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Conroy, Shannon
Von Behren, Julie
Kwan, Marilyn
et al.

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Neighborhood Attributes and Cardiovascular Disease Risk in Breast Cancer Survivors: the Pathways Study

Shannon M. Conroy, PhD, MPH[1,*], **Julie Von Behren, MPH**[2], **Marilyn L. Kwan, PhD**[3], **Lawrence H. Kushi, ScD**[3], **Mi-Ok Kim, PhD**[2,4], **Carlos Iribarren, MD, PhD, MPH**[3], **Janise M. Roh, MSW, MPH**[3], **Cecile A. Laurent, MS**[3], **Catherine Thomsen, MPH**[5], **Janet N. Chu**[6], **Heather Greenlee, ND, PhD, MPH**[7], **Scarlett Lin Gomez, PhD, MPH**[2,4], **Salma Shariff-Marco, PhD, MPH**[2,4]

[1]Department of Public Health Sciences, School of Medicine, University of California, Davis, Davis, CA

[2]Department of Epidemiology and Biostatistics, University of California San Francisco, San Francisco, CA

[3]Division of Research, Kaiser Permanente Northern California, Oakland, CA

[4]Helen Diller Family Comprehensive Cancer Center, University of California San Francisco, San Francisco, CA

[5]Zero Breast Cancer, San Rafael, CA

[6]Division of General Internal Medicine, University of California San Francisco, San Francisco, CA

[7]Public Health Sciences and Clinical Research Divisions, Fred Hutchinson Cancer Center, Seattle, WA

Abstract

Background: Breast cancer survivors are at higher risk of cardiovascular disease (CVD) morbidity and mortality compared with the general population. We examined the impact of objective social and built neighborhood attributes on CVD risk in a cohort of female breast cancer survivors.

Methods: We included 3,975 participants from the Pathways Study, a prospective cohort of women with invasive breast cancer from an integrated healthcare system in Northern California. Women diagnosed with breast cancer from 2006 through 2013 were enrolled on average about two months after diagnosis. We geocoded their baseline addresses and appended

Corresponding author Dr. Salma Shariff-Marco, Department of Epidemiology and Biostatistics, University of California, San Francisco, 550 16th Street, Second Floor, San Francisco, CA 94158, Salma.Shariff-Marco@ucsf.edu.

*Conroy and Von Behren are co-first authors

Author contributions: Conceptualization – SMC, MLK, LK, HG, SLG, SSM. Data curation - SMC, JVB, MLK, LK, JMR, CAL, HG, SLG, SSM. Formal analysis - SMC, JVB, MLK, LK, MK, JMR, CAL, HG, SLG, SSM. Funding acquisition - SMC, MLK, LK, HG, SLG. Investigation SMC, JVB, MLK, LK, MK, CI, JMR, CAL, CT, JNC HG, SLG, SSM. Methodology - SMC, JVB, MLK, LK, MK, CI, JMR, CAL, CT, JNC HG, SLG, SSM. Project administration – SMC, MLK, LK, JMR, HG, SLG, SSM. Supervision - SMC, MLK, LK, HG, SLG, SSM. Writing original draft – SMC, JVB, MLK, MK, HG, SLG, SSM. Writing review and editing- SMC, JVB, MLK, LK, MK, CI, JMR, CAL, CT, JNC HG, SLG, SSM.

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neighborhood attributes for racial/ethnic composition, socioeconomic status (SES), population density, urbanization, crime, traffic density, street connectivity, parks, recreational facilities, and retail food environment. Incident CVD events included ischemic heart disease, heart failure, cardiomyopathy, or stroke. Cox proportional hazards models estimated associations of neighborhood attributes with CVD risk, accounting for clustering by block groups. Fully adjusted models included sociodemographic, clinical, and behavioral factors.

Results: During follow-up through December 31, 2018, 340 (8.6% of) participants had CVD events. A neighborhood racial/ethnic composition measure, percent of Asian American/Pacific Islander residents (lowest quintile HR=1.85, 95% CI 1.03, 3.33), and crime index (highest quartile HR=1.48, 95% CI 1.08, 2.03) were associated with risk of CVD events, independent of individual SES, hormone receptor status, treatment, cardiometabolic comorbidities, body mass index, and physical activity.

Conclusions: By applying a socio-ecological framework, we can begin to understand how residential environments shape health outcomes in women with breast cancer and impact CVD risk on this growing population.

Keywords

cardiovascular risk; crime; social environment; breast cancer survivors; neighborhood

Introduction

Breast cancer survivors are a growing population of more than 3.8 million women in the U.S.[1] Breast cancer-specific mortality has declined steadily in recent years due to improvements in early detection and treatment.[2] About 90% of women diagnosed with breast cancer survive at least five years.[2] Relative to the general population, these survivors are at higher risk for developing and dying from cardiovascular disease (CVD), especially those diagnosed at older ages.[3–5]

Neighborhood environments are recognized social determinants of health.[6] Neighborhoods can be characterized by both objective measures, such as physical features, and by subjective measures, such as perceptions of safety. Ecological studies have shown that neighborhood social and built environments may independently impact health behaviors and outcomes,[7, 8] including breast cancer survival,[9–11] CVD risk,[12–16] and overall mortality.[17] Neighborhood attributes may impact health and health behaviors through several pathways, including social factors such as social cohesion, crime, and community support and the physical environment including walkability, the presence of parks, grocery stores, and fast food outlets.[7, 18] Studies have demonstrated that residing in neighborhoods of lower socioeconomic status (SES), high racial/ethnic residential segregation, high traffic volume, and high crime levels has been adversely associated with CVD outcomes independent of individual-level SES and risk factors.[12–15, 19] In contrast, neighborhoods characterized by physical features such as availability of healthy food stores and enhanced walking/physical activity opportunities, and subjective measures such as social cohesion, are associated with favorable CVD risk profiles.[19, 20]

Identifying the role of neighborhood factors in their impact on CVD risk is critical in ensuring optimal wellness and survivorship of breast cancer survivors.[21–23] A population-based study showed rural-urban disparities in CVD mortality among breast and gynecologic cancer survivors were largely explained by neighborhood characteristics.[24] Yet, a critical gap in knowledge exists on the role of residential neighborhoods on CVD risk in breast cancer survivors. Therefore, the goal of this study was to investigate prospectively the impact of objectively-measured residential neighborhood attributes on incident CVD events in a cohort of breast cancer survivors, with careful consideration of clinical, sociodemographic, and behavioral factors.

Methods

Study Population and Outcomes

The Pathways Study is a prospective cohort study of 4,505 women diagnosed with invasive breast cancer at Kaiser Permanente Northern California (KPNC). The women were recruited from 2006 through 2013 and enrolled in the study on average about two months after diagnosis. Participants completed a baseline questionnaire that captured sociodemographics, family health history, reproductive history, hormone use, smoking history, diet, and physical activity. Details of the breast cancer diagnosis and first course of treatment were obtained from the KPNC Cancer Registry and electronic health records (EHR); many data elements are available for research use in the Virtual Data Warehouse.[25–27] The design and methods of the Pathways Study have been published elsewhere.[28] All participants provided informed consent upon enrollment and the study protocol was approved by the Institutional Review Boards of all participating institutions.

Each participant's residential address at the time of enrollment was geocoded and assigned a 2010 census tract and block group.[29] For this study, we excluded women without a geocoded address (n=151), with a history of prior CVD defined as a CVD event within two years before the breast cancer diagnosis (n=67), and who were not KPNC health plan members during the year prior to their breast cancer diagnosis (n=312). The excluded women had similar distributions for most variables, except they were on average two years younger and more likely to be of lower SES (individual education and income). A total of 3,975 women remained for these analyses.

Cardiovascular disease events and clinical risk factors

Incident CVD was considered as the occurrence of any CVD event after breast cancer diagnosis through December 31, 2018. Based on definitions previously published in the parent Pathways Heart Study with a focus on cardiovascular disease in breast cancer survivors, a CVD event was defined as ischemic heart disease (including myocardial infarction), heart failure, cardiomyopathy, or stroke with ICD-9 or ICD −10 diagnosis codes and Current Procedural Terminology (CPT) codes from inpatient, ambulatory, and emergency department encounters and/or hospital discharge records.[4, 30] Death attributable to any of these causes was also included as a CVD event identified from the KPNC mortality file, which is regularly updated with data from the California State Department of Vital Statistics, U.S. Social Security Administration, and National Death Index. Over

the follow-up period, 340 CVD events were identified: heart failure or cardiomyopathy (n=126), ischemic heart disease (n=125), stroke (n=73) and CVD-related death (n=16). For those participants with no CVD event, observations were censored at date of death (non-CVD), date of KPNC membership disenrollment, or December 31, 2018, whichever came first. History of cardiometabolic risk factors (hypertension, diabetes, and dyslipidemia) was identified from a combination of ICD codes, lab values, and clinical visits up to 3 years before cancer diagnosis date.[30]

Objective Neighborhood Attributes of the Social and Built Environment

We used neighborhood data from the 2010 Census and the 2007–2011 American Community Survey (ACS) at the census block-group level to measure neighborhood SES (nSES), racial/ethnic composition, population density, and urbanization (Table 1). Details on these census-based characteristics were previously published.[29] Briefly, nSES was measured using an established composite index created from Principal Component Analysis (PCA) based on seven variables from the American Community Survey (2007–2011): median household income, Liu education index (among individuals age 25 and older), percent below 200% of poverty line, proportion with blue collar occupation, proportion without a job, median rent, and median house value.[31–33] Urbanization was based on population density and census-designated metropolitan area size. The four categories of urbanization were defined as metropolitan urban (population of one million or more and the highest quartile of population density), suburban (the rest of the population within the metropolitan areas with a population of one million or more), city (census-designated places with >50,000 people outside of a metropolitan area with one million or more), and small town/rural (places with <50,000 people outside of an urbanized areas).Street connectivity, an indicator of walkability, was developed using NavTeq's NavStreets dataset.[34] Street connectivity was measured as gamma, the ratio of actual number of street segments to maximum possible number of intersections (i.e., a higher ratio indicates more street connectivity/walkability).[35] We used census tract measures from the ACS for the percent foreign-born and percent commuting to work by car or motorcycle.

For additional measures of the more immediate neighborhood areas, residential buffers were created around each participant's address; details for these measures were previously published.[29] Traffic density was calculated within a 500-meter buffer based on traffic counts. We identified various neighborhood amenities based on business listings from Walls & Associates' National Establishment Time-Series Database,[36] farmer's markets,[37] and parks from NavTeq's NavStreets data to characterize the food environment and recreational facilities. These amenities were measured within a 1,600-meter network distance from a participant's residence.[38] Food availability was measured by the Restaurant Environment Index (ratio of fast food restaurants to other restaurants) and the Retail Food Environment Index (ratio of convenience stores, liquor stores, and fast food to supermarkets and farmers' markets). For analysis, quintiles of these neighborhood variables were calculated, based on either the California statewide distribution for measures defined at census geographies (nSES, population density, racial/ethnic composition, commuting, and percent foreign born) or the Pathways Study sample for measures based on participants' address (street connectivity, food environment, traffic density).

Distance to nearest major roadway was assessed using ArcGIS and StreetMap Premium networks; quintiles were based on Pathways sample distribution. Block group total crime index was based on the Federal Bureau of Investigation (FBI) Uniform Crime Report databases from 2005–2010.[39] The total crime measure includes both personal and property crimes and is based on a national average score of 100. Statewide quartiles were used.

Statistical Analysis

To estimate associations with CVD risk, we calculated hazard ratios (HR) and 95% confidence intervals (CI) using Cox proportional hazards regression models with clustering by block group to account for correlation among participants in the same block groups. First, each neighborhood attribute was modeled separately, adjusting for age, race/ethnicity, education, household income, family history of breast cancer, and menopausal status (minimally-adjusted models). The multivariable model was developed by adding the neighborhood attributes that were significantly associated with CVD risk based on p for trend (or p type 3) < 0.10 in these minimally-adjusted models. The fully-adjusted model additionally considered clinical and behavioral factors including tumor hormone receptor status (estrogen receptor positive or negative, progesterone receptor positive or negative), stage at diagnosis, radiation therapy (yes/no), chemotherapy (yes/no), endocrine therapy (yes/no), cigarette smoking history (current, former, never), body mass index (BMI) at baseline, physical activity at baseline, dyslipidemia (yes/no), diabetes (yes/no), and hypertension (yes/no). The proportional hazards assumption was tested using the interaction term between covariates and logarithmic transformation of survival time, and the assumptions were met. We also checked for issues of multicollinearity and found none. Tests for trend were performed by entering the categorical neighborhood variable as an ordinal parameter. Tests for heterogeneity by nSES (low, high) were conducted using the Wald test for interaction terms. Analyses were conducted using SAS version 9.4 (SAS Institute, Cary, North Carolina, USA).

RESULTS

In this prospective cohort of 3,975 breast cancer patients, 340 had an incident CVD event over a mean follow-up of 8.3 years (SD=3.20). Most participants were diagnosed with early-stage breast cancer (Stage I or II, 89%). Forty-seven percent of women received chemotherapy, 44% received radiation therapy, and 74% received endocrine therapy. At baseline, the cohort was predominantly post-menopausal (71%) with a mean age of 59 years (Table 2). The racial/ethnic composition was 66% non-Hispanic White, 13% Asian American, 11% Hispanic/Latina, and 8% Black. Most participants had at least some college education (84%) and an annual household income of at least $50,000 (60%). About one-third of participants were normal weight (34%) at baseline and 29% had none of the cardiometabolic risk factors.

In minimally-adjusted models (Table 3), neighborhood racial/ethnic composition, percent foreign-born residents, crime index, and urbanization were moderately associated with incident CVD events. Specifically, patients living in neighborhoods characterized with lower (quintiles 2 and 3, Q2 and Q3) compared with higher (Q5) proportions of Asian American/

Pacific Islander (AAPI) populations had a 40%–50% higher risk of CVD (Q2 HR=1.53; 95% CI: 1.09, 2.15; Q3 HR=1.42; 95% CI: 1.03, 1.95; p trend 0.0057). A suggestive inverse association of reduced CVD risk was observed among patients living in neighborhoods with a higher proportion of foreign-born residents (P_{trend}<0.07). Living in neighborhoods of high (Q4) versus low (Q1) crime (HR=1.31, 95% CI 0.97–1.76), and living in cities which are outside of the largest metropolitan areas compared with metropolitan urban areas (HR=1.45, 95% CI 0.95–2.21) were associated with higher risk of CVD, although associations did not reach statistical significance (P_{trend}=0.080 and $P_{type\ 3}$ 0.082, respectively).

In the fully-adjusted multivariable model (Table 4), AAPI composition and crime index remained significant predictors of CVD events among breast cancer patients with adjustment for demographic, clinical and behavioral factors; no associations were observed for percent foreign-born and urbanization. A larger magnitude of association of lower AAPI composition and higher CVD risk was observed, reaching 85% higher CVD risk (Q1 vs. Q5 HR=1.85, 95% CI 1.03–3.33, P_{trend}=0.02). Living in neighborhoods of high (Q4) versus low (Q1) crime showed higher CVD risk (HR=1.48, 95% CI 1.08–2.03, p trend=0.0057). We observed different patterns of association for racial/ethnic composition and crime index in nSES-stratified analyses; heterogeneity by nSES was not statistically significant (Supplemental Table 1). Among participants residing in high SES neighborhoods, those residing in neighborhoods characterized by low versus high AAPI composition had two-fold higher risk of CVD (HR=2.07, 95% 1.06–4.06, P for heterogeneity = 0.420). Among participants residing in low SES neighborhoods, those residing in high versus low crime neighborhoods had a nearly two-fold higher CVD risk (HR=1.82, 95% 1.07–3.09, P for heterogeneity = 0.622).

We conducted a sensitivity analysis by excluding CVD cases that were diagnosed within two years of breast cancer diagnosis (N=71). The observed associations from the multivariable model remained consistent (data not shown). As we were limited by our sample size to test for cross-level interactions with the ordinal neighborhood variables, we conducted a second sensitivity analysis to test for cross-level interactions between neighborhood crime index and percent Asian American residents as continuous variables by three individual-level factors: age at diagnosis, race/ethnicity and education. None were statistically significant at p-value <0.05.

The adjusted risk estimates for incident CVD for the individual-level characteristics were generally as expected, with increased risk observed for older age, low household income, smoking, diabetes, dyslipidemia, and hypertension as well as decreased risk for high physical activity (Supplementary Table 2). Correlations among neighborhood variables were modest (Supplementary Table 3).

DISCUSSION

This study points to several aspects of the neighborhood environment that may influence risk of CVD outcomes in women with breast cancer. These findings contribute to the growing literature applying a socio-ecological framework to understand how residential environments shape health outcomes in breast cancer survivors, a growing population of women in the

U.S. Neighborhood racial/ethnic composition and crime index were associated with risk of CVD events independent of individual SES (education and income), and known prognostic factors including breast cancer tumor type, treatment, cardiometabolic comorbidities, BMI, and physical activity. By examining CVD risks associated with a comprehensive suite of social and built environment attributes, this research can help to understand health disparities in cardio-oncology and elucidate the neighborhood factors that can affect the underlying biology and health.[23]

Chronic stress is a recognized risk factor for CVD [40] and a diagnosis of breast cancer itself can be a stressful event. This resultant stress may be compounded by living in neighborhoods with high exposure to chronic psychosocial and environmental stressors such as crime, negatively impacting CVD health via pathways of chronic systemic inflammation.[41] In this cohort of breast cancer survivors, women who resided in areas with the highest overall crime had increased risk for CVD, even after adjustment for individual-level risk factors. In addition, certain sub-populations may be particularly vulnerable to the negative effects of crime. Sprung et al.[42] found that CVD risk factors such as elevated glucose levels and high blood pressure were associated with increased neighborhood crime in African American women, but not in African American men, White men or White women. Conversely, living in communities and neighborhoods with lower crime may contribute to better overall health and less adverse health outcomes [40, 43] and is associated with neighborhood attributes linked with resiliency and physiological stress recovery, particularly green spaces.[44]

In the present analysis, living in areas with a high proportion of AAPI residents was associated with reduced CVD risk. Such neighborhoods were all located within large metropolitan areas, had more parks, more businesses, and were more likely to be in the highest category for nSES. However, these neighborhoods were also more likely to have some of the negative attributes that are found more often in urbanized areas, such as higher crime and higher traffic density. Neighborhoods with higher proportion of AAPI residents are likely proxies for higher racial/ethnic diversity. For example, in our study catchment area, the percent of AAPI residents was positively correlated with the percent of non-Hispanic Black residents. There could also be remaining differences in individual-level risk factors for women living in neighborhoods with higher proportion AAPI residents that we could not fully account for in our multivariable models. While we controlled for many individual-level risk factors, it is interesting to note that a recent U.S. study of the largest 500 cities found that places with a higher proportion of Asian American residents had lower rates of obesity, mental stress, and longer life expectancy than cities with a high proportion of non-Hispanic White residents.[45] We need to better understand the pathways by which living in neighborhoods with higher proportions of AAPI residents protects against CVD risk; identifying these mechanisms may help to inform neighborhood-level interventions to mitigate risk among breast cancer survivors at high risk of CVD.

Other studies have shown that traffic density, nSES, food environment, greenspace, and parks are associated with CVD risk in the general population.[12–14, 19, 46–51] However, we did not find that these factors were associated with CVD risk in the Pathways Study. While

we observed a modest increase in CVD risk in Pathways women living close to major roads and in areas with high traffic density, these associations were not statistically significant.

Though we observed an increased risk of CVD in survivors living in neighborhoods classified as lowest SES in minimally adjusted models (HR=1.38), with only about 5% of women living in the lowest SES neighborhoods, this increased risk was not statistically significant (95% CI 0.84, 2.26). We also did not see any increased risks associated with measures of the food environment or number of parks in the neighborhood, although in some previous research presence of green spaces and healthy food options have been associated with CVD risk.[13, 16, 19] Differences in measures used across studies may contribute to these mixed results. The Pathways cohort is a group of women with health insurance coverage, and, as breast cancer risk is associated with higher SES, it is not surprising that the majority lived in relatively high SES neighborhoods. Thus, differences in some of these neighborhood attributes, such as food environments, may not vary as much or be a distinguishing factor within this study population as in some previous studies that focused on more economically-disadvantaged women.[12, 13]

There are several strengths to this study and some limitations. Loss-to-follow-up is minimized in the Pathways Study, with only 10% of the participants dropped out of the study as of September 2017; as long as participants do not leave the KPNC health plan, we are also able to follow them for CVD endpoints. Our approach integrates existing rich individual data from self-reported questionnaire and EHR data with small-area, well-defined, neighborhood data on a broad range of social and built environment attributes. These neighborhood indicators have been applied in many epidemiologic investigations of neighborhood contextual factors and health outcomes, including studies of breast cancer survival.[9, 10, 52] However, we assessed residential neighborhood only at the address at the time of study enrollment, and did not account for study participants' residential history over time and changes in neighborhood attributes. We also did not assess other geographic contexts where they may have spent time, e.g., work and recreational activities. In addition, we only included objective measures of neighborhood attributes, although subjective measures such as perceptions of neighborhood safety and quality may also impact health.[53] We did not validate through neighborhood audits whether restaurants and other amenities were present and functioning in these neighborhoods. However, other studies have shown that use of the NETS Database is as valid a resource for capturing businesses as other secondary database.[54] Unmeasured confounding could also be present due to environmental exposures such as air pollution, which has been shown to be related to both neighborhood factors and CVD risk in breast cancer survivors.[55] As the cohort represents insured patients from an integrated healthcare system, the study will inherently control for differences in health insurance and healthcare access, however, these results do not represent the experience of uninsured populations. We were not able to look at these associations by treatment due to small sample size. Finally, though CVD events were identified using diagnosis and procedure codes in the EHR, which could be subject to misclassification, a prior study found positive predictive values with chart review validation ranging from 89% to 94%.[4]

CONCLUSION

This study demonstrates the value of considering the multilevel factors that contribute to adverse health outcomes in breast cancer survivors. As one of the first studies to examine social and built environment attributes that may contribute to CVD risk in women with breast cancer, neighborhood-level crime and racial/ethnic composition were found to be associated with CVD risk, suggesting a stress pathway linking these upstream factors to health outcomes following a cancer diagnosis. Future studies are needed to better understand how these upstream factors impact women's heart health after a breast cancer diagnosis, and whether they differ by race/ethnicity, SES, and other social status factors. To capture the complex interactions across neighborhood attributes as well as other social, clinical and biological factors, advanced approaches that account for the interactions and/or simultaneous effects of multiple environmental attributes such as archetypes and mixture models as well as multilevel interactions are needed. Understanding how these factors independently and jointly contribute to CVD risk in breast cancer survivors can inform interventions to reduce the burden of CVD and addressing social determinants to advance health equity in this growing population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Description of the baseline neighborhood social and built environment measures, Pathways Study.

Neighborhood Contextual Data	Data Source	Description of measure
Socioeconomic status	2007–2011 American Community Survey (ACS)	Block group-level composite measure derived from Principal Component Analysis (PCA) based on seven factors: median household income, Liu education index, percent below 200% of poverty line, proportion with blue collar occupation, proportion without a job, median rent, and median house value.
Racial/ethnic composition	US Census 2010 short form data	Block group-level measures of percent residents of each racial/ethnic group
Immigration	2007–2011 ACS	Tract-level measures of residential composition on percent foreign-born
Population density	US Census 2010 short form data	Block group-level measures of population size per square mile
Urbanization (Rural/ Urban)	US Census 2010 short form data	Block group-level composite measure based on census defined urbanized area, population size and population density. Four categories: 1. urban (metropolitan area with population ≥ one million and the highest quartile of population density), 2. suburban (rest of population within the metropolitan areas with population ≥ one million), 3. city (census-designated places with >50,000 people outside of a metropolitan area ≥ one million), and 4. small town/rural (places with <50,000 people outside of an urbanized area)
Businesses	Dunn & Bradstreet annual business listings (), via Walls & Associates	Residential buffer (1600m) measures of total businesses, total number of recreational facilities, retail food environment index, and restaurant environment index. Businesses and amenities were averaged over a 4-year window of 2005–2008.
Commuting by car	2007–2011 ACS	Tract- level measures of proportion of population who drive to work
Street connectivity	NAVTEQ	Block group-level measure of walkability, using the gamma index (ratio of actual number of street segments to maximum possible number of intersections, with a higher ratio indicating more street connectivity/ walkability)
Parks	NAVTEQ	Residential buffer (1600m) measure of total of parks
Farmers Markets	California Department of Food and Agriculture	Locations of farmers markets
Traffic density	California Department of Transportation	Residential buffer (500m) measure of volume of traffic (vehicle miles traveled per square mile)
Crime Index	Federal Bureau of Investigation (FBI) Uniform Crime Report databases 2005–2010	Block group-level total crime index, includes both personal and property crimes, and based on a national average score of 100

Table 2.

Study population characteristics in the Pathways Heart Study at baseline by neighborhood socioeconomic status (nSES).

	All Study Participants		Low Neighborhood SES[a]		High Neighborhood SES[b]	
	N	Percent or mean	N	Percent or mean	N	Percent or mean
Total	3975	100	1474	100	2501	100
Mean age at cancer diagnosis, years	3975	59.4		59.2		59.5
Menopausal at baseline	2821	71.0	1029	69.8	1792	71.7
Race/ethnicity						
Asian American	524	13.2	155	10.5	369	14.8
Black, non-Hispanic	297	7.5	198	13.4	99	4.0
Hispanic	443	11.1	231	15.7	212	8.5
American Indian, Alaska Native	76	1.9	36	2.4	40	1.6
Pacific Islander	12	0.3	4	0.3	8	0.3
White, non-Hispanic	2623	66.0	850	57.7	1773	70.9
Education (individual)						
High School or less	611	15.4	339	23.0	272	10.9
Some college	1369	34.4	593	40.2	776	31.0
College graduate	1985	50	541	36.7	1444	57.7
Unknown	10	0.3	1	<1	9	0.4
Household income (individual)						
< $25,000	358	9.0	200	13.6	158	6.3
$25,000-$49,000	714	18.0	351	23.8	363	14.5
$50,000-$89,000	1132	28.5	459	31.1	673	26.9
≥ $90,000	1268	31.9	271	18.4	997	39.9
Unknown	503	12.7	193	13.1	310	12.4
Family history of breast cancer	812	20.4	294	19.9	518	20.7
Body Mass Index (BMI), kg/m^2						
Normal weight, < 25	1338	33.7	417	28.3	921	36.8
Overweight, 25–24.9	1245	31.3	426	28.9	819	32.7
Obese, ≥ 30	1354	34.1	620	42.1	734	29.3
Unknown	38	1.0	11	0.7	27	1.1
Cigarette smoking history						
Never	2251	56.6	808	54.8	1443	57.7
Current	196	4.9	90	6.1	106	4.2
Former	1513	38.1	574	38.9	939	37.5
Unknown	15	0.4	2	0.1	13	0.5
Physical activity at baseline, MET hours/week						
Quartile 1 (<8.1)	949	23.9	419	28.4	530	21.2

	All Study Participants		Low Neighborhood SES[a]		High Neighborhood SES[b]	
	N	Percent or mean	N	Percent or mean	N	Percent or mean
Quartile 2 (8.1–20.9)	990	24.9	383	26.0	607	24.3
Quartile 3 (21.0–43.4)	995	25.0	327	22.2	668	26.7
Quartile 4 (>43.4)	953	24.0	309	21.0	644	25.7
Unknown	88	2.2	36	2.4	52	2.1
Cardiometabolic risk factors[c]						
None	1157	29.1	387	26.3	770	30.8
Diabetes	771	19.4	352	23.9	419	16.8
Dyslipidemia	2133	53.7	814	55.2	1319	52.7
Hypertension	2125	53.5	842	57.1	1283	51.3
Hormone receptor status						
ER+ and PR+	2538	63.8	900	61.1	1638	65.5
ER- or PR-	768	19.3	294	19.9	474	19.0
ER- and PR-	665	16.7	278	18.9	387	15.5
Unknown	<5	<1	2	0.1	2	0.1
AJCC Stage at diagnosis, version 7						
I	2142	53.9	757	51.4	1385	55.4
II	1400	35.2	548	37.2	852	34.1
III/IV	433	10.9	169	11.5	264	10.6
Radiation therapy received	1749	44.0	609	41.3	1140	45.6
Chemotherapy received	1873	47.1	708	48.0	1165	46.6
Endocrine therapy received	2938	73.9	1050	71.2	1888	75.5

Means for continuous or n (%) for categorical variables; percentages may not add to 100 because of rounding

[a] lowest three quintiles of neighborhood SES

[b] highest two quintiles of neighborhood SES

[c] Condition present up to 3 years before cancer diagnosis date.

Table 3.

Minimally adjusted associations of neighborhood attributes and risk of incident CVD with each neighborhood attribute modeled separately in the Pathways Heart Study

Neighborhood attributes	N participants (%)		N CVD events	HR*	95% CI	
Social Environment						
Neighborhood SES[a]						
Quintile 1: low (score < -0.9)	187	(4.7)	27	1.38	0.84	2.26
Quintile 2 (-0.9 to -0.3)	469	(11.8)	51	1.31	0.90	1.91
Quintile 3 (-0.4 to 0.2)	818	(20.6)	67	1.04	0.75	1.44
Quintile 4 (-.3 to 0.9)	1167	(29.4)	96	1.10	0.83	1.46
Quintile 5: high (>0.9)	1334	(33.6)	99	1.00		
P trend				0.1456		
Percent Hispanic residents [a]						
Quintile 1: low (<11.0 %)	1382	(34.7)	117	1.20	0.52	2.77
Quintile 2 (11.0–20.4%)	1221	(30.7)	95	1.10	0.48	2.52
Quintile 3 (20.5–36.3%)	879	(22.1)	73	1.18	0.51	2.71
Quintile 4 (36.4–62.4%)	399	(10)	49	1.79	0.77	4.15
Quintile 5: high (>62.4%)	94	(2.4)	6	1.00		
P trend				0.2134		
Percent Asian American/Pacific Islander residents [a]						
Quintile 1: low (<2.0%)	229	(5.8)	23	1.44	0.90	2.30
Quintile 2 (2.0–4.8%)	581	(14.6)	69	**1.53**	**1.09**	**2.15**
Quintile 3 (4.9–9.2%)	792	(19.9)	81	**1.42**	**1.03**	**1.95**
Quintile 4 (9.3–18.8%)	1027	(25.8)	71	1.10	0.80	1.52
Quintile 5: high (>18.8%)	1346	(33.9)	96	1.00		
P trend				**0.0057**		
Percent Non-Hispanic Black residents [a]						
Quintile 1: low (<0.7%)	568	(14.3)	53	0.92	0.64	1.33
Quintile 2 (0.7–1.5%)	814	(20.5)	74	0.99	0.71	1.38
Quintile 3 (1.6–3.1%)	863	(21.7)	63	0.78	0.56	1.10
Quintile 4 (3.2–7.5%)	708	(17.8)	54	0.87	0.60	1.25
Quintile 5: high (>7.5%)	1022	(25.7)	96	1.00		
P trend				0.8850		
Percent Non-Hispanic White residents [a]						
Quintile 1: low (<12.2%)	250	(6.3)	21	0.95	0.55	1.66
Quintile 2 (12.2–32.1%)	715	(18.0)	59	0.92	0.64	1.32
Quintile 3 (32.2–53.7%)	980	(24.7)	80	0.93	0.68	1.27
Quintile 4 (53.8–72.0%)	1024	(25.8)	80	0.87	0.65	1.17
Quintile 5: high (>72.0%)	1006	(25.3)	100	1.00		

Neighborhood attributes	N participants (%)		N CVD events	HR*	95% CI	
P trend				0.7591		
Percent foreign born residents [a]						
Quintile 1: low (<12.7%)	938	(23.6)	97	1.00		
Quintile 2 (12.7–20.1%)	984	(24.8)	86	0.90	0.67	1.21
Quintile 3 (20.2–29.3%)	944	(23.8)	80	0.84	0.62	1.14
Quintile 4 (29.4–40.9%)	631	(15.9)	43	0.72	0.49	1.04
Quintile 5: high (>40.9%)	478	(12.0)	34	0.74	0.48	1.15
P trend				0.0683		
Neighborhood crime index [a]						
Quartile 1: low (<45)	1392	(35.0)	108	1.00		
Quartile 2 (45–80)	1042	(26.2)	88	0.99	0.74	1.31
Quartile 3 (81–146)	769	(19.4)	65	0.98	0.72	1.34
Quartile 4: high (>146)	773	(19.5)	79	1.31	0.97	1.76
P trend				0.0803		
Built Environment						
Urbanization						
Metropolitan urban	407	(10.2)	30	1.00		
Suburban (metro areas)	2247	(56.5)	183	1.10	0.74	1.63
City outside of metro areas	1085	(27.3)	110	1.45	0.95	2.21
Small town/Rural	236	(5.9)	17	1.00	0.55	1.82
P value (type 3)				0.0821		
Population density[a](residents per square mile)						
Quartile 1: low (<1245)	1039	(26.1)	93	1.00		
Quartile 2 (1245–2673)	1245	(31.3)	107	0.97	0.73	1.29
Quartile 3 (2674–4429)	1023	(25.7)	85	0.91	0.68	1.24
Quartile 4: high (>4429)	668	(16.8)	55	0.97	0.69	1.37
P trend				0.7291		
Proportion commuting by car/motorcycle [b]						
Quintile 1: low (<76%)	787	(19.8)	55	1.00		
Quintile 2 (76–83%)	795	(20.0)	83	1.15	0.79	1.68
Quintile 3 (83–87%)	810	(20.4)	74	1.40	0.97	2.00
Quintile 4 (88–90%)	799	(20.1)	64	**1.51**	**1.07**	**2.13**
Quintile 5: high (>90%)	784	(19.7)	64	1.28	0.88	1.88
P trend				0.7172		
Traffic density[b](vehicle miles traveled per square mile)						
Quintile 1: low (<0.05)	789	(19.9)	59	1.00		
Quintile 2 (0.05 –0.16)	798	(20.1)	68	1.03	0.73	1.52
Quintile 3 (0.17–0.31)	810	(20.4)	67	1.07	0.76	1.52
Quintile 4 (0.32–0.64)	796	(20.0)	73	1.10	0.77	1.56

Neighborhood attributes	N participants (%)		N CVD events	HR*	95% CI	
Quintile 5: high (>0.64)	782	(19.7)	73	1.22	0.86	1.74
P trend				0.2467		
Distance to major roads [b]						
Quintile 1: low proximity (far from road) (>1520 m)	794	(20.0)	61	1.00		
Quintile 2 (821–1520)	793	(20.0)	68	1.17	0.83	1.65
Quintile 3 (483–820)	797	(20.1)	60	1.00	0.70	1.43
Quintile 4 (241–482)	796	(20.0)	82	1.36	0.97	1.90
Quintile 5: high proximity (close to road) (<241)	795	(20.0)	69	1.29	0.91	1.83
P trend				0.4422		
Street connectivity [b]						
Quintile 1: low (<0.38)	810	(20.4)	59	1.00		
Quintile 2 (0.38–041)	788	(19.8)	58	0.98	0.68	1.42
Quintile 3 (0.42–0.44)	800	(20.1)	81	**1.43**	**1.02**	**2.02**
Quintile 4 (0.45–0.48)	788	(19.8)	73	1.18	0.82	1.67
Quintile 5: high (>0.48)	789	(19.9)	69	1.18	0.83	1.68
P trend				0.2160		
Number of businesses [c]						
Quintile 1: low (<46)	788	(19.8)	69	1.00		
Quintile 2 (46–105)	794	(20.0)	60	0.84	0.59	1.19
Quintile 3 (106–210)	803	(20.2)	79	1.12	0.80	1.56
Quintile 4 (>210)	787	(19.8)	73	1.06	0.76	1.48
Quintile 5: high	803	(20.2)	59	0.86	0.61	1.22
P trend				0.9248		
Number of recreational facilities [c]						
Quintile 1: low (none)	524	(13.2)	43	1.00		
Quintile 2 (0.25–0.5)	874	(22.0)	81	1.05	0.73	1.53
Quintile 3 (0.75–1.25)	983	(24.7)	81	1.00	0.69	1.45
Quintile 4 (1.5–2. 8)	811	(20.4)	70	1.13	0.78	1.65
Quintile 5: high (>2.8)	783	(19.7)	65	1.03	0.70	1.51
P trend				0.7948		
Retail Food Environment Index [c]						
0	296	(7.5)	26	1.00		
<1	1561	(39.3)	127	0.79	0.51	1.22
≥ 1	1675	(42.1)	149	0.94	0.61	1.42
No retail food	443	(11.1)	38	0.81	0.49	1.35
P type 3				0.4840		
Restaurant Environment Index [c]						
None	1081	(27.2)	96	1.00		

Neighborhood attributes	N participants (%)		N CVD events	HR*	95% CI	
Some, less than median	1264	(31.8)	95	0.87	0.65	1.16
Some, above median	1225	(30.8)	119	1.10	0.84	1.45
No businesses	405	(10.2)	30	0.84	0.56	1.27
P type 3				0.2879		
Parks [c]						
None	1050	(26.4)	98	1.00		
1 park	1057	(26.6)	90	0.98	0.73	1.31
2 parks	831	(20.9)	66	0.88	0.64	1.22
3 parks or more	1037	(26.1)	86	0.93	0.69	1.25
P trend				0.5313		

*Adjusted for age, race/ethnicity (Pacific Islander, American Indian, Alaska Native combined as “other” category), education, household income, family history of breast cancer, and menopausal status.

[a]Statewide quartiles/quintiles

[b]Study-specific quartiles/quintiles

[c]Within 1600 meter walking network distance

Table 4.

Multivariable associations of neighborhood attributes and risk of incident CVD in the Pathways Heart Study

	HR*	95% CI	
Percent Asian American/Pacific Islander Residents			
Quintile 1: low (<2.0%)	**1.85**	**1.03**	**3.33**
Quintile 2 (2.0–4.8%)	1.48	0.96	2.28
Quintile 3 (4.9–9.2%)	1.26	0.86	1.84
Quintile 4 (9.3–18.8%)	1.02	0.72	1.46
Quintile 5: high (>18.8%)	1.00		
P trend	**0.0228**		
Percent Foreign Born Residents			
Quintile 1: low (<12.7%)	1.00		
Quintile 2 (12.7–20.1%)	0.90	0.58	1.39
Quintile 3 (20.2–29.3%)	0.96	0.66	1.37
Quintile 4 (29.4–40.9%)	1.04	0.75	1.43
Quintile 5: high (>40.9%)	1.01	0.59	1.75
P trend	0.7691		
Neighborhood Crime Index			
Quartile 1: low (<45)	1.00		
Quartile 2 (45–80)	0.95	0.71	1.28
Quartile 3 (81–146)	0.97	0.70	1.33
Quartile 4: high (>146)	**1.48**	**1.08**	**2.03**
P trend	**0.0470**		
Urbanization			
Metropolitan urban	1.00		
Suburban (metro areas)	0.99	0.65	1.52
City outside of metro areas	1.21	0.75	1.96
Small town/Rural	0.75	0.37	1.53
P value (type 3)	0.2371		

*Adjusted for age, race/ethnicity (Pacific Islander, American Indian, Alaska Native combined as “other” category), education, household income, family history of breast cancer, menopausal, tumor type (ER PR), stage at diagnosis, radiation therapy (yes/no), chemotherapy (yes/no), endocrine therapy (yes/no), smoking history, BMI at baseline, physical activity at baseline, cardiometabolic risk factors: dyslipidemia, diabetes, and hypertension (condition present up to 3 years before diagnosis date), and the neighborhood attributes in the table.