.59–1.40)	2.17 (0.91–5.19)	1.16 (0.77–1.73)	1.01 (0.65–1.55)	0.89 (0.71–1.12)	1.06 (0.80–1.42)
≥3	0.97 (0.83–1.15)	1.08 (0.89–1.31)	1.18 (0.77–1.81)	1.10 (0.70–1.73)	0.70 (0.42–1.17)	1.44 (0.55–3.80)	0.84 (0.55–1.27)	1.07 (0.69–1.65)	1.12 (0.88–1.41)	1.00 (0.73–1.37)
P_{trend}	0.76	0.32	0.31	0.65	0.21	0.27	0.82	0.60	0.26	0.78

NOTE: Values in bold represent a *P* value < 0.05.

[a]Stratified by stage (AJCC) and study (AABCS, CARE, CTS, MEC, SFBCS). Adjusted for age, log (age), year of diagnosis, block group clustering, education, number of births, smoking status, alcohol consumption, hypertension, and diabetes. Analysis for all groups combined also adjusted for race/ethnicity.

[b]On the basis of SES composite index of seven indicator variables for Census block groups (Liu education index, proportion blue collar job, proportion older than age 16 in the workforce without a job, median household income, percent below 200% of federal poverty line, median rent, median house value).

[c]U.S. census data; categories based on CA statewide distribution.

[d]Percent occupied housing with ≥1 occupant per room.

[e]Percent of housing structures with ≥2 units.

[f]Ratio of actual number of street segments to maximum possible number of intersections.

[g]Ratio of the number of fast food restaurants to non–fast food restaurants.

[h]Business or traffic data; categories based on study participant distribution.

Table 2. Association between prediagnosis BMI, the neighborhood environment, and breast cancer–specific mortality, California Breast Cancer Survivorship Consortium

	All $n = 8,995$		African Americans $n = 1,719$	Asian Americans $n = 1,234$	Latinas $n = 1,754$	Non-Latina whites $n = 4,234$
	Deaths (n)	HR[a] (95% CI)	HR[a] (95% CI)	HR[a] (95% CI)	HR[a] (95% CI)	HR[a] (95% CI)
BMI (kg/m^2)						
Normal weight	548	1.00	1.00	1.00	1.00	1.00
Overweight	393	1.04 (0.90–1.19)	0.79 (0.60–1.05)	1.44 (0.93–2.22)	0.99 (0.68–1.44)	1.09 (0.86–1.37)
Obese	213	1.08 (0.90–1.29)	0.83 (0.60–1.14)	1.96 (0.96–3.98)	1.06 (0.69–1.64)	1.21 (0.87–1.69)
Severly obese	75	1.06 (0.81–1.37)	0.87 (0.56–1.37)	—	0.88 (0.45–1.71)	1.37 (0.86–2.19)
Morbidly obese	55	1.22 (0.89–1.68)	1.00 (0.61–1.64)		**2.13 (1.10–4.15)**	0.94 (0.46–1.92)
P_{trend}		0.21	0.66	0.15	0.23	0.24
Socioeconomic status[b,c]						
Q5-high	308	1.00	1.00	1.00	1.00	1.00
Q4	267	0.95 (0.79–1.14)	**0.59 (0.37–0.93)**	0.66 (0.36–1.22)	0.79 (0.48–1.30)	1.19 (0.91–1.56)
Q3	247	1.00 (0.81–1.24)	0.69 (0.43–1.11)	0.85 (0.38–1.86)	1.11 (0.64–1.93)	1.19 (0.85–1.68)
Q2	251	1.14 (0.89–1.46)	0.73 (0.45–1.20)	0.93 (0.38–2.27)	0.76 (0.40–1.42)	**1.73 (1.12–2.67)**
Q1-low	210	1.19 (0.87–1.62)	0.65 (0.37–1.13)	1.20 (0.41–3.53)	1.16 (0.54–2.52)	**2.75 (1.47–5.12)**
P_{trend}		0.10	0.91	0.90	0.96	<**0.01**
Household crowding[c,d]						
Q1-low	272	1.00	1.00	1.00	1.00	1.00
Q2	269	0.89 (0.74–1.07)	0.59 (0.38–0.92)	0.72 (0.36–1.43)	0.86 (0.45–1.65)	0.96 (0.75–1.24)
Q3	345	0.99 (0.81–1.22)	0.87 (0.57–1.32)	1.10 (0.54–2.26)	1.17 (0.62–2.21)	0.76 (0.55–1.05)
Q4-high	397	0.90 (0.70–1.17)	0.82 (0.50–1.34)	0.62 (0.25–1.54)	0.93 (0.45–1.92)	0.73 (0.45–1.18)
P_{trend}		0.67	0.90	0.82	0.96	0.10
% Multifamily housing units[c,e]						
Q1-low %	274	1.00	1.00	1.00	1.00	1.00
Q2	310	1.19 (1.00–1.42)	1.10 (0.73–1.64)	1.08 (0.61–1.90)	**1.91 (1.17–3.10)**	1.00 (0.77–1.30)
Q3	343	1.13 (0.94–1.37)	1.27 (0.85–1.89)	0.69 (0.36–1.33)	**1.98 (1.20–3.26)**	0.79 (0.58–1.07)
Q4-high %	356	1.08 (0.89–1.32)	1.07 (0.71–1.63)	1.34 (0.69–2.58)	1.67 (0.96–2.88)	0.90 (0.64–1.26)
P_{trend}		0.87	0.98	0.88	0.14	0.16
Street connectivity: Gamma[f,g]						
Q1-low %	276	1.00	1.00	1.00	1.00	1.00
Q2	284	0.87 (0.73–1.05)	0.89 (0.56–1.41)	1.36 (0.76–2.45)	0.82 (0.50–1.35)	**0.77 (0.59–0.99)**
Q3	339	0.91 (0.75–1.10)	0.86 (0.54–1.35)	1.75 (0.92–3.35)	1.01 (0.61–1.65)	0.76 (0.56–1.03)
Q4-high %	385	0.95 (0.77–1.17)	0.87 (0.55–1.39)	1.30 (0.65–2.61)	1.53 (0.88–2.66)	0.76 (0.54–1.08)
P_{trend}		0.77	0.74	0.48	0.05	0.12
Number of businesses[g]						
Q1-low	277	1.00	1.00	1.00	1.00	1.00
Q2	323	1.01 (0.84–1.21)	0.95 (0.61–1.49)	1.27 (0.68–2.38)	0.68 (0.42–1.12)	1.04 (0.80–1.36)
Q3	369	1.07 (0.88–1.30)	1.28 (0.81–2.01)	0.91 (0.47–1.76)	**0.55 (0.32–0.96)**	1.19 (0.87–1.63)
Q4-high	314	0.97 (0.77–1.22)	1.18 (0.72–1.95)	0.54 (0.25–1.16)	**0.46 (0.25–0.85)**	1.09 (0.73–1.61)
P_{trend}		0.82	0.27	0.10	**0.04**	0.39
Number of parks[g]						
0	337	1.00	1.00	1.00	1.00	1.00
1	398	1.01 (0.86–1.18)	1.10 (0.81–1.50)	0.79 (0.49–1.28)	**1.66 (1.01–2.73)**	1.01 (0.78–1.30)
2	284	1.07 (0.90–1.28)	1.15 (0.82–1.60)	0.96 (0.56–1.64)	**1.75 (1.05–2.90)**	0.99 (0.73–1.36)
>3	264	0.97 (0.80–1.16)	0.98 (0.69–1.40)	0.70 (0.36–1.37)	**2.02 (1.19–3.43)**	0.92 (0.67–1.26)
P_{trend}		0.90	0.87	0.44	**0.03**	0.60

NOTE: Values in bold represent a P value < 0.05.

[a]Stratified by stage (AJCC) and study (AABCS, CARE, CTS, MEC, SFBCS). Adjusted for age, log (age), year of diagnosis, histology, grade, ER/PR status, nodal involvement, tumor size, second primary tumor, multiple primary tumor, days from diagnosis of index tumor to secondary primary diagnosis, days from diagnosis of index tumor to multiple primary tumor, surgery type, chemotherapy, radiation, clustering by block group, education, parity, smoking, alcohol consumption, hypertension, and diabetes. Analysis for all groups combined also adjusted for race/ethnicity.

[b]On the basis of SES composite index of 7 indicator variables for Census block groups (Liu education index, proportion blue collar job, proportion older than age 16 in the workforce without a job, median household income, percent below 200% of federal poverty line, median rent, median house value).

[c]U.S. census data; categories based on CA state-wide distribution.

[d]Percent occupied housing with ≥1 occupant per room.

[e]Percent of housing structures with ≥2 units.

[f]Ratio of actual number of street segments to maximum possible number of intersections.

[g]Business or traffic data; categories based on study participant distribution.

0.54–0.95; $P_{trend} < 0.01$). Living in streets with high versus low connectivity was associated with a significant increased odds of obesity ($P_{trend} = 0.02$) in African Americans, but there were no other significant BMI–neighborhood associations. No BMI–neighborhood associations were observed among Asian Americans.

Among all breast cancer cases, prediagnostic BMI was not associated with breast cancer–specific mortality (Table 2) and was marginally associated with all-cause mortality ($P_{trend} = 0.05$; Table 3). For Latinas, those who were morbidly obese (BMI > 40 kg/m^2) were at increased risks of breast cancer–specific (HR, 2.13; 95% CI, 1.10–4.15) and all-cause (HR,

Table 3. Association between prediagnosis BMI, the neighborhood environment, and all-cause mortality, California Breast Cancer Survivorship Consortium

	All $n = 8{,}995$		African Americans $n = 1{,}719$	Asian Americans $n = 1{,}234$	Latinas $n = 1{,}754$	Non-Latina whites $n = 4{,}234$
	Deaths (*n*)	**HR[a] (95% CI)**	**HR[a] (95% CI)**	**HR[a] (95% CI)**	**HR[a] (95% CI)**	**HR[a] (95% CI)**
BMI (kg/m^2)						
Normal weight	1,008	1.00	1.00	1.00	1.00	1.00
Overweight	753	1.01 (0.91–1.12)	0.87 (0.7–1.07)	1.23 (0.88–1.71)	1.00 (0.75–1.33)	1.01 (0.87–1.17)
Obese	419	1.07 (0.94–1.22)	0.81 (0.64–1.04)	1.45 (0.84–2.48)	1.20 (0.88–1.65)	1.18 (0.96–1.46)
Severly obese	150	1.12 (0.93–1.35)	0.86 (0.62–1.2)	—	1.33 (0.86–2.06)	**1.41 (1.02–1.94)**
Morbidly obese	96	1.24 (0.98–1.57)	1.04 (0.72–1.5)		**2.15 (1.31–3.53)**	1.06 (0.64–1.76)
P_{trend}		**0.05**	0.42	0.42	<**0.01**	**0.05**
Socioeconomic status[b,c]						
Q5-high	584	1.00	1.00	1.00	1.00	1.00
Q4	501	0.95 (0.83–1.08)	**0.54 (0.38–0.77)**	0.87 (0.53–1.43)	0.90 (0.62–1.31)	1.05 (0.88–1.26)
Q3	490	1.08 (0.93–1.26)	0.72 (0.50–1.03)	1.16 (0.63–2.14)	1.30 (0.86–1.96)	1.13 (0.91–1.40)
Q2	472	1.12 (0.94–1.34)	**0.66 (0.45–0.95)**	0.87 (0.42–1.78)	0.92 (0.57–1.48)	**1.42 (1.07–1.87)**
Q1-low	376	1.11 (0.89–1.38)	**0.58 (0.38–0.89)**	1.11 (0.48–2.58)	1.07 (0.61–1.90)	**1.75 (1.17–2.62)**
P_{trend}		0.16	0.27	0.78	0.71	0.01
Household crowding[c,d]						
Q1-low	516	1.00	1.00	1.00	1.00	1.00
Q2	535	1.03 (0.90–1.17)	0.82 (0.58–1.15)	1.20 (0.68–2.09)	0.98 (0.61–1.57)	1.07 (0.91–1.27)
Q3	646	1.11 (0.96–1.29)	1.09 (0.78–1.51)	1.45 (0.80–2.63)	0.98 (0.61–1.58)	1.03 (0.84–1.27)
Q4-high	726	1.04 (0.87–1.25)	1.03 (0.71–1.49)	1.12 (0.55–2.30)	0.96 (0.57–1.62)	0.89 (0.66–1.21)
P_{trend}		0.41	0.52	0.39	0.78	0.86
% Multifamily housing units[c,e]						
Q1-low %	490	1.00	1.00	1.00	1.00	1.00
Q2	573	1.12 (0.98–1.27)	1.00 (0.74–1.35)	1.16 (0.74–1.81)	**1.62 (1.15–2.28)**	1.04 (0.87–1.25)
Q3	650	1.09 (0.95–1.25)	1.22 (0.91–1.65)	0.87 (0.53–1.42)	**1.47 (1.03–2.09)**	0.90 (0.74–1.11)
Q4-high %	710	1.12 (0.97–1.3)	1.15 (0.85–1.56)	1.12 (0.66–1.91)	1.39 (0.94–2.04)	1.02 (0.82–1.27)
P_{trend}		0.25	0.28	0.92	0.28	0.62
Street connectivity: Gamma[f,g]						
Q1-low %	505	1.00	1.00	1.00	1.00	1.00
Q2	587	0.98 (0.87–1.12)	1.06 (0.75–1.52)	1.32 (0.84–2.09)	1.08 (0.76–1.56)	0.92 (0.78–1.09)
Q3	610	0.93 (0.81–1.06)	1.05 (0.74–1.49)	1.45 (0.88–2.39)	0.95 (0.66–1.37)	**0.80 (0.65–0.97)**
Q4-high %	723	1.03 (0.89–1.19)	1.08 (0.76–1.53)	1.18 (0.68–2.03)	1.42 (0.95–2.14)	0.91 (0.73–1.14)
P_{trend}		0.86	0.70	0.41	0.13	0.21
Number of businesses[g]						
Q1-low	519	1.00	1.00	1.00	1.00	1.00
Q2	614	1.01 (0.89–1.15)	0.91 (0.65–1.28)	1.09 (0.66–1.79)	0.84 (0.59–1.21)	1.06 (0.88–1.26)
Q3	679	1.02 (0.89–1.18)	1.00 (0.71–1.41)	0.98 (0.58–1.66)	0.83 (0.56–1.24)	1.12 (0.91–1.37)
Q4-high	611	0.93 (0.79–1.09)	1.00 (0.69–1.46)	0.61 (0.34–1.1)	0.70 (0.44–1.09)	0.99 (0.77–1.27)
P_{trend}		0.38	0.67	0.05	0.20	0.73
Number of parks[g]						
0	617	1.00	1.00	1.00	1.00	1.00
1	734	1.00 (0.9–1.13)	1.07 (0.84–1.35)	0.74 (0.51–1.08)	1.27 (0.90–1.80)	1.02 (0.86–1.21)
2	537	1.05 (0.92–1.19)	1.11 (0.86–1.44)	0.87 (0.58–1.32)	1.30 (0.91–1.85)	1.05 (0.86–1.28)
≥3	535	1.03 (0.90–1.17)	1.19 (0.91–1.55)	0.76 (0.46–1.25)	1.26 (0.86–1.85)	0.99 (0.81–1.22)
P_{trend}		0.55	0.27	0.31	0.33	0.95

NOTE: Values in bold represent a *P* value < 0.05.

[a]Stratified by stage (AJCC) and study (AABCS, CARE, CTS, MEC, SFBCS). Adjusted for age, log (age), year of diagnosis, histology, grade, ER/PR status, nodal involvement, tumor size, second primary tumor, multiple primary tumor, days from diagnosis of index tumor to secondary primary diagnosis, days from diagnosis of index tumor to multiple primary tumor, surgery type, chemotherapy, radiation, clustering by block group, education, parity, smoking, alcohol consumption, hypertension, and diabetes. Analysis for all groups combined also adjusted for race/ethnicity.

[b]On the basis of SES composite index of 7 indicator variables for Census block groups (Liu education index, proportion blue collar job, proportion older than age 16 in the workforce without a job, median household income, percent below 200% of federal poverty line, median rent, median house value).

[c]U.S. census data; categories based on CA state-wide distribution.

[d]Percent occupied housing with ≥1 occupant per room.

[e]Percent of housing structures with ≥2 units.

[f]Ratio of actual number of street segments to maximum possible number of intersections.

[g]Business or traffic data; categories based on study participant distribution.

2.15; 95% CI, 1.31–3.53) mortalities versus normal-weight women. Neighborhood–mortality associations were most notable among Latinas. Latinas living in neighborhoods with a high versus low proportion of multifamily housing units were at increased risks of breast cancer–specific and all-cause mortalities. Latinas living in neighborhoods with a high versus low number of businesses had a lower risk of breast cancer–specific mortality (HR, 0.46; 95% CI, 0.25–0.85), while those living in neighborhoods with >1 park were at greater risk of breast cancer–specific mortality versus those living in neighborhoods with no parks ($P_{trend} = 0.03$).

Neighborhood SES was associated with mortality among non-Latina whites and African Americans but in opposite directions (Tables 2 and 3). Non-Latina whites living in low versus high SES neighborhoods were at increased risk of breast cancer–specific (Q1 vs. Q5: HR, 2.75; 95% CI, 1.47–5.12; $P_{trend} < 0.01$) and all-cause (Q1 vs. Q5: HR, 1.75; 95% CI, 1.17–2.62; $P_{\text{trend}} = 0.01$) mortalities. Conversely, African Americans living in SES neighborhoods (Q1–Q4) had decreased risks of breast cancer–specific and all-cause mortalities versus those living in the highest SES (Q5) neighborhood, but these relationships were not linear. Because of the differing proportions of non-Latina whites and African Americans in the higher SES groups (Q4 and Q5 = 70.2% and 24.5%, respectively), we examined SES and mortality associations using race/ethnicity-specific cut points and found similar mortality associations between the lowest versus highest levels of SES in comparison to using the state-wide cut points (data not shown). For Asian Americans, no neighborhood–mortality associations were observed.

Discussion

Our central aim of this large consortium study was to examine breast cancer mortality in relation to obesity and specific attributes of the neighborhood environment potentially related to obesity across diverse racial/ethnic groups. In cross-sectional analysis, we identified that greater household crowding and more street connectivity (among Latinas) and low neighborhood SES and less multifamily housing (among non-Latina whites) were important risk factors for obesity. In addition, low neighborhood SES (among non-Latina whites) and high multifamily housing neighborhoods (among Latinas) were associated with higher mortality in a prospective analysis; and lower neighborhood SES (among African Americans) and greater number of businesses (among Latinas) were associated with lower mortality. To our knowledge, this is one of the first studies to evaluate a comprehensive suite of neighborhood attributes and their associations with breast cancer mortality across multiple racial/ethnic groups.

In a previous pooled analysis (18) of 4,345 breast cancer cases from the San Francisco Bay Area that included SFBCS participants (21, 22), lower neighborhood SES was associated with higher overall mortality. Our findings confirm the inverse association between SES and mortality reported by Keegan and colleagues (18) and others (23–28) that have largely focused on whites and examined SES alone and no other neighborhood attributes. Furthermore, we identified heterogeneous effects by race/ethnicity for the associations of neighborhood SES with overall mortality ($P_{\text{interaction}} < 0.01$) as evidenced by the higher risk of mortality with increasing SES for non-Latina whites and the lack of clear associations in other racial/ethnic groups. In addition, we did not observe an association between the number of neighborhood parks and breast cancer–specific mortality as previously reported (18) except among Latina women. As this finding with neighborhood parks was unexpected in the prior study (18) and the SFBCS was included in our CBCSC pooled analysis, we conducted a sensitivity analysis among Latinas excluding those from the SFBCS and found no association between the number of parks and breast cancer–specific mortality. This indicates that our finding may be related to differences in neighborhood features among Latinas in the SFBCS compared with the other Latinas in the CBCSC. For example, Latinas in SFBCS lived in neighborhoods of higher SES and fewer connected streets than other Latinas in the CBCSC (Latinas in SFBCS vs. other Latinas in CBCSC: SES Q4 and Q5 = 58% vs. 31.8%; street connectivity Q1 and Q2 = 49.5% vs. 40%). This association also may be related to the quality of parks, important information that may underlie the reported association (18) but was not available in our study.

For Latinas, living in neighborhoods with a greater number of businesses was associated with a lower risk of breast cancer–specific mortality. We hypothesize that such neighborhoods may offer more opportunities for physical activity via walking as a means of transportation, as well as provide availability of resources (29, 30) that may have positive effects on breast cancer–specific mortality for Latinas. Physical activity has been associated with lower mortality of breast cancer (31). In contrast, living in neighborhoods with a greater proportion of multifamily housing units was associated with increased all-cause and breast cancer–specific mortalities among Latinas. We hypothesize that the higher mortality associated with higher housing density may be related to limited open space that would reduce opportunities for physical activity (29, 32). As there was no evidence of an association between multifamily housing and obesity among Latinas in our study, this finding highlights the need to identify other factors underlying this association with housing density.

In a recent review of cancer research and neighborhood factors of the social and built environment (33), 12 studies were identified that examined mortality following cancer diagnosis (18, 34–44), including 7 studies specifically focused on breast cancer (18, 34–36, 41–43). These studies of breast cancer primarily examined racial/ethnic density or segregation with neighborhood SES in relation to mortality (34, 35, 41–43, 45), and only one study as discussed above (18) has similarly examined specific social and built environment attributes as reported here. Our findings build upon our prior CBCSC study (1) that reported obesity as a prognostic factor among non-Latina whites and Latinas by identifying neighborhood attributes that have independent effects on mortality among Latinas and non-Latina whites in conjunction with obesity.

In this consortium of approximately 9,000 diverse breast cancer cases, we identified features of the neighborhood environment that impact obesity and mortality following breast cancer diagnosis for Latinas and non-Latina whites; however, evidence that the neighborhood environment influences mortality for African American and Asian American women with breast cancer was not seen. We were limited by insufficient numbers to disaggregate Latinas and Asian Americans into specific population subgroups (46–48). An important consideration is that our neighborhood definition based on administrative boundaries may not correspond to residents' perceptions of their neighborhood environment (49). However, using Census boundaries does allow us to efficiently examine a number of social and built environment factors across a large number of geographic units that would have been costly to obtain through other sources (e.g., self-report, neighborhood audits); moreover, it is plausible that the attributes of census boundaries may highly correlate with perceived neighborhoods (50). In addition, we were unable to account for neighborhood disorder, safety, and deterioration (51), factors that could influence the associations that we observed (e.g., higher odds of obesity among Latinas and African Americans residing in neighborhoods with more connected streets). We tested *a priori* selected neighborhood factors and because no validated cumulative index of street connectivity exists for California, we were unable to examine such an index, which that may better capture physical activity environments. Finally, we did not adjust for multiple testing and recognize that some of our findings may be due to chance. Future research should incorporate these elements when evaluating factors underlying the neighborhood associations with obesity and mortality. Such insight is important for identifying interventions to improve survival outcomes for breast cancer patients across all racial/ethnic populations.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Disclaimer

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.

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Grant Support

This work was supported by the California Breast Cancer Research Program (CBCRP; grant 16ZB-8001 to A.H. Wu, R. Sposto, C. Vigen; 16ZB-8002 to S.L. Gomez, T.H. Keegan, S. Shariff-Marco, J. Koo, J. Yang, A.W. Kurian, E.M. John; 16ZB-8003 to L. Bernstein, Y. Lu; 16ZB-8004 to M.L. Kwan; and 16ZB-8005 to K. R. Monroe, I. Cheng, B.E. Henderson). The Asian American Breast Cancer Study was supported by CBCRP grants 1RB-0287, 3PB-0120, and 5PB-0018 to. A.H. Wu. The San Francisco Bay Area Breast Cancer Study was supported by National Cancer Institute grants R01 CA063446 and R01 CA077305; by the U.S. Department of Defense (DOD) grant DAMD17-96-1-6071; and by the CBCRP grants 4JB-1106 and 7PB-0068 to E.M. John. 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). The California Teachers Study was funded by the California Breast Cancer Act of 1993; National Cancer Institute grants (R01 CA77398 and K05 CA136967) to L. Bernstein and the California Breast Cancer Research Fund (contract 97-10500) to L. Bernstein. The Multiethnic Cohort Study was supported by National Cancer Institute grants R01 CA54281, R37CA54281, and UM1 CA164973 to B.E. Henderson, L.N. Kolonel, L. Le Marchand, and L.R. Wilkens. The Life After Cancer Epidemiology Study is supported by National Cancer Institute grant R01 CA129059 to B.J. Caan. 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.

Received January 15, 2015; revised May 21, 2015; accepted May 26, 2015; published OnlineFirst June 10, 2015.

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