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

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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.



## 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; 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

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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: $\leq 18.5$ kg/m$^2$; normal weight: 18.6–24.9; overweight: 25.0–29.9; obese: $\geq 30.0$) (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 ($\geq 2\%$), stable ($\pm 1\%$), 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 $\geq 50{,}000$) 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