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Impact of neighborhoods and body size on survival after breast cancer diagnosis

Salma Shariff-Marco[a,b,c,*,1], **Scarlett L. Gomez**[a,b,c,1], **Meera Sangaramoorthy**[a,1], **Juan Yang**[a,1], **Jocelyn Koo**[a,1], **Andrew Hertz**[a,1], **Esther M. John**[a,b,c,1], **Iona Cheng**[a,c,1], and **Theresa H.M. Keegan**[d,2]

Scarlett L. Gomez: Scarlett.Gomez@cpic.org; Meera Sangaramoorthy: Meera.Sangaramoorthy@cpic.org; Juan Yang: Juan.Yang@cpic.org; Jocelyn Koo: Jocelyn.Koo@cpic.org; Andrew Hertz: Andrew.Hertz@cpic.org; Esther M. John: Esther.John@cpic.org; Iona Cheng: Iona.Cheng@cpic.org; Theresa H.M. Keegan: tkeegan@ucdavis.edu

[a]Cancer Prevention Institute of California, Fremont, CA, USA

[b]Department of Health Research and Policy (Epidemiology), Stanford University School of Medicine, Stanford, CA, USA

[c]Stanford Cancer Institute, Stanford, CA, USA

[d]Division of Hematology and Oncology, UC Davis School of Medicine, Sacramento, CA, USA

Abstract

With data from the Neighborhoods and Breast Cancer Study, we examined the associations between body size, social and built environments, and survival following breast cancer diagnosis among 4347 women in the San Francisco Bay Area. Lower neighborhood socioeconomic status and greater neighborhood crowding were associated with higher waist-to-hip ratio (WHR). After mutual adjustment, WHR, but not neighborhood characteristics, was positively associated with overall mortality and marginally with breast cancer-specific mortality. Our findings suggest that WHR is an important modifiable prognostic factor for breast cancer survivors. Future WHR interventions should account for neighborhood characteristics that may influence WHR.

Keywords

Body size; Waist-to-hip ratio; Breast cancer survival; Neighborhood

1. Introduction

With the growing number of breast cancer survivors in the United States, it is important to identify modifiable factors that contribute to better survival after breast cancer diagnosis (American Cancer Society, 2012). Prior studies have shown that lifestyle factors, including physical activity and body size, influence survival (Vance et al, 2011; Hauner et al, 2011;

[*]Corresponding author at: Cancer Prevention Institute of California, 2201 Walnut Ave, Suite 300, Fremont, CA 94536, USA. Fax: +510 608 5085. Salma.Shariff-Marco@cpic.org (S. Shariff-Marco).
[1]Cancer Prevention Institute of California, 2201 Walnut Ave, Suite 300, Fremont, CA 94536, USA.
[2]UC Davis Comprehensive Cancer Center, 4501 X Street, Suite 3016, Sacramento, CA 95817, USA.

Conflict of Interest
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Protani et al, 2010; Carmichael and Bates, 2004; Chen et al, 2010; Caan et al, 2008; Conroy et al, 2011; Kwan et al, 2012, 2014). Neighborhood social and built environment factors may be associated with body size and ultimately with survival through several pathways, including material deprivation, health behaviors (healthy eating, physical activity) and access to resources (Feng et al., 2010; Northridge et al., 2003; Diez Roux and Mair, 2010; Yen et al., 2009; Meijer et al., 2012; Krieger, 2001; Gomez et al., 2015). Few studies, however, have examined associations between body size and survival among racially/ ethnically diverse groups (Conroy et al., 2011; Kwan et al., 2012, 2014), and no studies have assessed how neighborhood factors are associated with body size and survival among women diagnosed with breast cancer.

Obesity has been consistently associated with worse overall (Hauner et al., 2011) and breast cancer-specific (Protani et al., 2010; Chen et al., 2010; Caan et al., 2008; Kwan et al., 2012, 2014) survival, with no variation by race/ethnicity (Conroy et al., 2011; Kwan et al., 2012). While body mass index (BMI) has been the most commonly studied indicator of body size, weight change (Vance et al., 2011; Chen et al., 2010; Caan et al., 2008) and waist-to-hip ratio (WHR), a measure of body fat distribution that reflects both adipose tissue and muscle mass (Molarius and Seidell, 1998), have also been considered. Although the findings for weight gain have been mixed (Vance et al., 2011; Chen et al., 2010; Caan et al., 2008), associations between larger WHR and worse survival after breast cancer diagnosis have been noted in two (Protani et al., 2010; Kwan et al., 2014) of three studies that examined these associations (Protani et al., 2010; Chen et al., 2010; Kwan et al., 2014).

We used data from the Neighborhoods and Breast Cancer (NABC) Study to examine the association of body size with survival after breast cancer diagnosis among a racially/ ethnically diverse cohort of women with breast cancer. We also assessed the associations of neighborhood characteristics with body size and survival.

2. Materials and methods

2.1. Subjects

Breast cancer cases in the NABC Study, described in more detail elsewhere (Shariff-Marco et al., 2014; Keegan et al., 2014), were identified through the Greater Bay Area Cancer Registry and participated in the San Francisco Bay Area Breast Cancer Study (SFBCS), a case-control study in African American (AA), Hispanic, and non-Hispanic white (NHW) women that included breast cancer cases aged 35–79 years and diagnosed between 1995 and 2002 (John et al., 2003, 2005), or in the Northern California site of the Breast Cancer Family Registry (NC-BCFR), a multiethnic family study that included breast cancer cases aged 18–64 years and diagnosed between 1995 and 2009 (John et al., 2004, 2007). Cases were screened by telephone to assess study eligibility, with 84% and 83% participation among those contacted in SFBCS and NC-BCFR, respectively. Eligible cases completed an in-person interview (n = 2258 (88%) in SFBCS; and n= 3631 (77%) in NC-BCFR as of September 2009).

We limited the analysis to 5237 women diagnosed with a first primary invasive breast cancer between 1995 and 2008 who completed the interview themselves. We excluded cases for the following reasons: NC-BCFR duplicate cases who also participated in SFBCS (*n*= 339), no geocodeable address (*n*= 198) or follow-up information (*n*= 25) from the cancer registry, a prior cancer (*n*= 259), Native American or mixed race/ethnicity (*n*= 11), or unknown BMI (*n*= 58). The final analysis included 4347 cases interviewed on average 21.0 months (SD=11.1 months) after diagnosis. Mean follow-up after interview was 7.4 years. Study participants provided written informed consent and all protocols were approved by the Institutional Review Board of the Cancer Prevention Institute of California.

2.2. Data collection

In both studies, professional interviewers conducted in-person interviews at the participants' homes in English, Spanish, or Chinese using similarly structured questionnaires which facilitated data harmonization and pooling for analysis. In both studies, the reference year was defined as the calendar year prior to diagnosis. Data were collected on age at diagnosis, race/ethnicity, education, first-degree family history of breast cancer, personal history of benign breast disease, years since last pregnancy, history of oral contraceptive use, history of menopausal hormone therapy use, alcohol intake during the reference year (Block et al., 1986, 1990), and recent (during the 3 years prior to diagnosis) recreational physical activity (hours per week) (Bernstein et al., 1994; John et al., 2003; Yang et al., 2003; Dallal et al., 2007; West-Wright et al., 2009; Keegan et al., 2014). In SFBCS, recreational physical activity was assessed using an approach developed by Dr. Leslie Bernstein that asked participants to list all episodes of sports and exercise in which they engaged (Bernstein et al., 1994); other studies of breast cancer have observed inverse associations with physical activity using a similar approach (John et al., 2003; Yang et al., 2003). In NC-BCFR, the questions on recreational physical activity were modeled after the approach used in the California Teachers Study where participants were asked to list hours per week that they spent doing moderate and strenuous physical activities (Dallal et al., 2007; West-Wright et al., 2009). Assessment and harmonization of recreational physical activity for these two studies has been previously reported in detail (Keegan et al., 2014).

Both studies assessed self-reported weight in the reference year (i.e., pre-diagnosis weight) and adult height. NC-BCFR also assessed self-reported weight at interview, whereas SFBCS measured weight and height at interview. For women who declined the measurements, self-reported height was used for the BMI calculation. Pre-diagnosis BMI (kg/m^2) was calculated as weight (kg) in the reference year divided by height (m) and was categorized according to World Health Organization cut points (underweight: ≤ 18.5 kg/m^2; normal weight: 18.6–24.9; overweight: 25.0–29.9; obese: ≥ 30.0) (World Health Organization, 2000). Percent weight change (kg) was calculated as the difference between weight at interview and weight in the reference year divided by weight in the reference year; percent weight change was categorized based on previously published work with the following distribution of total cases: decrease (≥ 2%), stable (± 1%), moderate increase (2–10%), and large increase (> 10%) (Bradshaw et al., 2012). Waist and hip circumferences were measured at interview in SFBCS only (*n*= 1916 cases). WHR was calculated as waist circumference (cm) divided by hip circumference (cm) measured at interview, and as done in prior studies WHR was categorized according to the quartile distribution among all cases (John et al., 2013, 2011; Kwan et al., 2014; Protani et al. 2010).

For each case, we obtained cancer registry information on year of diagnosis, ICD-O-3 tumor histologic subtype, histological grade, estrogen receptor (ER) and progesterone receptor (PR) status, AJCC stage, time to first and second subsequent tumors, first-course treatment, marital status, and vital status (routinely determined by the cancer registry through hospital follow-up and database linkages) as of December 31, 2009, and, for the deceased, the underlying cause of death (California Cancer Registry, 2009). Using cause of death information for breast cancer from cancer registries has been validated previously (Hu et al. 2013).

2.3. Neighborhood social and built environment characteristics

Data on neighborhood characteristics were obtained from the California Neighborhoods Data System (Gomez et al., 2011). We examined a broad suite of social and built environment factors to better understand which specific factors are contributing to body size and survival after breast cancer. Residential address at the time of diagnosis was geocoded to latitude and longitude coordinates and then assigned a 2000 Census block group (representing an average of 1500 residents with a range of 600–3000 residents). For 2% of cases, we geocoded their address at time of interview as their address at time of diagnosis was incomplete or not geocodeable (e.g., PO Box). For neighborhood-level socioeconomic status (nSES), we used a previously validated composite measure of seven SES indicators from Census data at the level of block group (Yost et al., 2001). In addition to population density (persons/square meter), neighborhood density was characterized at the block group level by urban/rural status (Reynolds et al., 2005) and percentage of occupied housing units with more than one occupant per room (crowding). Urban/rural status is derived from census defined Urbanized Areas (population ≥ 50,000) and Urban Clusters (population between 2500 and 50,000) (see footnotes of tables). Street connectivity was measured using Gamma, the ratio of actual number of street segments to maximum possible number of intersections, with a higher ratio indicating more street connectivity/ walkability (Berrigan et al., 2010). Data on traffic counts from the California Department of Transportation (California Department of Transportation, 2004) were used to obtain traffic density within a 500-meter buffer of each residence, using methods described previously (Gunier et al., 2003). Other neighborhood social factors include percentage of total housing units that are not single family dwellings (i.e., structures with more than 2 units), percentage of foreign-born residents, and percentage of linguistically isolated households (US Census Bureau, 2002). Quintiles/quartiles cut-points were based on distributions among the study cases with the exception of neighborhood SES and population density which were based on statewide distributions.

We derived information on neighborhood amenities including business listings from Walls and Associates' National Establishment Time-Series Database from 1990 to 2008 (Walls and Associates, 2008), and farmers' markets listings in 2010 from the California Department of Food and Agriculture (California Department of Food and Agriculture, 2010). Using ArcGIS software, neighborhood amenities within a 1600-meter network distance (Thornton et al., 2011) from residence at diagnosis were averaged over a 4 year window-one year before diagnosis, during the year of diagnosis, and two years after diagnosis. For the small proportion of cases diagnosed in 2007 and 2008 (2%) for whom we did not have 4 years of business data, we averaged over a 2 or 3 year window, depending on data availability. The average number of recreational facilities included places where recreational activities could take place. The Restaurant Environment Index is the ratio of the average number of fast food restaurants to other restaurants, and the Retail Food Environment Index (California Center for Public Health Advocacy et al., 2008) is the ratio of the average number of convenience stores, liquor stores, and fast food restaurants to supermarkets and farmers' markets. Quintiles/quartiles cut-points for these measures were based on distributions among the study cases, with the exception of the Restaurant Environment Index, Retail Food Environment Index and number of farmer's markets (see footnotes of tables).

2.4. Statistical analysis

We examined the association between body size (BMI, % weight change, WHR) with overall and breast cancer (BC)-specific mortality using stage- and study-stratified Cox proportional hazards regression to calculate hazard ratios (HR) and 95% confidence intervals (CI). Our base hazard regression models were adjusted for age at diagnosis, year of diagnosis (calendar year), study, and race/ethnicity. Subsequently, we adjusted for tumor characteristics, treatment, and personal factors associated with survival. We performed stratified analyses by age at diagnosis (< 50 or ≥ 50 years), ER status (ER+, ER−, unknown), and race/ ethnicity (NHW, AA, Hispanic, Asian American). Tests for heterogeneity across strata were conducted using likelihood ratio tests comparing models with and without an interaction term between body size measures and the stratified variable; no significant interactions were found (data not shown).

Because WHR was the only body size measure significantly associated with mortality, we examined the relationship between WHR (> median vs. ≤ median) and neighborhood factors, using logistic regression to calculate odds ratios (OR) and 95% CIs. Neighborhood factors that were associated with WHR and/or survival were included in the multivariable Cox regression models. Tests for linear trend were used to evaluate associations between mortality and increasing ordinal categories of body size and neighborhood characteristics (Liu, 2007). We also tested for interactions between nSES and WHR and found no statistically significant interactions (data not shown). All models included cluster adjustment for census block groups, as there were insufficient numbers of cases within each block group to warrant multilevel modeling; of the 1371 block groups in the WHR analysis, over 70% had only one case. The sandwich estimator of the covariance structure, applied to Cox proportional hazards regression models, accounted for any intracluster dependence and yielded robust standard error estimates even under model misspecification (Lin and Wei, 1989). Analyses were conducted using SAS (version 9.3, Cary, NC). We also tested for spatial autocorrelation (using Moran's I) in the multivariable Cox regression models with deviance residuals from our fully-adjusted regression models using ArcGIS -ESRI (version 10.1, Redding, CA) and found no evidence of it.

For deceased women, survival time was measured in days from the date of diagnosis to the date of death of any cause for overall mortality and to the date of death from breast cancer for BC-specific mortality. We used left truncation at the date of interview to adjust for the time from diagnosis to interview. For BC-specific mortality, women who died from other causes were censored at the time of death. Women alive at the study end date (December 31, 2009) were censored at the earlier of the two—the study end date or the date of last follow-up (i.e., last known contact) which was obtained from the California Cancer Registry in October 2011. The proportional hazards assumption was tested for WHR and neighborhood variables using significance tests of interactions with the time scale, and visual examination of scaled Schoenfeld residual plots; there was no evidence that these variables violated the assumption of proportional hazards.

3. Results

The case cohort was comprised of women from diverse racial/ ethnic backgrounds (Table 1). A majority of women were diagnosed with breast cancer at age 45 years or older (73%), or at an early stage (AJCC stage I and II) (88%). The subset of women with WHR measures had similar distributions for most characteristics as the full case cohort, with a few exceptions (Table 1). In the WHR subset, higher proportions of women identified as Hispanic (52%), or reported being physically inactive (49%), and a higher proportion of deaths was due to non-breast cancer causes (45%). For the total case cohort, most women were overweight or obese in the reference year (57%) and did not experience a weight change (51%); in the subset with WHR data, half the women had a WHR > 0.82 (Table 2).

3.1. Body size and survival

3.1.1. Body mass index (BMI)—Women who were obese (versus normal weight) in the year before diagnosis had higher overall mortality in base (HR=1.21, 95% CI = 1.02–1.43, p-trend=0.03), but not in the fully-adjusted regression models. No association with pre-diagnosis BMI and BC-specific mortality was observed (Table 2).

3.1.2. Percent weight change—No associations with percent weight change were observed for overall mortality or BC-specific mortality (Table 2).

3.1.3. Waist-to-hip ratio (WHR)—Compared to women in the lowest WHR quartile, those with higher WHRs had higher overall mortality in the fully adjusted model (quartile 3: HR=1.33, 95% CI=0.99–1.78; quartile 4: HR=1.65, 95% CI =1.20–2.26, p-trend < 0.01). Similar associations were observed for BC-specific mortality (highest vs. lowest quartile: HR=1.62, 95% CI= 1.06–2.48, p-trend=0.03) (Table 2).

We also examined how subsets of the covariates in the fully adjusted model impacted the hazard ratio (HR) among women with Q4 versus Q1 WHR, and found that the driving factor is treatment, in particular, surgery (data not shown).

3.2. Neighborhood associations with WHR

Of women with WHR measures, the majority resided in neighborhoods of higher SES (62%) and higher population density (68%) (Table 3). In fully-adjusted models, only nSES, crowding, and Restaurant Environment Index remained significantly associated with higher WHR. Residing in lower SES neighborhoods was associated with over two times the odds of having higher WHRs (lowest vs. highest nSES: OR=2.54, 95% CI=1.26–5.11, p-trend < 0.01). Similar associations were observed for neighborhoods with more crowded housing (highest vs. lowest quartile: OR=1.70, 95% CI=1.02–2.82, p-trend=0.04). Lack of fast food was suggestively associated with lower WHR (No fast food restaurants vs. <median ratio of fast food restaurants to other restaurants OR=0.70, 95% CI=0.48–1.02).

3.3. WHR, neighborhood, and survival

While we observed associations between specific neighborhood characteristics and overall mortality in base models (see Table 4, Model 1), no associations remained in models that additionally adjusted for tumor, treatment and personal characteristics, as well as all other neighborhood characteristics (Table 4, Models 2 and 3). WHR remained associated with higher overall mortality in models adjusting for neighborhood characteristics (highest vs. lowest quartile: HR =1.64, 95% CI=1.19–2.25; p-trend < 0.01). Results were similar for BC-specific mortality (highest vs. lowest quartile: HR=1.63, 95% CI =1.05–2.53; p-trend=0.03).

4. Discussion

In this study of racial/ethnically diverse women with breast cancer and data on clinical and tumor characteristics, personal factors, and social and built environment neighborhood characteristics, we found that WHR was independently associated with both overall and BC-specific mortality. These findings are consistent with prior studies (Protani et al., 2010; Kwan et al., 2014). In addition, like our study, others also did not observe that body size/survival associations varied by race/ethnicity (Conroy et al., 2011; Kwan et al., 2012). Furthermore, we found that lower nSES and more household crowding, were associated with higher WHR, but not with survival, after adjustment for tumor, treatment, and personal characteristics and other neighborhood characteristics. Our WHR findings contribute to the growing literature on WHR as an important, modifiable prognostic factor that can be intervened upon (e.g., diet and/or physical activity programs or more regular follow-up for recurrence or other comorbidities).

Our findings of higher WHR associated with higher overall and BC-specific mortality are consistent with two of three studies that examined these associations (Protani et al., 2010; Kwan et al., 2014; Chen et al., 2010). A meta-analysis found that higher WHR was associated with higher BC-specific mortality (pooled HR across 4 studies=1.31; 95% CI=1.14–1.50) (Protani et al., 2010). The California Breast Cancer Survivorship Consortium, which included data from SFBCS and 5 other studies, also showed that higher WHR was associated with higher risk of both overall (among all women, African Americans, and Asian Americans) and breast cancer-specific (among Asian Americans) mortality (Kwan et al., 2014). Our finding of a borderline association between percent weight loss (≥ 2%) and mortality is consistent with prior studies; however, the more modest association in our study compared to others may be due to variability in the timing of post-diagnosis weight measurement as well as the influence of treatment, such as chemotherapy, on weight across studies (Vance et al., 2011; Chen et al., 2010; Caan et al., 2008). Conversely, we found that BMI in the year before breast cancer diagnosis, unlike in most prior studies (Hauner et al., 2011; Protani et al., 2010; Chen et al., 2010; Caan et al., 2008; Conroy et al., 2011; Kwan et al., 2012, 2014), was not associated with survival after adjusting for tumor characteristics, treatment and personal factors. While BMI is the most commonly used body size measure, some evidence suggests that it may not be the best measure, particularly in multiethnic populations (Protani et al., 2010; Kwan et al., 2014; Boeing, 2013). Our finding of an association with WHR illustrates the importance of considering multiple measures of body size to assess associations with survival among diverse racial/ethnic populations of breast cancer patients.

This is the first study to demonstrate that social and built environment factors were associated with WHR among women with breast cancer. We demonstrated that lower nSES, and more household crowding were associated with higher WHR while the lack of fast food restaurants was suggestively associated with lower WHR. Similar associations for nSES and restaurants environment have been shown in prior studies among non-cancer populations (Keller et al., 2013; Xu et al., 2013,; haix et al., 2008). However, in analyses that considered the associations of neighborhood characteristics and WHR with survival, only WHR remained associated with survival. To assess whether WHR attenuated associations between neighborhood characteristics and survival, we modeled neighborhood factors without WHR and did not find significant associations, suggesting that WHR was not mediating associations between neighborhood and mortality (data not shown). Furthermore, the lack of association with nSES once we accounted for other neighborhood factors may also have resulted from interactions with other neighborhood characteristics, as found previously for nSES and ethnic enclaves (Keegan et al., 2010). Although statistical power was limited to detect such interactions in this study and there was no evidence of multi-collinearity in the fully adjusted Cox regression models, distributions of the other neighborhood characteristics by nSES suggest that participants living in low-SES neighborhoods were also living in neighborhoods with higher traffic density, more crowding and more linguistically isolated households (data not shown). Future research is needed to determine the potential pathways through which neighborhood features (e.g., SES, housing and food environment) and individual factors (e.g. body size) may contribute to survival after breast cancer diagnosis.

Our study is subject to some limitations. As weight was a self-reported measure, it may be sensitive to inaccurate recall; however, correlation of self-reported and measured weight in a subset of participants who had both measures was very high (r=0.84). Other covariates such as alcohol consumption and physical activity also were self-reported and were not validated though these measures have been extensively used in prior studies (Block G et al., 1986, 1990; Bernstein et al., 1994; John et al., 2003; Yang et al., 2003; Dallal et al., 2007; West-Wright et al., 2009; Keegan et al., 2014). Also, because WHR was only available for participants in the SFBCS study, the statistical power for the WHR analysis was limited and our findings may not be generalizable to Asian Americans. However, we did not find race/ethnicity to modify the body size and survival findings, in agreement with two other studies (Conroy et al., 2011; Kwan et al., 2012). Due to data availability, some of our neighborhood measures were based on more contemporary data (e.g., farmers markets) that may not reflect neighborhoods prior to this time. We did not have perceived or audit neighborhood measures to assess quality and use by study participants. Lastly, while our study sample is representative of women with breast cancer in the San Francisco Bay Area, the findings may not be generalizable to other geographic regions across the country. Despite these limitations, this study considers social and built environment features at a small geography using objective measures from secondary data sources for the study of breast cancer survival. Additional strengths include a population-based design, high response rates from participants, and a racially/ethnically diverse study population. A large number of prognostic factors from both interview and clinical sources were considered and bias due to differential follow-up was minimized by linkage to population-based cancer registries and death registry records.

Our findings indicate that future research on modifiable prognostic factors after breast cancer diagnosis should consider body size measures beyond BMI, such as WHR, which may better characterize distribution of adiposity among diverse groups of women (Protani et al., 2010; Kwan et al., 2014; Boeing, 2013). We also found that certain neighborhood characteristics were associated with WHR. These findings could be used, along with WHR, to identify a priority subgroup of breast cancer survivors that might benefit from lifestyle interventions or increased medical surveillance that aim to improve their WHR and survival after diagnosis. Interventions aimed at improving WHR need to take into consideration neighborhood characteristics that can influence WHR and provide tailored resources and strategies that leverage neighborhood resources or overcome deficits.

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Appendix. Distribution of waist-to-hip ratio (WHR) by body mass index (BMI)1, Neighborhoods and Breast Cancer Study, 1995–2008 (N=1916)

Waist-to-hip ratio	Body mass index				
	Underweight (≤ 18.5)	Normal (18.6–24.9)	Overweight (25–29.9)	Obese (≥ 30)	Total
≤ **Median** (≤ **0.82**)	73.68%	72.73%	45.47%	29.61%	50.42%
>**Median** (>**0.82**)	26.32%	27.27%	54.53%	70.39%	49.58%

Waist-to-hip ratio	Body mass index				
	Underweight (≤ 18.5)	Normal (18.6–24.9)	Overweight (25–29.9)	Obese (≥ 30)	Total
Total	19	682	607	608	1916

[1]Waist and hip circumferences were measured at interview in SFBCS only.

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Table 1

Characteristics of breast cancer patients with body mass index and waist-to-hip ratio measures, Neighborhoods and Breast Cancer Study, 1995–2008 (*N* = 4347).

	Body mass index (*N*= 4347)		**Waist-to-hip ratio (*N*= 1916)**	
	N	**%**	***N***	**%**
Age at diagnosis (years)				
< 35	298	6.9%	0	0.0%
35–44	862	19.8%	384	20.0%
45–54	1439	33.1%	593	31.0%
55–64	1222	28.2%	480	25.1%
≥ 65	526	12.1%	459	24.0%
AJCC stage at diagnosis				
I	1899	43.7%	867	45.3%
II	1930	44.4%	864	45.1%
III	306	7.0%	104	5.4%
IV	79	1.8%	26	1.4%
Unknown	133	3.1%	55	2.9%
Tumor estrogen and progesterone receptor status				
ER−PR−	921	21.2%	380	19.8%
ER+ or PR+	3003	69.1%	1339	69.9%
Unknown	423	9.7%	197	10.3%
Subsequent primary tumor				
No	3722	85.6%	1598	83.4%
Yes	625	14.4%	318	16.6%
Type of surgery				
None	89	2.0%	34	1.8%
Lumpectomy	2375	54.6%	1054	55.0%
Mastectomy	1882	43.3%	828	43.2%
Unknown	1	0.0%	0	0.0%
Chemotherapy				
No	1895	43.6%	956	49.9%

	Body mass index (*N*= 4347)		Waist-to-hip ratio (*N*= 1916)	
	N	**%**	***N***	**%**
Yes	2400	55.2%	937	48.9%
Unknown	52	1.2%	23	1.2%
Radiation				
No	1788	41.1%	780	40.7%
Yes	2559	58.9%	1136	59.3%
Study recruitment				
San Francisco Bay Area Breast Cancer Study (SFBCS)	2075	47.7%	1916	100.0%
Northern California site of the Breast Cancer Family Registry (NC-BCFR)	2272	52.3%	0	0.0%
Race/ethnicity				
African American	975	22.4%	424	22.1%
Asian American	667	15.3%	1	0.1%
Hispanic	1646	37.9%	1003	52.3%
Non-Hispanic white	1059	24.4%	488	25.5%
Education				
Less than high school	825	19.0%	471	24.6%
High school graduate	772	17.8%	421	22.0%
Some college	1403	32.3%	574	30.0%
College graduate or post graduate	1318	30.3%	424	22.1%
Unknown	29	0.7%	26	1.4%
Marital status				
Single	794	18.3%	292	15.2%
Married	2609	60.0%	1123	58.6%
Separated or divorced	547	12.6%	234	12.2%
Widowed	293	6.7%	208	10.9%
Unknown	104	2.4%	59	3.1%
History of benign breast disease				
No	3572	82.2%	1523	79.5%
Yes	772	17.8%	390	20.4%
Unknown	3	0.1%	3	0.2%
Menopausal status				

	Body mass index (*N*= 4347)		Waist-to-hip ratio (*N*= 1916)	
	N	**%**	***N***	**%**
Premenopausal	1516	34.9%	628	32.8%
Postmenopausal	2560	58.9%	1141	59.6%
Unknown	271	6.2%	147	7.7%
History of menopausal hormone therapy use				
Never	2849	65.5%	1124	58.7%
Former	715	16.4%	290	15.1%
Current	783	18.0%	502	26.2%
Alcohol consumption in reference year (g/day)				
0	2650	61.0%	1017	53.1%
< 5	644	14.8%	440	23.0%
5–9.9	344	7.9%	110	5.7%
10–14.9	264	6.1%	124	6.5%
≥ 15	429	9.9%	225	11.7%
Unknown	16	0.4%	0	0.0%
Recent recreational physical activity (hrs/wk) (quartiles)[a]				
None	1444	33.2%	943	49.2%
Q1: 0.01–1.92	721	16.6%	263	13.7%
Q2: 1.93–3.00	772	17.8%	189	9.9%
Q3: 3.01–6.38	676	15.6%	266	13.9%
Q4: 46.39	730	16.8%	255	13.3%
Unknown	4	0.1%	0	0.0%
Vital status through December 31, 2009				
Alive	3452	79.4%	1427	74.5%
Deceased	895	20.6%	489	25.5%
% of deaths due to breast cancer[b]	560	62.6%	267	54.6%

[a]Based on the quartile distribution among all cases in study population with non-zero values.

[b]Percentages calculated using deceased cases as denominators.

Table 2

Body size associations with survival after breast cancer diagnosis: hazard ratios (HR) with 95% confidence intervals (CI), adjusting for clinical and individual-level characteristics, Neighborhoods and Breast Cancer Study, 1995–2008 (N = 4347).

	Total case cohort		Overall mortality						Breast Cancer-Specific Mortality					
	No. cases	**%**	**No. of deaths**	**%**	**HR**[a]	**95% CI**	**HR**[b]	**95% CI**	**No. of deaths**	**%**	**HR**[a]	**95% CI**	**HR**[b]	**95% CI**
Pre-diagnosis BMI (kg/m^2)														
≤ 18.5: Underweight	78	2%	18	2%	1.43	0.92–2.23	1.55	0.97–2.48	9	2%	0.92	0.48–1.76	0.94	0.48–1.84
18.6–24.9: Normal	1795	41%	323	36%	1.00		1.00		226	40%	1.00		1.00	
25–29.9: Overweight	1264	29%	261	29%	1.08	0.91–1.28	1.05	0.88–1.26	154	28%	1.02	0.82–1.27	1.03	0.82–1.29
≥ 30: Obese	1210	28%	293	33%	**1.21**	**1.02–1.43**	1.11	0.92–1.33	171	31%	1.13	0.91–1.40	1.08	0.86–1.36
p trend[c]						**0.03**		*0.23*				*0.26*		*0.42*
% Weight change[d]														
Decreased, ≥ 2%	604	14%	174	21%	1.29	0.98–1.69	1.23	0.92–1.63	87	17%	1.34	0.96–1.88	1.35	0.94–1.95
Stable, ± 1%	2112	51%	339	42%	1.00		1.00		247	48%	1.00		1.00	
Increased, 2–10%	784	19%	154	19%	0.84	0.63–1.12	0.88	0.65–1.20	81	16%	0.98	0.67–1.42	1.09	0.73–1.63
Increased, > 10%	668	16%	148	18%	0.88	0.66–1.18	0.89	0.65–1.21	99	19%	1.09	0.75–1.59	1.19	0.79–1.79
p trend[e]						0.54		*0.61*				*0.35*		*0.25*
Waist-to-hip ratio (quartiles)[f]														
Q1: ≤ 0.77	482	25%	96	20%	1.00		1.00		59	22%	1.00		1.00	
Q2: 0.78–0.82	484	25%	109	22%	1.15	0.86–1.53	1.20	0.89–1.62	65	24%	1.22	0.84–1.76	1.29	0.87–1.90
Q3: 0.83–0.86	479	25%	130	27%	**1.48**	**1.07–1.83**	1.33	0.99–1.78	72	27%	1.42	0.99–2.03	1.39	0.94–2.07
Q4: ≥ 0.87	471	25%	154	31%	**1.68**	**1.28–2.22**	**1.65**	**1.20–2.26**	71	27%	1.44	0.99–2.09	**1.62**	**1.06–2.48**
p trend						**<0.01**		**<0.01**				**0.04**		**0.03**

[a]Adjusted for age at diagnosis (continuous), year of diagnosis (continuous calendar year), race/ethnicity (non-Hispanic white, African American, Hispanic, Asian American), clustering by block group, and stratified by study (SFBCS, NC-BCFR) and AJCC stage (I, II, III, IV, unknown) except WHR models which were not stratified by study as all women were from SFBCS.

[b]Adjusted for age at diagnosis (continuous), year of diagnosis (continuous calendar year), race/ethnicity (non-Hispanic white, African American, Hispanic, Asian American), histology (ductal, lobular, other), histological grade (1, 2, 3 or 4,unknown), ERPR status (ER−PR−, ER+ or PR+, unknown), first subsequent primary tumor (no, yes), time to first subsequent primary tumor (months, continuous), type of surgery (none, lumpectomy, mastectomy, unknown), chemotherapy (no, yes, unknown), radiation (no, yes), marital status (single, married, separated/divorced, widowed, unknown), education (less than high school (HS), HS graduate, vocational/technical school or some college, college graduate or graduate school, unknown), history of benign breast disease (no, yes, unknown), menopausal status (premenopausal, postmenopausal, unknown), age at menarche (< 12,12,13, ≥ 14), number of full-term pregnancies (0,1, 2, 3, ≥ 4), months of breastfeeding (nulliparous, 0, < 12,12–23, ≥ 24, unknown), years since last full-term pregnancy (< 2,2–4, ≥ 5, unknown), history of hormonal contraception use (never, ever, unknown), history of menopausal hormone therapy use (never, former, current, unknown), recent recreational physical activity (0, Q1, Q2, Q3, Q4), alcohol consumption in grams/day (0, < 5,5–9,10–14, ≥ 15, unknown), and clustering by block group, and stratified by study (SFBCS, NC-BCFR)

and AJCC stage (I, II, III, IV, unknown) except WHR models which were not stratified by study as all women were from SFBCS. If the main effect variable is % weight change or waist-to-hip ratio, the models are further adjusted for pre-diagnosis BMI (underweight, normal, overweight, obese).

[c]Trend excludes those with BMI $\leq$ 18.5 (underweight).

[d]Percent change between pre- (reference year) and post-diagnosis (interview) weight.

[e]Trend excludes those with decreased weight change.

[f]Sample size for these analyses is 1916.

Table 3

Association of neighborhood characteristics with high waist-to-hip ratio[a]: multivariable odds ratios (OR) with 95% confidence intervals (CI), Neighborhoods and Breast Cancer Study, 1995–2008 (*N* =;1916).

	N	%	**Model 1: OR, 95% CI[b]**		**Model 2: OR, 95% CI[c]**	
Neighborhood socioeconomic status (SES) (quintiles)[d]						
Q5: > 0.84 (high SES)	694	36.2%	1.00		1.00	
Q4: 0.23–0.84	493	25.7%	**1.47**	**1.15–1.88**	1.17	0.88–1.56
Q3: −0.30−0.22	358	18.7%	**2.11**	**1.59–2.80**	**1.45**	**1.01–2.07**
Q2: −0.90 to −0.31	277	14.5%	**2.45**	**1.80–3.34**	**1.63**	**1.07–2.48**
Q1: <−0.90 (low SES)	94	4.9%	**4.25**	**2.40–7.55**	**2.54**	**1.26–5.11**
p trend				**< 0.01**		**< 0.01**
Population density (persons/square meter) (quartiles)[d]						
Q1: < 0.00108	239	12.5%	1.00		1.00	
Q2: 0.00108–0.00256	380	19.8%	1.13	0.80–1.61	1.01	0.68–1. 51
Q3: 0.00257–0.00428	561	29.3%	**1.45**	**1.04–2.02**	1.05	0.69–1.58
Q4: > 0.00428	736	38.4%	**2.09**	**1.52–2.89**	1.20	0.74–1.94
p trend				**< 0.01**		0.46
Percentage of non-single family units (quartiles)[e]						
Q1: < 3.6	479	25.0%	1.00		1.00	
Q2: 3.6–23.3	468	24.4%	1.27	0.97–1.66	1.07	0.81–1.43
Q3: 23.4–51.8	475	24.8%	**1.69**	**1.29–2.21**	1.11	0.81–1.52
Q4: > 51.8	494	25.8%	**1.73**	**1.32–2.28**	1.10	0.78–1.56
p trend				**< 0.01**		0.58
Percentage of occupied housing units with more than one occupant per room (crowding) (quartiles)[e]						
Q1: < 3.29	450	23.5%	1.00		1.00	
Q2: 3.30–9.80	481	25.1%	**1.53**	**1.16–2.03**	1.17	0.86–1.60
Q3: 9.81–21.11	472	24.6%	**1.93**	**1.45–2.57**	1.34	0.91–1.96
Q4: > 21.11	513	26.8%	**2.95**	**2.20–3.95**	**1.70**	**1.02–2.82**
p trend				**< 0.01**		**0.04**
Percentage of foreign-born residents (quartiles)[e]						

	N	%	Model 1: OR, 95% CI[b]		Model 2: OR, 95% CI[c]	
Q1: < 15.9	463	24.2%	1.00		1.00	
Q2: 15.9–26.3	495	25.8%	**1.34**	**1.02–1.76**	1.00	0.72–1.39
Q3: 26.4–41.5	473	24.7%	**1.66**	**1.24–2.21**	1.06	0.71–1.58
Q4: 441.5	485	25.3%	**1.89**	**1.42–2.52**	0.99	0.61–1.63
p trend				**< 0.01**		0.97
Percentage of linguistically isolated (quartiles) [e]						
Q1: < 3.01	457	23.9%	1.00		1.00	
Q2: 3.01–7.32	500	26.1%	**1.49**	**1.13–1.96**	1.12	0.81–1.55
Q3: 7.33–13.96	468	24.4%	**1.76**	**1.32–2.34**	0.99	0.66–1. 4 8
Q4: > 13.96	491	25.6%	**2.16**	**1.63–2.87**	0.91	0.56–1. 4 9
p trend				**< 0.01**		0.64
Block Group-level Gamma (quartiles) [e]						
Q1: < 0.40	443	23.1%	1.00		1.00	
Q2: 0.40–0.43	475	24.8%	**1.36**	**1.03–1.79**	1.09	0.79–1. 4 8
Q3: 0.44–0.48	485	25.3%	**1.72**	**1.30–2.28**	1.27	0.91–1.78
Q4: > 0.48	513	26.8%	**1.89**	**1.43–2.48**	1.22	0.84–1.78
p trend				**< 0.01**		0.21
Traffic density within 500 m of residence (vehicle miles traveled per square mile) (quartiles) [e]						
Q1: < 31,280	426	22.2%	1.00		1.00	
Q2: 31,281–60,581	462	24.1%	**1.36**	**1.03–1.81**	1.15	0.84–1. 57
Q3: 60,582–99,608	478	24.9%	**1.43**	**1.07–1.90**	1.03	0.73–1. 4 4
Q4: > 99,608	490	25.6%	**1.69**	**1.28–2.24**	1.09	0.75–1.59
Unknown	60	3.1%	0.89	0.51–1.53	1.04	0.56–1.93
p trend[f]				**< 0.01**		0.93
Restaurant Environment Index within 1600 m of residence[g]						
0 (No fast-food restaurants)	492	25.7%	**0.54**	**0.41–0.70**	0.70	0.48–1.02
M1:< 0.11	625	32.6%	1.00		1.00	
M2:> 0.11	665	34.7%	0.98	0.78–1.23	0.99	0.75–1. 31
No restaurants	134	7.0%	**0.53**	**0.36–0.78**	1.10	0.58–2.09
p trend[h]				**< 0.01**		**0.04**

	N	%	**Model 1: OR, 95% CI[b]**		**Model 2: OR, 95% CI[c]**	
Retail Food Environment Index within 1600 meters of residence[i]						
0	233	12.2%	1.00		1.00	
< 1	1,186	61.9%	**1.79**	**1.30–2.45**	1.05	0.68–1.63
≥ 1	346	18.1%	**1.48**	**1.03–2.12**	1.12	0.71–1.75
No retail food outlets	151	7.9%	0.69	0.43–1.10	0.62	0.35–1.10
p trend[j]				0.11		0.06
Number of total businesses within 1600 m (quartiles) [e]						
Q1: < 68	424	22.1%	1.00		1.00	
Q2: 681–132	460	24.0%	1.27	0.97–1.66	0.79	0.55–1.14
Q3: 133–258	484	25.3%	**1.55**	**1.18–2.03**	0.84	0.54–1.28
Q4: > 258	548	28.6%	**1.70**	**1.29–2.25**	0.92	0.53–1.59
ptrend				**< 0.01**		0.86
Number of farmer's markets within 1600 m						
0	1389	72.5%	1.00		1.00	
1–2	483	25.2%	**1.25**	**1.00–1.56**	0.96	0.72–1. 27
3+	44	2.3%	1.35	0.72–2.41	0.93	0.46–1.87
p trend				**0.04**		0.85
Number of recreational facilities within 1600 m (quartiles) [e]						
Q1: < 2	552	28.8%	1.00		1.00	
Q2: 2–3	484	25.3%	1.16	0.89–1.50	0.97	0.71–1.32
Q3: 4–7	488	25.5%	1.08	0.83–1.40	0.82	0.58–1.16
Q4: > 7	392	20.5%	**1.34**	**1.02–1.77**	0.94	0.60–1.45
p trend				0.07		0.48
Urban/Rural Status[k]						
Metropolitan urban	515	26.9%	1.00		1.00	
Metropolitan suburban	1,104	57.6%	**0.68**	**0.55–0.85**	1.15	0.81–1. 6 4
City	282	14.7%	**0.54**	**0.39–0.74**	1.01	0.62–1.65
Town/Rural	15	0.8%	0.44	0.12–1.58	1.06	0.29–3.85

[a]Waist-to-hip ratio was categorized into high (>median) vs. low (≤ median).

[b]Adjusted for age at diagnosis (continuous), study (SFBCS, NC-BCFR), race/ethnicity (non-Hispanic white, African American, Hispanic, Asian American), AJCC stage (I, II, III, IV, unknown), and clustering by block group.

[c]Adjusted for all covariates in Model 1 and all neighborhood variables shown in the table, and clustering by block group.

[d]Based on the quintile/quartile distribution for block groups in California.

[e]Based on the quartile distribution among all study cases.

[f]Does not include unknown category.

[g]For the Restaurant Environment index, 0 indicates a neighborhood with no fast food restaurants; for neighborhoods with fast food restaurants, we used the median value of the ratio of fast foods to other restaurants to split the sample into those living in neighborhoods with relatively fewer fast foods to other restaurants (M1) and those living in neighborhoods with relatively more fast foods to other restaurants (M2). M2 includes those who have a numerator value > 0 and a denominator=0.

[h]Does not include no restaurants category.

[i]For the Retail Food Environment Index, 0 indicates that the neighborhood has no unhealthy food outlets, a ratio of < 1 indicates that there are fewer unhealthy food outlets compared to healthy food outlets, where as a ratio greater than 1 indicates that there are more unhealthy food outlets compared to healthy ones.

[j]Does not include no retail food outlets category.

[k]Urban/rural status is derived from census defined Urbanized Areas (population ≥ 50,000) and Urban Clusters (population between 2500 and 50,000). Classification is performed at the Block level. Blocks are then aggregated to Block Groups according to the dominant classification (by population). Blocks in Urbanized Areas with population ≥ 1,000,000 are classified as Metropolitan. Those blocks are further classified based on population density with the highest quartile being classified as Metropolitan Urban and the remaining as Metropolitan Suburban. The remaining Blocks in Urbanized Areas (population between 50,000 and 1,000,000) are classified as City. Blocks in Urban Clusters (population between 2500 and 50,000) and not in the lowest quartile of population density are classified as Town. The remaining blocks are classified as Rural (in Urban Clusters and the lowest quartile of population density or in neither Urbanized Areas nor Urban Clusters).

Table 4

Association of waist-to-hip ratio, neighborhood features and survival after breast cancer diagnosis: multivariable hazard ratios (HR) with 95% confidence intervals (CI), Neighborhoods and Breast Cancer Study, 1995–2008 (*N*=1916).

	Overall mortality						Breast Cancer-Specific Mortality					
	Model 1: HR 95% CI[a]		**Model 2: HR 95% CI[b]**		**Model 3: HR 95% CI[c]**		**Model 1: HR 95% CI[a]**		**Model 2: HR 95% CI[b]**		**Model 3: HR 95% CI[c]**	
Waist-to-hip ratio (quartiles)												
Q1: ≤ 0.77	1.00		1.00		1.00		1.00		1.00		1.00	
Q2: 0.78–0.82	1.15	0.86–1.53	1.14	0.86–1.53	1.21	0.90–1.64	1.22	0.84–1.76	1.21	0.84–1.75	1.32	0.89–1. 97
Q3: 0.83–0.86	**1.40**	**1.07–1.83**	**1.34**	**1.02–1.76**	1.32	0.98–1.77	1.42	0.99–2.03	1.39	0.96–2.02	1.43	0.95–2.16
Q4: ≥ 0.87	**1.68**	**1.28–2.22**	**1.62**	**1.23–2.13**	**1.64**	**1.19–2.25**	1.44	0.99–2.09	1.41	0.96–2.06	**1.63**	**1.05–2.53**
p trend		**< 0.01**		***< 0.01***		***< 0.01***		***0.04***		*0.06*		***0.03***
Neighborhood socioeconomic status (SES) (quintiles)[d]												
Q1: <−0.90 (low SES)	**1.73**	**1.17–2.55**	1.29	0.78–2.14	1.15	0.71–1.88	1.27	0.73–2.20	0.89	0.42–1.85	0.83	0.41–1. 6 8
Q2: −0.90 to −0.31	**1.42**	**1.05–1.91**	1.17	0.81–1.70	1.02	0.69–1.49	1.27	0.85–1.88	1.03	0.61–1.75	1.02	0.58–1.79
Q3: −0.30–0.22	1.18	0.90–1.54	1.00	0.72–1.39	0.99	0.71–1.39	1.00	0.70–1.44	0.87	0.54–1.39	0.94	0.59–1.52
Q4: 0.23–0.84	1.00	0.78–1.29	0.87	0.66–1.16	0.79	0.59–1.04	0.92	0.65–1.29	0.80	0.54–1.20	0.79	0.52–1.18
Q5: > 0.84 (high SES)	1.00		1.00		1.00		1.00		1.00		1.00	
p trend		**< 0.01**		0.21		0.47		0.21		0.93		0.99
Percentage of occupied housing units with more than one occupant per room (crowding) (quartiles)[e]												
Q1: < 3.29	1.00		1.00		1.00		1.00		1.00		1.00	
Q2: 3.30–9.80	0.97	0.75–1.26	1.21	0.91–1.62	0.97	0.73–1.27	0.88	0.61–1.27	0.85	0.59–1.23	1.02	0.70–1. 4 8
Q3: 9.81–21.11	1.09	0.84–1.42	1.23	0.86–1.76	0.93	0.67–1.30	0.89	0.62–1.26	0.79	0.53–1.19	0.79	0.50–1.25
Q4: > 21.11	**1.30**	**1.01–1.68**	1.07	0.70–1.66	1.12	0.78–1.61	1.31	0.94–1.83	1.24	0.80–1.92	1.27	0.78–2.05
p trend		**0.03**		0.73		0.61		0.11		0.42		0.49
Percentage of linguistically isolated (quartiles)[e]												
Q1:< 3.01	1.00		1.00		1.00		1.00		1.00		1.00	
Q2:3.01–7.32	1.20	0.92–1.57	1.21	0.91–1.62	1.15	0.85–1.56	0.86	0.59–1.25	0.94	0.62–1.41	0.90	0.59–1.38
Q3:7.33–13.96	1.31	1.00–1.72	1.23	0.86–1.76	1.20	0.82–1.75	1.28	0.89–1.83	1.34	0.84–2.16	1.34	0.80–2.24
Q4: > 13.96	**1.41**	**1.08–1.86**	1.07	0.70–1.66	1.01	0.63–1.59	1.17	0.81–1.68	0.97	0.55–1.72	0.87	0.47–1.60
ptrend		**0.01**		0.73		0.94		0.14		0.75		0.95

	Overall mortality						Breast Cancer-Specific Mortality					
	Model 1: HR 95% CI[a]		Model 2: HR 95% CI[b]		Model 3: HR 95% CI[c]		Model 1: HR 95% CI[a]		Model 2: HR 95% CI[b]		Model 3: HR 95% CI[c]	
Traffic density within 500 meters of residence (vehicle miles traveled per square mile) (quartiles)[e]												
Q1:80	1.00		1.00		1.00		1.00		1.00		1.00	
Q2: 31,281–60,581	1.00	0.76–1.31	0.94	0.70–1.24	0.93	0.69–1.25	0.87	0.59–1.28	0.87	0.58–1.28	0.89	0.58–1.36
Q3: 60,582–99,608	**1.31**	**1.01–1.69**	1.18	0.88–1.57	1.15	0.85–1.56	**1.42**	**1.02–1.97**	1.36	0.94–1.97	1.32	0.89–1.95
Q4:> 99,608	1.25	0.97–1.61	1.11	0.81–1.50	1.07	0.77–1.47	1.14	0.81–1.63	1.08	0.71–1.64	1.03	0.65–1.63
Unknown	1.14	0.69–1.89	1.16	0.69–1.98	1.42	0.82–2.45	0.79	0.34–1.84	0.83	0.35–1.98	1.01	0.39–2.67
ptrend[f]		**0.02**		0.22		0.36		0.09		0.22		0.34
Restaurant Environment Index within 1600 meters of residence												
0	0.90	0.71–1.14	1.15	0.88–1.51	1.13	0.85–1.51	0.91	0.66–1.25	1.10	0.76–1.58	1.04	0.71–1.54
M1: −0.11	1.00		1.00		1.00		1.00		1.00		1.00	
M2:> 0.11	1.13	0.91–1.41	1.21	0.96–1.53	1.17	0.92–1.49	0.97	0.72–1.31	1.01	0.73–1.40	1.00	0.71–1.40
No Restaurants	0.94	0.66–1.33	1.25	0.80–1.95	1.13	0.70–1.81	0.92	0.56–1.51	1.22	0.68–2.18	1.02	0.55–1. 91
p trend[g]		**0.04**		0.51		0.67		0.72		0.60		0.80
Number of farmers' markets within 1600 meters												
0	1.00		1.00		1.00		1.00		1.00		1.00	
1–2	1.17	0.96–1.40	1.13	0.91–1.40	1.09	0.88–1.36	1.15	0.88–1.50	1.13	0.84–1.50	1.17	0.86–1.58
≥ 3	1.46	0.87–2.44	1.33	0.74–2.41	1.21	0.62–2.36	1.05	0.52–2.11	1.03	0.47–2.26	0.91	0.35–2.36
p trend		**0.05**		0.20		0.39		0.38		0.51		0.52

[a] Adjusted for age at diagnosis (continuous), year of diagnosis (continuous calendar year), race/ethnicity (non-Hispanic white, African American, Hispanic, Asian American), clustering by block group, and stratified by AJCC stage (I, II, III, IV, unknown).

[b] Adjusted for all variables in Model 1 including all neighborhood variables shown in the table, waist-to-hip ratio, clustering by block group, and stratified by AJCC stage (I, II, III, IV, unknown).

[c] Adjusted for all variables in Model 2 and histology (ductal, lobular, other), histological grade (1, 2, 3 or 4, unknown), ERPR status (ER−PR−, ER+ or PR+, unknown), first subsequent primary tumor (no, yes), time to first subsequent primary tumor (months, continuous), type of surgery (none, lumpectomy, mastectomy, unknown), chemotherapy (no, yes, unknown), radiation (no, yes), marital status (single, married, separated/divorced, widowed, unknown), education (less than high school (HS), HS graduate, vocational/technical school or some college, college graduate or graduate school, unknown), history of benign breast disease (no, yes, unknown), menopausal status (premenopausal, postmenopausal, unknown), age at menarche (< 12,12,13, ≥ 14), number of full-term pregnancies (0,1, 2, 3, ≥ 4), months of breastfeeding (nulliparous, 0, < 12,12–23, ≥ 24, unknown), years since last full-term pregnancy (< 2,2–4, ≥ 5, unknown), history of hormonal contraception use (never, ever, unknown), history of menopausal hormone therapy use (never, former, current, unknown), recent recreational physical activity (0, Q1, Q2, Q3, Q4), alcohol consumption in grams/day (0, < 5, 5–9,10–14, ≥ 15, unknown), pre-diagnosis BMI (underweight, normal, overweight, obese), clustering by block group, and stratified by study (SFBCS, NC-BCFR) and AJCC stage (I, II, III, IV, unknown).

[d] Based on the quintile distribution for block groups in California.

[e] Based on the quartile distribution among all study cases.

[f] Does not include unknown category.

[g] Does not include no restaurants category.