Evaluating the Impact of Social and Built Environments on Health-Related Quality of Life among Cancer Survivors

Janet N. Chu[1], Alison J. Canchola[2], Theresa H.M. Keegan[3], Alyssa Nickell[4], Ingrid Oakley-Girvan[5], Ann S. Hamilton[6], Rosa L. Yu[7], Scarlett Lin Gomez[2,8], and Salma Shariff-Marco[2,8]

ABSTRACT

Background: With almost 17 million U.S. cancer survivors, understanding multilevel factors impacting health-related quality of life (HRQOL) is critical to improving survivorship outcomes. Few studies have evaluated neighborhood impact on HRQOL among cancer survivors.

Methods: We combined sociodemographic, clinical, and behavioral data from three registry-based studies in California. Using a three-level mixed linear regression model (participants nested within block groups and study/regions), we examined associations of both independent neighborhood attributes and neighborhood archetypes, which capture interactions inherent among neighborhood attributes, with two HRQOL outcomes, physical (PCS) and mental (MCS) composite scores.

Results: For the 2,477 survivors, 46% were 70+ years, 52% were non-Hispanic White, and 53% had localized disease. In models minimally adjusted for age, stage, and cancer recurrence, HRQOL was associated with neighborhood socioeconomic status (nSES), racial/ethnic composition, population density, street connectivity, restaurant environment index, traffic density, urbanicity, crowding, rental properties, and non–single family units. In fully adjusted models, higher nSES remained associated with better PCS, and restaurant environment index, specifically more unhealthy restaurants, associated with worse MCS. In multivariable-adjusted models of neighborhood archetype, compared with upper middle-class suburb, Hispanic small town and inner city had lower PCS, and high status had higher MCS.

Conclusions: Among survivors, higher nSES was associated with better HRQOL; more unhealthy restaurants were associated with worse HQROL. As some neighborhood archetypes were associated with HRQOL, they provide an approach to capture how neighborhood attributes interact to impact HRQOL.

Impact: Elucidating the pathways through which neighborhood attributes influence HRQOL is important in improving survivorship outcomes.

Introduction

With over 17 million cancer survivors in the United States (1), understanding factors that impact health-related quality of life (HRQOL) after cancer diagnosis is critical to improving survivorship outcomes for this diverse population with heterogeneous needs (2, 3). HRQOL is a multidimensional survivorship concept that encompasses physical health, mental health, symptoms and social functioning, and spiritual well-being (4). In a national survey of cancer survivors, about a quarter reported poor physical HRQOL, and 10% reported poor mental HRQOL (5). Studies have also highlighted disparities in HRQOL with worse HRQOL among racial/ethnic minorities, individuals with low socioeconomic status (SES), or those with comorbidities (5–8).

Neighborhoods influence health outcomes through access to resources, environmental exposures, health behaviors (e.g., smoking, physical activity, diet), material deprivation (e.g., inadequate housing), and psychosocial mechanisms (e.g., stress; refs. 9, 10). There has been a growing body of evidence focused on the impact of neighborhood factors on HRQOL among cancer survivors. An oral cancer study reported that patients residing in more deprived areas had lower survival and worse social–emotional functioning and overall QOL (11). Other studies have demonstrated the impact of neighborhood racial/ethnic composition on HRQOL. A study of African American and White cancer survivors reported that individuals living in high Black-segregated areas reported poorer HRQOL, regardless of race (8, 12). In addition, a study of breast, colorectal, and prostate cancer survivors demonstrated that racial minorities living in areas with a higher percentage of racial minorities had increased odds of greater illness intrusion (i.e., disruptions in activities/interests due to illness) when compared with White individuals living in areas with a low percentage of racial minorities (13).

While prior studies have evaluated the impact of either separate social (i.e., social class, community support, crime; ref. 14) or built (i.e., grocery stores, fast food restaurants, walkability; refs. 10, 15) environments on HRQOL, few studies have evaluated the impact of a broad set of social and built environment attributes on HRQOL (9). Furthermore, there have been no studies accounting for the interaction between these neighborhood attributes. To address this gap, existing clinical, demographic, social, and behavioral data from three population-based cancer survivorship studies in California [the Assessment of Patients' Experience of Cancer Care (APECC; ref. 16), Experiences of Care and Health Outcomes of survivors of Non-Hodgkin's Lymphoma (ECHOS-NHL; ref. 17), and Follow-up Care Use among Survivors (FOCUS; ref. 18)], were combined with data from the California Cancer Registry (CCR) and the California Neighborhoods

[1]Department of Medicine, University of California San Francisco, San Francisco, California. [2]Department of Epidemiology and Biostatistics, University of California San Francisco, San Francisco, California. [3]Department of Internal Medicine, University of California Davis, Davis, California. [4]Shanti Project, San Francisco, California. [5]Public Health Institute, Washington, D.C. [6]Department of Preventive Medicine, Keck School of Medicine, Los Angeles, California. [7]Department of Medicine, Beth Israel Deaconess Medical Center, New York, New York. [8]Helen Diller Family Comprehensive Cancer Center, University of California San Francisco, San Francisco, California.

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

Corresponding Author: Salma Shariff-Marco, Department of Epidemiology and Biostatistics, University of California, San Francisco, 550 16th Street, San Francisco, CA 94158. E-mail: Salma.Shariff-Marco@ucsf.edu

Cancer Epidemiol Biomarkers Prev 2022;31:161–74

doi: 10.1158/1055-9965.EPI-21-0129

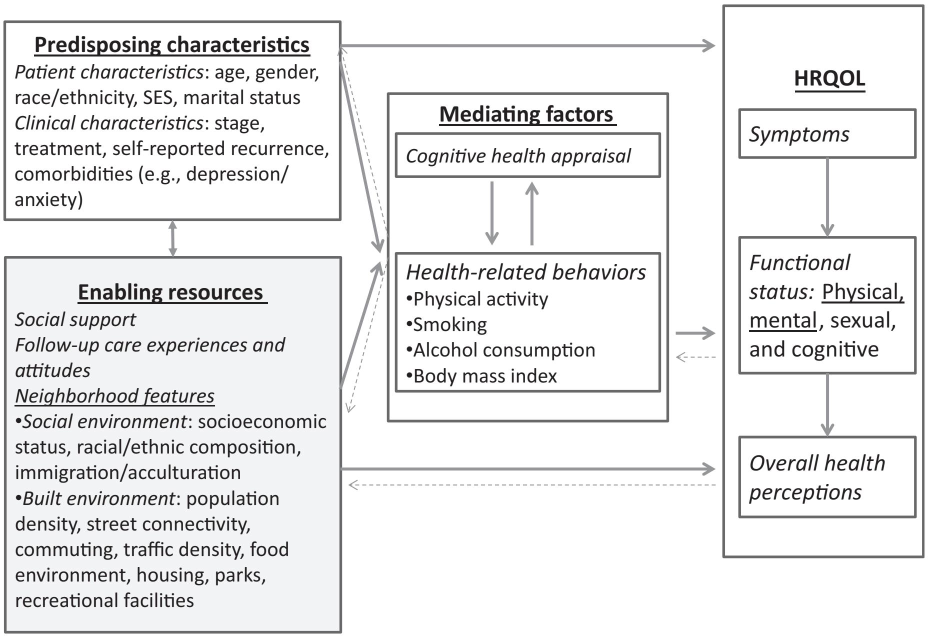

Figure 1.
Conceptual framework for the study of health-related quality of life among cancer survivors. Adapted and reprinted in part by permission from Springer Nature Customer Service Center GmbH: Springer Nature. J Cancer Surviv. Arora NK, Hamilton AS, Potosky AL, Rowland JH, Aziz NM, Bellizzi KM, Klabunde CN, McLaughlin W, Stevens J. Population-based survivorship research using cancer registries: a study of non-Hodgkin's lymphoma survivors, Copyright (2007).

Data System (CNDS; ref. 19) and analyzed. We adapted a conceptual framework linking predisposing factors, enabling resources, and mediating factors to HRQOL for cancer survivors, expanding it to incorporate a multilevel perspective by including social and built environment factors as additional enabling resources (**Fig. 1**; ref. 8). We examined the associations between attributes of the neighborhood social and built environments and HRQOL as well as a neighborhood archetype measure that accounts for interactions across the neighborhood attributes and HRQOL.

Materials and Methods

Study population

We pooled data from APECC, ECHOS-NHL, and FOCUS. APECC included 774 bladder, colorectal, and leukemia survivors from the San Francisco Bay Area (BA) who were interviewed between 2003 and 2004 (16). Eligible cases included living adult survivors, 2–5 years after diagnosis, able to read English, had received cancer treatment, had the cancer of interest as their first diagnosis, and without any subsequent tumors. ECHOS-NHL was a study of 408 African-American, Hispanic, or Non-Hispanic (NH) White non-Hodgkin's Lymphoma survivors from Los Angeles (LA) County who were interviewed between 2003 and 2005 (8). Eligible cases included living adult survivors of aggressive NHL, 2–5 years after diagnosis, with the NHL diagnosis as their only primary cancer diagnosis. FOCUS was a study of 1,666 breast, colorectal, ovarian, prostate, and uterine cancer adult survivors from the San Francisco BA and LA County who were interviewed between 2005 and 2006 (18). Eligible cases were 4–14 years post diagnosis, able to read English, and had completed active treatment. For our study, the analytic sample included 2,477 participants for both PCS and MCS; we excluded participants with missing data for the physical or mental composite score ($n = 285$) and whose residential addresses could not be geocoded ($n = 86$).

Each of these studies collected patient-reported data on sociodemographic, clinical, social, and behavioral factors, allowing us to account for individual-level predisposing, enabling, and mediating factors. Individual-level data was harmonized across the three studies and included information from study questionnaires and the CCR. Many of the items on the study questionnaires came from previously validated instruments for cancer survivors (8). Residential address at the time of interview (2003–2006) was geocoded to latitude and longitude coordinates using address or street locators and matched to corresponding 2000 Census block groups.

The Institutional Review Boards of the Cancer Prevention Institute of California, the University of Southern California, and the University of California, San Francisco, approved this study.

Study measures

HRQOL was calculated using responses to two versions of the Short-Form (SF) health survey (version 2), the SF-12 for FOCUS and the SF-36 for APECC and ECHOS. These instruments have been validated for use in adults (18+) and include eight subscales: physical functioning, physical role limitations, bodily pain, general health, vitality, social functioning, emotional role limitations, and mental health (20, 21). The subscales were combined and standardized to a national norm to provide physical composite score (PCS) and mental composite score (MCS) outcome measures, with higher scores indicating better HRQOL.

Predisposing characteristics were obtained from questionnaires and the cancer registry. Questionnaire items included age at interview, race/ethnicity, gender, individual SES (education, employment, income), marital status, and health insurance as well as treatment, recurrence, comorbidities, and history of depression or anxiety. Clinical characteristics from the CCR included date of diagnosis, cancer site, tumor characteristics (stage, grade, histology), and treatment (surgery, radiation, chemotherapy).

Enabling resources were obtained from study questionnaires and included follow-up care experiences and attitudes. In addition to these individual-level variables, we hypothesized that social and built environment neighborhood features should be considered as enabling resources. The neighborhood data have been compiled from a variety of sources: 2000 Census short and long forms (nSES, racial/ethnic composition, population density, housing, and urbanicity), Dun and Bradstreet (business data), California Department of Food and

Agriculture (farmers' markets), NavTeq (street connectivity, parks), and California Department of Transportation (traffic density) (22–26). The Census block group-level measures include SES, racial/ethnic composition, population density (persons/square meter), urbanicity, housing, and street connectivity. Neighborhood SES was measured using an established composite index, Yost SES Index, developed through principal components analysis, and that includes 7 indicator variables, including poverty, income, education, unemployment, blue collar workforce, median home value, and rent (27). For racial/ethnic composition, we created separate indicators of whether the block group population for NH White, NH Black, NH Asian American, and Hispanic were each at/above or below the statewide median for that racial/ethnic group. We combined these indicators into a single variable with mutually exclusive categories as follows: if NH Black, NH Asian American, or Hispanic were at or above the median and NH White was below the median, the block group was considered minority predominant; if NH Black, NH Asian American, and Hispanic were below the median and NH White was at or above the median, the block group was considered White predominant; otherwise, the block group was considered mixed (28). Urbanicity measured urban/rural status using census defined Urbanized Areas (population ≥ 50,000) and Urban Clusters (population between 2500 and 50,000). Housing characteristics included measures of crowding, defined as percentage of occupied housing units with more than one occupant per room, percentage of rental households, and percentage of total housing units that are not single-family dwellings (i.e., structures with more than two units). 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 (29). Selected amenities (parks and recreational facilities), and food environment was captured based on a 1,600 m or 1 mile walking distance using pedestrian street networks. Business counts and recreational facility counts were averaged over a 3-year window around interview year. Food environment included the Retail Food Environment Index (ratio of average number of convenience stores, liquor stores, and fast food restaurants to supermarkets and farmers' markets) and the Restaurant Environment Index (ratio of the average number of fast food restaurants to other restaurants; ref. 30). Traffic density was measured within a 500 m buffer of each residence, using methods previously described, and was categorized into quintiles based on the sample distribution (31). Population density, nSES, gamma, percent crowding, percent renting, and percent non-single family units were categorized into statewide quintiles. We also used a summary neighborhood variable that uses latent class analysis (LCA) to classify each census tract into an archetype, that accounts for the synergistic effects of 39 social and built environment attributes (32–34). The best fitting LCA models identified 9 distinct archetypes for census tracts in California (see Supplementary Table S1).

Mediating factors were health behaviors obtained from study questionnaires. These included moderate and vigorous physical activity at least once a week in the last four weeks (no, yes), smoking status (never, former, current), alcohol use in the last 14 days (not current, current—low, current—high), and body mass index (BMI) (underweight, normal, overweight, obese). Physical activity, smoking, alcohol, and BMI were not included on the APECC study questionnaire, and thus was missing for 28.1% of the total sample.

Statistical analysis

We used multivariable three-level mixed linear regression models to estimate least square means and 95% confidence intervals (CI) for associations with outcomes of physical and mental composite scores. We used a 3-level model with a random effect for study/region (defined as APECC-BA, ECHOS-LA, FOCUS-BA, and FOCUS-LA) and a random effect for block groups nested within study/region. Using study/region as a random effect assumes that participants in different studies/regions were from populations with different characteristics and with different effects. This modeling approach estimates the fixed effects for each of the four studies/regions and then averages across them while accounting for true variation in effect size (35–37). To examine associations with neighborhood archetypes, we used a random effect of census tract nested within study/region, as the archetypes were defined at the census tract level. For all models, census block groups or tracts with participants from two different studies (8.5% of block groups and 20.7% of census tracts), were artificially split into two different census block groups or tracts to allow for neighborhoods to uniquely nest within studies/regions. As a sensitivity analysis for models with archetypes, we used a 2-level model with census tract as a random effect instead of using a three-level model, and results were similar.

Separately for each of the two outcomes (PCS and MCS), we defined a series of models in which groups of variables were entered together. We started with a minimally adjusted model that considered age at diagnosis, tumor stage, and recurrence, as these have been shown to be associated with HRQOL; stage was not associated with MCS so was not included as an adjustment. Each neighborhood attribute was then included separately in a minimally adjusted model (Model 1). Next, nSES was added to the models with each neighborhood attribute separately (Model 2). For the multivariable models, we included neighborhood attributes that were significant in a multivariable model, adjusted for patient and clinical characteristics (Model 3) and health-related behaviors (Model 4) that were associated with both HRQOL in a multivariable model and the retained neighborhood attribute. Final multivariable models were adjusted as follows: PCS: age, stage, recurrence, race/ethnicity, employment, income, marital status, ever depression/anxiety, moderate and strenuous physical activity, smoking, alcohol, and BMI; MCS: age, race/ethnicity, education, income, marital status, insurance, and alcohol.

As sensitivity analyses, we reran the final multivariable models separately for APECC and FOCUS (both LA and BA sites combined) which showed similar results; however, we did not perform separate analyses for ECHOS-NHL due to small sample size. For sensitivity analyses by region (LA: ECHOS-NHL and FOCUS-LA combined; and BA: APECC and FOCUS-BA combined), findings were driven by BA (see Supplementary Tables S2 and S3).

Neighborhood archetypes were added to the minimal and final multivariable models, in place of the neighborhood attributes.

Analyses were performed in SAS Software v.9.4 (SAS Institute).

Results

Table 1 shows the mean PCS and MCS scores by sociodemographic, clinical, and behavioral characteristics of the 2,477 survivors (see Supplementary Table S4 for distributions by study/region). Over half of study participants were over 60 years of age at the time of interview (72%), married (64%), and had at least some college education (75%). Most were female (54%), retired (55%), or made less than \$60,000 (53%). Fifty-two percent identified as NH White, 13% as Hispanic, 16% as African American, and 17% as Asian American/Pacific Islander. Colorectal cancer was the most common type of cancer among study participants (33%), followed by prostate (16%) and breast (14%) cancers. A majority had localized cancer (53%) and were diagnosed within six years of participating (55%).

Table 1. Distribution of sample characteristics and mean physical and mental composite scores (PCS, MCS).

	n (%)	Mean PCS (SD)	Mean MCS (SD)
Total sample	2,477	44.7 (11.6)	50.5 (9.7)
Age at interview[a,b]			
18–49	266 (10.7%)	49.5 (10.5)	47.1 (10.0)
50–59	432 (17.4%)	47.3 (11.5)	47.8 (11.0)
60–69	646 (26.1%)	45.7 (11.5)	51.3 (8.8)
70+	1,133 (45.7%)	42.0 (11.4)	51.9 (9.1)
Race/ethnicity[a,b]			
NH White	1,284 (51.8%)	45.3 (11.8)	50.6 (9.6)
Hispanic	342 (13.1%)	45.1 (11.6)	48.6 (10.9)
African American	398 (16.1%)	42.2 (11.7)	50.4 (9.7)
Asian American/Pacific Islander	424 (17.1%)	45.2 (10.7)	51.4 (8.6)
Other	47 (1.9%)	41.9 (11.5)	51.6 (10.1)
Gender[a,b]			
Male	1,134 (45.8%)	46.1 (11.0)	51.2 (9.3)
Female	1,343 (54.2%)	43.5 (12.0)	49.9 (9.9)
Education[a,b]			
High school or less	612 (24.7%)	41.8 (12.0)	49.2 (10.5)
Some college or college graduate	1,299 (52.4%)	44.7 (11.6)	50.7 (9.8)
Post graduate	552 (22.3%)	47.8 (10.5)	51.5 (8.3)
Employment[a,b]			
Full-time/part-time	796 (32.1%)	50.0 (9.3)	50.4 (9.2)
Retired	1,371 (55.3%)	42.5 (11.5)	51.6 (9.3)
Unemployed	106 (4.3%)	38.8 (12.5)	43.5 (12.0)
Income[a,b]			
<$60,000	1,323 (53.4%)	41.5 (11.7)	49.3 (10.4)
$60,000–$99,999	487 (19.7%)	47.9 (10.4)	51.3 (8.8)
≥$100,000	449 (18.1%)	50.5 (9.3)	52.4 (7.9)
Marital status[a,b]			
Married	1,586 (64.0%)	46.2 (11.0)	51.2 (8.9)
Not married	882 (35.6%)	42.0 (12.2)	49.1 (10.8)
Insurance status[a,b]			
Private only	1,173 (47.4%)	47.0 (11.3)	50.1 (9.6)
Public only	480 (19.4%)	41.5 (11.8)	48.9 (10.6)
Private and public	700 (28.3%)	43.2 (11.3)	52.3 (8.8)
No insurance	54 (2.2%)	42.6 (12.1)	46.8 (10.7)
Cancer site[a,b]			
Colorectal cancer	809 (32.7%)	45.6 (11.3)	50.4 (9.3)
Bladder	174 (7.0%)	46.9 (11.0)	50.1 (8.7)
Leukemia	80 (3.2%)	43.2 (13.1)	49.0 (9.6)
Non-Hodgkin lymphoma	292 (11.8%)	44.7 (12.0)	49.6 (11.1)
Breast	357 (14.4%)	43.2 (11.9)	50.5 (9.7)
Uterine	181 (7.3%)	41.0 (12.3)	49.9 (10.8)
Ovarian	198 (8.0%)	44.7 (11.3)	50.2 (9.7)
Prostate	386 (15.6%)	45.3 (11.2)	52.3 (9.0)
Stage at diagnosis[a]			
Localized	1,321 (53.3%)	44.6 (11.7)	50.5 (9.6)
Regional	726 (29.3%)	45.8 (11.2)	50.6 (9.6)
Distant	269 (10.9%)	43.5 (11.6)	50.2 (9.9)
Not applicable	80 (3.2%)	43.2 (13.1)	49.0 (9.6)
Unknown	81 (3.3%)	41.9 (11.8)	51.9 (10.0)
Recurrence[a,b]			
No	2,158 (87.1%)	45.1 (11.5)	50.7 (9.6)
Yes	280 (11.3%)	41.3 (12.2)	49.0 (10.4)
Radiation[a]			
No	1,698 (68.6%)	45.3 (11.5)	50.5 (9.5)
Yes	748 (30.2%)	43.4 (12.0)	50.5 (10.1)
Diagnosis of depression/anxiety[a,b]			
No	1912 (77.2%)	45.7 (11.2)	52.4 (8.4)
Yes	534 (21.6%)	41.5 (12.4)	43.8 (10.8)

(Continued on the following page)

Table 1. Distribution of sample characteristics and mean physical and mental composite scores (PCS, MCS). (Cont'd)

	n (%)	Mean PCS (SD)	Mean MCS (SD)
BMI[a,b]			
Underweight	32 (1.3%)	42.9 (13.3)	50.5 (11.2)
Normal	644 (26.0%)	45.8 (11.3)	51.9 (9.0)
Overweight	618 (24.9%)	44.9 (11.1)	50.9 (9.7)
Obese	444 (17.9%)	40.5 (12.0)	49.7 (10.9)
Missing[c]	739 (29.8%)	46.2 (11.5)	49.4 (9.2)
Vigorous physical activity[a,b]			
No	928 (37.5%)	40.4 (12.2)	49.7 (10.5)
Yes	825 (33.3%)	47.8 (9.9)	52.2 (8.9)
Missing[c]	724 (29.2%)	46.5 (11.2)	49.6 (9.1)
Moderate physical activity[a,b]			
No	421 (17.0%)	38.5 (12.5)	47.5 (11.6)
Yes	1,335 (53.9%)	45.7 (10.9)	51.9 (9.1)
Missing[c]	721 (29.1%)	46.5 (11.3)	49.7 (9.0)
Smoker[a,b]			
Never	928 (37.5%)	44.9 (11.6)	50.9 (9.7)
Former	665 (26.8%)	42.9 (11.7)	51.5 (9.5)
Current	120 (4.8%)	42.2 (11.9)	47.5 (11.8)
Missing	764 (30.8%)	46.4 (11.4)	49.7 (9.3)
Alcohol[a,b]			
Not current	994 (40.1%)	41.8 (12.2)	50.3 (10.2)
Current, low	508 (20.5%)	46.5 (10.4)	51.3 (9.3)
Current, high	250 (10.1%)	47.3 (10.8)	52.6 (9.5)
Missing[c]	725 (29.3%)	46.4 (11.2)	49.5 (9.1)

[a]PCS scores statistically significant at $P < 0.05$.
[b]MCS scores statistically significant at $P < 0.05$.
[c]Most missing data for BMI, physical activity, smoking status, and alcohol use accounted for by not being available for Assessment of Patients' Experience of Cancer Care (APECC).

Table 2 shows the distribution of neighborhood characteristics for the study sample. Thirty-six percent of participants lived in lower SES (quintiles 1–3) neighborhoods. About half of participants resided in the two highest quintiles of population density (46%). Forty-three percent resided in minority predominant neighborhoods, and almost half in racially/ethnically-mixed neighborhoods (48%). A majority of participants lived in neighborhoods with low street connectivity (62%). Three-fourths of participants lived near at least one park and 86% were within 1 mile walking distance of at least 1 recreational facility. About 40% lived in neighborhoods where the number of unhealthy food outlets outnumbered healthy ones.

HRQOL: PCS and MCS

Differences in the PCS and MCS were seen for both sociodemographic (**Table 1**) and neighborhood factors (**Table 2**). With regards to sociodemographic factors, younger patients had the highest PCS, with PCS decreasing with increasing age, whereas older patients had higher MCS. African American participants and those with Other race/ethnicity had the lowest PCS; Hispanic participants had the lowest MCS. Females had lower PCS but higher MCS than males. Participants who had more education had higher PCS and MCS. Those with more advanced disease and recurrence reported lower PCS and MCS. In terms of neighborhood factors, participants who lived in neighborhoods with lower SES, minority-predominant neighborhoods, highest population density, higher street connectivity, more recreational facilities, more parks, more unhealthy restaurants, more crowding, more rental households, and more non-single family units had lower PCS and MCS.

Neighborhood attributes associated with HRQOL

In models minimally adjusted for age, cancer stage, and cancer recurrence (**Table 3**, Model 1), residing in neighborhoods with higher nSES was associated with higher PCS [mean 45.5, 95% confidence interval (95% CI), 43.7–47.3 for quintile 5 vs. mean 39.3, 95% CI (37.0–41.5) for quintile 1, $P_{\text{trend}} < 0.001$]. Neighborhood racial/ethnic composition was also associated with PCS; NH White-predominant (mean, 44.0; 95% CI, 41.7–46.3) and mixed racial/ethnic composition (mean, 44.1; 95% CI, 42.3–46.0) neighborhoods had higher PCS compared with predominantly minority neighborhoods (mean 41.6; 95% CI, 39.8–43.4). Those residing in rural areas (mean, 45.5; 95% CI, 42.0–49.0), suburbs (mean, 43.5; 95% CI, 41.6–45.5), or cities (mean, 42.2; 95% CI, 40.1–44.3) had higher PCS than those residing in metropolitan areas (mean, 40.7; 95% CI, 38.6–43.2). In addition, those residing in neighborhoods with the following characteristics were associated with lower PCS scores: high population density ($P_{\text{trend}} < 0.001$); high street connectivity ($P_{\text{trend}} = 0.003$); more recreational facilities ($P_{\text{trend}} = 0.028$); higher ratio of unhealthy restaurants to healthy ($P_{\text{trend}} = 0.011$); higher traffic density ($P_{\text{trend}} = 0.010$); more crowding ($P_{\text{trend}} < 0.001$); higher percent of rental properties ($P_{\text{trend}} < 0.001$); and higher percent of non–single family units ($P_{\text{trend}} < 0.001$). However, when additionally adjusting for nSES, only those residing in rural areas (mean, 44.5; 95% CI, 41.1–47.9) was significantly associated with PCS (**Table 3**, Model 2). In fully adjusted models adjusting for clinical, sociodemographic (**Table 3**, Model 3), and behavioral factors (**Table 3**, Model 4), only nSES remained statistically significantly associated with PCS ($P_{\text{trend}} < 0.001$).

In models minimally adjusted for age, and cancer recurrence (**Table 4**, Model 1), residing in neighborhoods with higher nSES

Table 2. Distribution of neighborhood attributes and mean PCS and MCS.

	n (%)	Mean PCS (SD)	Mean MCS (SD)
Neighborhood SES (Yost Index)[a,b,c]			
Q1: Low SES: −4.3 to −0.90	184 (7.4%)	40.6 (12.1)	49.1 (11.4)
Q2: −0.90 to −0.31	290 (11.7%)	40.3 (12.2)	49.4 (10.3)
Q3: −0.31–0.22	422 (17.0%)	44.5 (11.4)	49.7 (10.1)
Q4: 0.22–0.84	579 (23.4%)	44.2 (11.7)	50.5 (9.7)
Q5: High SES: 0.84–3.5	1,002 (40.5%)	47.1 (10.8)	51.4 (8.8)
Neighborhood racial/ethnic composition[b,c,d]			
Minority predominant	1,292 (52.2%)	43.4 (11.7)	49.9 (10.2)
Mixed	968 (39.1%)	46.2 (11.4)	51.0 (9.0)
White predominant	217 (8.8%)	45.7 (11.8)	51.8 (9.1)
Urbanicity[b,c,e]			
Metropolitan	483 (19.5%)	42.3 (12.0)	48.9 (10.1)
Suburb	1,510 (61.0%)	45.4 (11.3)	50.8 (9.5)
City	414 (16.7%)	44.5 (12.0)	50.9 (9.8)
Town	16 (0.6%)	41.8 (12.1)	52.4 (11.1)
Rural	54 (2.2%)	48.5 (10.2)	51.5 (8.4)
Population density[a,b,c]			
Q1: Low population density: 0–0.00073	312 (12.6%)	46.2 (11.2)	50.9 (9.6)
Q2: 0.00073–0.0020	513 (20.7%)	46.2 (11.3)	51.5 (8.8)
Q3: 0.0020–0.0031	509 (20.5%)	45.4 (11.5)	51.4 (9.5)
Q4: 0.0031–0.0049	552 (22.3%)	43.6 (11.8)	49.6 (10.0)
Q5: High population density: 0.0049–0.067	591 (23.9%)	43.0 (11.8)	49.5 (10.1)
Street Connectivity/Gamma[b,c,f]			
Q1: Low street connectivity: 0.064–0.39	539 (21.8%)	45.6 (11.4)	50.9 (9.4)
Q2: 0.39–0.42	519 (21.0%)	45.5 (11.3)	51.3 (9.5)
Q3: 0.42–0.46	477 (19.3%)	45.1 (11.5)	50.9 (9.0)
Q4: 0.46–0.50	465 (18.8%)	43.8 (11.9)	49.8 (10.0)
Q5: High street connectivity: 0.50–1	477 (19.3%)	43.3 (12.0)	49.4 (10.5)
Recreational facilities (per 1,000 residents)[b,g]			
0	338 (13.6%)	46.8 (10.9)	50.3 (9.4)
1–2	513 (20.7%)	45.1 (11.8)	51.0 (9.1)
3–4	418 (16.9%)	43.6 (12.0)	50.8 (9.9)
5+	1,208 (48.8%)	44.3 (11.6)	50.2 (9.9)
Parks (per 1,000 residents)[c,h]			
0	598 (24.1%)	45.4 (11.1)	51.2 (9.3)
1–2	1,191 (48.1%)	44.3 (11.9)	50.6 (9.6)
3–4	492 (19.9%)	45.1 (11.7)	49.9 (9.8)
5+	196 (7.9%)	44.3 (11.6)	48.9 (10.7)
Restaurant environment index (REI)[b,c,i]			
REI = 0: No unhealthy restaurants	518 (20.9%)	45.8 (11.3)	51.5 (8.8)
REI < 1: Unhealthy < healthy restaurants	1,660 (67.0%)	44.0 (11.7)	50.2 (10.0)
REI ≥ 1: Unhealthy ≥ healthy restaurants	62 (2.5%)	45.1 (12.7)	48.3 (10.9)
No restaurants	237 (9.6%)	46.9 (11.1)	51.1 (8.8)
Retail Food Environment Index (RFEI)[j]			
RFEI = 0: No unhealthy outlets	171 (6.9%)	45.3 (11.4)	51.8 (8.7)
RFEI < 1: Unhealthy < healthy outlets	1,111 (44.9%)	44.0 (11.8)	50.0 (10.0)
RFEI ≥ 1: Unhealthy ≥ healthy outlets	973 (39.3%)	44.6 (11.7)	50.7 (9.7)
No food outlets	222 (9.0%)	48.1 (10.4)	51.1 (8.2)
Traffic density (vehicle kilometers traveled)[b,k]			
Q1: Low density: 0–13,073	475 (19.2%)	46.3 (11.0)	51.0 (9.3)
Q2: 13,074–28,617	476 (19.2%)	44.9 (11.6)	50.6 (9.4)
Q3: 28,619–45,171	476 (19.2%)	43.1 (12.0)	50.3 (9.9)
Q4: 45,175–83,642	476 (19.2%)	44.4 (11.5)	50.5 (9.8)
Q5: High density: 83,691–508,873	476 (19.2%)	44.1 (12.0)	49.8 (10.2)
Percent crowding (>1 occupant/room)[a,b,c]			
Q1: Low crowding: 0–0.026	635 (25.6%)	46.9 (11.3)	51.6 (8.3)
Q2: 0.026–0.067	505 (20.4%)	45.5 (11.4)	50.5 (9.9)
Q3: 0.067–0.14	547 (22.1%)	44.5 (11.2)	50.3 (10.3)
Q4: 0.14–0.29	472 (19.1%)	43.1 (11.8)	50.0 (10.0)
Q5: High crowding: 0.29–1	318 (12.8%)	41.7 (12.2)	49.4 (10.3)

(Continued on the following page)

Table 2. Distribution of neighborhood attributes and mean PCS and MCS. (Cont'd)

	***n* (%)**	**Mean PCS (SD)**	**Mean MCS (SD)**
Percent rental households[a,b,c]			
Q1: Low renting: 0–0.15	674 (27.2%)	46.6 (10.8)	52.2 (8.6)
Q2: 0.15–0.28	510 (20.6%)	44.7 (11.7)	50.6 (9.1)
Q3: 0.28–0.46	451 (18.2%)	44.0 (11.9)	50.1 (10.0)
Q4: 0.46–0.68	474 (19.1%)	43.7 (11.9)	49.5 (10.1)
Q5: High renting: 0.68–1	368 (14.9%)	43.2 (12.0)	49.2 (10.9)
Percent non–single family units[a,b,c]			
Q1: Low non–single family units: 0–0.025	563 (22.7%)	45.8 (11.1)	51.5 (8.6)
Q2: 0.025–0.15	524 (21.2%)	46.1 (10.9)	51.0 (9.1)
Q3: 0.15–0.33	440 (17.8%)	44.1 (12.1)	50.4 (9.9)
Q4: 0.33–0.59	487 (19.7%)	43.5 (12.1)	50.0 (10.5)
Q5: High non-single family units: 0.59–1	463 (18.7%)	43.7 (12.0)	49.3 (10.2)
Neighborhood archetypes[b,c,l]			
Upper middle-class suburb	347 (14.0%)	46.5 (11.2)	50.9 (8.9)
High status	604 (24.4%)	46.6 (10.9)	52.4 (8.2)
New urban/pedestrian	527 (21.3%)	45.7 (11.6)	50.3 (10.0)
Mixed SES suburbs	86 (3.5%)	45.1 (11.7)	50.2 (9.6)
Rural/micropolitan	20 (0.8%)	40.6 (13.3)	50.0 (9.9)
City pioneer	341 (13.8%)	44.1 (11.5)	49.6 (9.4)
Suburban pioneer	236 (9.5%)	41.3 (11.8)	48.7 (11.5)
Hispanic small town	72 (2.9%)	40.8 (12.7)	48.9 (11.8)
Inner city	244 (9.9%)	40.7 (11.6)	49.4 (10.7)

[a]Census 2000 block group-level measures, quintiles based on state distributions.
[b]PCS scores statistically significant at $P < 0.05$.
[c]MCS scores statistically significant at $P < 0.05$.
[d]Census 2000 block group-level measures. Minority predominant if percent of NH Black, NH Asian American, or Hispanic was above the statewide median and percent of NH White was below the statewide median; White predominant if percent of NH White was above the statewide median and percent of NH Black, NH Asian American, and Hispanic was below the statewide median; Mixed otherwise.
[e]Urban/rural status using census-defined Urbanized Areas (population ≥ 50,000) and Urban Clusters (population between 2,500 and 50,000).
[f]Census 2000 block group-level measures, quintiles based on state distributions. Ratio of actual number of street segments to maximum possible number of intersections; a higher ratio indicates more street connectivity.
[g]Total number of recreational facilities that were active during the 3-year window around year of interview within a 1,600-meter network distance.
[h]Total number of parks within a 1,600-meter network distance.
[i]Residential buffer measure within a 1,600-meter network distance: ratio of the average number of fast food restaurants to other restaurants. If denominator = 0 and numerator > 0, classified as REI ≥ 1.
[j]Residential buffer measure within a 1,600-meter network distance: ratio of the average number of convenience stores, liquor stores, and fast food restaurants to supermarkets and farmers' markets. If denominator = 0 and numerator > 0, classified as RFEI ≥ 1.
[k]Vehicle kilometers traveled (VkmT) within a 500-meter distance, quintiles based on sample distribution.
[l]Census 2000 tract-level summary neighborhood measure that accounts for the synergistic effects of 39 social and built environment attributes.

was associated with higher MCS [mean 51.2, 95% CI (49.9–52.5) for quintile 5 vs. mean 48.5, 95% CI (46.7–50.3) for quintile 1, $P_{trend} < 0.001$]. Neighborhood racial/ethnic composition was associated with MCS: NH White-predominant (mean, 51.4; 95% CI, 49.7–53.1) and mixed racial/ethnic composition (mean, 50.7; 95% CI, 49.4–52.0) neighborhoods had higher MCS compared with minority neighborhoods (mean, 49.4; 95% CI, 48.2–50.6). Those residing in towns (mean, 52.3; 95% CI, 47.5–57.2), rural areas (mean, 51.3; 95% CI, 48.6–54.1), cities (mean, 50.6; 95% CI, 49.2–52.0), or suburbs (mean, 50.4; 95% CI, 49.2–51.6) had higher MCS than those residing in metropolitan areas (mean, 48.4; 95% CI, 47.1–49.8), although this was not statistically significant. In addition, those residing in neighborhoods with the following characteristics were associated with lower MCS scores: high population density ($P_{trend} < 0.001$), high street connectivity ($P_{trend} < 0.001$), more parks ($P_{trend} = 0.002$), higher ratio of unhealthy restaurants to healthy restaurants ($P_{trend} = 0.003$), more traffic density ($P_{trend} = 0.039$), more crowding ($P_{trend} < 0.001$), higher percent of rental properties ($P_{trend} < 0.001$), and higher percent of non–single family units ($P_{trend} < 0.001$). When additionally adjusted for nSES, all of these neighborhood attributes remained significantly associated with MCS except for neighborhood racial/ethnic composition, traffic density, and crowding (**Table 4**, Model 2). However, in fully-adjusted multivariable models adjusted for clinical and sociodemographic (**Table 4**, Model 3), and behavioral factors (**Table 4**, Model 4), only the ratio of more unhealthy to healthy restaurants remained significantly associated with lower MCS.

Neighborhood archetypes associated with HRQOL

Table 5 examines neighborhood archetypes associated with PCS and MCS. For PCS, Upper middle-class suburb (mean 45.1; 95% CI, 43.1–47.1) and High status (mean, 44.8; 95% CI, 42.9–46.7) neighborhoods had the highest PCS in minimally adjusted models (**Table 5**, Model 1). City pioneer (mean, 42.3; 95% CI, 40.3–44.3), Suburban pioneer (mean, 40.2; 95% CI, 35.1–45.3), Hispanic small town (mean, 39.9; 95% CI, 36.9–42.9) and Inner city neighborhoods (mean, 39.3; 95% CI, 37.2–41.4) had lower PCS compared with Upper middle-class suburb. In a multivariable model adjusting for sociodemographic, clinical, and behavioral variables (**Table 5**, Model 2), Suburban pioneer (mean, 37.3; 95% CI, 34.1–40.6) and Inner city (mean, 37.3; 95% CI, 34.0- 40.6) remained associated with lower PCS compared with Upper middle-class suburb (mean, 39.4; 95% CI, 36.1–42.6).

Table 3. Associations between neighborhood attributes and PCS.

	Model 1: Neighborhood variable only[a] LS Mean PCS (95% CI)	Model 2: Neighborhood variable+ nSES[a] LS Mean PCS, (95% CI)	Model 3: Multivariable model[b] LS Mean PCS, (95% CI)	Model 4: Multivariable model + health-related behaviors[c] LS Mean PCS, (95% CI)
Neighborhood SES (Yost Index)[d]				
Q1: Low SES: −4.3 to −0.90	39.3 (37.0–41.5)		36.3 (32.9–39.8)	37.8 (34.4–41.2)
Q2: −0.90 to −0.31	38.9 (36.8–40.9)		35.5 (32.3–38.7)	36.7 (33.4–39.9)
Q3: −0.31–0.22	**42.9 (41.0–44.9)**		**38.8 (35.7–42.0)**	39.4 (36.2–42.6)
Q4: 0.22–0.84	**42.5 (40.7–44.4)**		38.1 (35.0–41.3)	38.4 (35.2–41.6)
Q5: High SES: 0.84–3.5	**45.5 (43.7–47.3)**		**39.9 (36.7–43.0)**	**39.9 (36.7–43.1)**
P_{trend}	**<0.001**		**<0.001**	**<0.001**
Neighborhood racial/ethnic composition[e]				
Minority predominant	41.6 (39.8–43.4)	41.8 (40.1–43.6)		
Mixed	**44.1 (42.3–46.0)**	41.9 (40.0–43.8)		
White predominant	**44.0 (41.7–46.3)**	41.4 (39.1–43.7)		
Urbanicity[f]				
Metropolitan	40.7 (38.6–42.7)	41.1 (39.3–43.0)		
Suburb	**43.5 (41.6–45.5)**	42.3 (40.6–44.1)		
City	**42.2 (40.1–44.3)**	41.4 (39.4–43.3)		
Town	40.5 (34.7–46.3)	40.1 (34.5–45.7)		
Rural	**45.5 (42.0–49.0)**	**44.5 (41.1–47.9)**		
Population Density[e]				
Q1: Low population density: 0–0.00073	43.9 (41.7–46.0)	42.1 (40.0–44.3)		
Q2: 0.00073–0.0020	44.2 (42.3–46.2)	42.5 (40.5–44.4)		
Q3: 00020–0.0031	43.5 (41.6–45.5)	42.2 (40.2–44.1)		
Q4: 0.0031–0.0049	**41.5 (39.6–43.5)**	41.0 (39.1–42.9)		
Q5: High population density: 0.0049–0.067	**41.2 (39.3–43.2)**	41.7 (39.9–43.6)		
P_{trend}	**<0.001**	0.12		
Street connectivity/Gamma[g]				
Q1: Low street connectivity: 0.064–0.39	43.1 (41.0–45.1)	41.2 (39.2–43.1)		
Q2: 0.39–0.42	43.4 (41.4–45.4)	42.2 (40.2–44.1)		
Q3: 0.42–0.46	43.3 (41.3–45.4)	**42.6 (40.6–44.5)**		
Q4: 0.46–0.50	41.9 (39.8–43.9)	41.7 (39.8–43.6)		
Q5: High street connectivity: 0.50–1	**41.4 (39.4–43.5)**	41.3 (39.4–43.3)		
P_{trend}	**0.003**	0.91		
Recreational facilities (per 1,000 residents)[h]				
0	44.0 (41.9–46.2)	42.9 (40.8–44.9)		
1–2	43.2 (41.2–45.2)	42.3 (40.4–44.2)		
3–4	**41.8 (39.8–43.8)**	**41.2 (39.3–43.1)**		
5+	**42.5 (40.6–44.4)**	41.7 (40.0–43.5)		
P_{trend}	**0.028**	0.068		
Parks (per 1,000 residents)[i]				
0	43.4 (41.3–45.4)	42.1 (40.2–44.0)		
1–2	42.3 (40.4–44.2)	41.6 (39.8–43.3)		
3–4	42.9 (40.8–45.0)	42.2 (40.3–44.1)		
5+	41.9 (39.5–44.3)	41.5 (39.2–43.8)		
P_{trend}	0.22	0.73		
Restaurant Environment Index (REI)[j]				
REI = 0: No unhealthy restaurants	43.9 (42.0–45.9)	42.3 (40.3–44.2)		
REI<1: Unhealthy < healthy restaurants	**42.2 (40.4–44.0)**	41.7 (40.0–43.4)		
REI≥1: Unhealthy ≥ healthy restaurants	42.8 (39.5–46.0)	41.7 (38.6–44.9)		
P_{trend}	**0.011**	0.39		
No restaurant	44.2 (41.9–46.4)	42.4 (40.2–44.6)		
Retail Food Environment Index (RFEI)[k]				
RFEI = 0: No unhealthy outlets	43.3 (40.9–45.8)	41.4 (39.0–43.8)		
RFEI<1: Unhealthy < healthy outlets	42.2 (40.4–44.0)	41.9 (40.1–43.6)		
RFEI≥1: Unhealthy ≥ healthy outlets	42.6 (40.8–44.4)	41.6 (39.8–43.3)		
P_{trend}	0.99	0.77		
No food outlets	45.3 (43.0–47.6)	43.4 (41.2–45.7)		

(Continued on the following page)

Table 3. Associations between neighborhood attributes and PCS. (Cont'd)

	Model 1: Neighborhood variable only[a] LS Mean PCS (95% CI)	Model 2: Neighborhood variable+ nSES[a] LS Mean PCS, (95% CI)	Model 3: Multivariable model[b] LS Mean PCS, (95% CI)	Model 4: Multivariable model + health-related behaviors[c] LS Mean PCS, (95% CI)
Traffic density (vehicle kilometers traveled)[l]				
Q1: Low density: 0–13,073	44.0 (42.0–46.1)	42.5 (40.6–44.5)		
Q2: 13,074–28,617	42.6 (40.6–44.7)	41.5 (39.6–43.4)		
Q3: 28,619–45,171	**41.6 (39.6–43.6)**	41.1 (39.2–43.0)		
Q4: 45,715–83,642	**42.6 (40.6–44.5)**	42.0 (40.2–43.9)		
Q5: High density: 83,691–508,873	**41.9 (39.9–44.0)**	41.7 (39.8–43.6)		
P_{trend}	**0.010**	0.44		
Percent crowding (>1 occupant/room)[d]				
Q1: Low crowding: 0–0.026	45.1 (43.2–47.0)	42.2 (40.1–44.2)		
Q2: 0.026–0.067	**43.6 (41.7–45.6)**	41.5 (39.4–43.5)		
Q3: 0.067–0.14	**42.7 (40.8–44.6)**	41.4 (39.5–43.4)		
Q4: 0.14–0.29	**41.1 (39.2–43.1)**	41.5 (39.6–43.4)		
Q5: High crowding: 0.29–1	**40.3 (38.3–42.4)**	42.4 (40.3–44.5)		
P_{trend}	**<0.001**	0.59		
Percent rental households[d]				
Q1: Low renting: 0–0.15	44.6 (42.6–46.5)	42.3 (40.4–44.3)		
Q2: 0.15–0.28	**42.8 (40.8–44.8)**	41.6 (39.6–43.5)		
Q3: 0.28–0.46	**42.2 (40.2–44.3)**	41.6 (39.7–43.6)		
Q4: 0.46–0.68	**41.9 (39.9–43.9)**	41.9 (40.0–43.8)		
Q5: High renting: 0.68–1	**41.1 (39.0–43.2)**	41.5 (39.5–43.5)		
P_{trend}	**<0.001**	0.41		
Percent non–single family units[f]				
Q1: Low non–single family units: 0–0.025	43.8 (41.8–45.8)	41.7 (39.7–43.6)		
Q2: 0.025–0.15	44.0 (42.0–46.1)	42.7 (40.7–44.6)		
Q3: 0.15–0.33	**42.3 (40.3–44.3)**	41.8 (39.9–43.7)		
Q4: 0.33–0.59	**41.7 (39.7–43.7)**	41.6 (39.7–43.5)		
Q5: High non-single family units: 0.59–1	**41.7 (39.7–43.8)**	41.6 (39.7–43.5)		
P_{trend}	**<0.001**	0.43		

Note: Bold indicates $P < 0.05$ compared with the first category (reference level).
Abbreviation: LS, least square.
[a]Neighborhood variables entered into models separately, minimally adjusted for age at interview (years), stage, and self-reported recurrence, using a three-level model with a random effect for study/region and a random effect for block group nested within study/region.
[b]Same three-level model as in footnote a. Model included neighborhood attributes that were significantly associated with PCS in a multivariable model, adjusted for patient and clinical characteristics that were associated with both PCS (in a multivariable model) and neighborhood SES. The model shown here was adjusted for age, stage, recurrence, race/ethnicity, employment, income, marital status, and ever depression/anxiety.
[c]Additionally added to multivariable model in footnote b health-related behavior covariates that were associated with both PCS and neighborhood SES: moderate and strenuous physical activity, smoking, alcohol, and BMI.
[d]Census 2000 block group-level measures, quintiles based on state distributions.
[e]Census 2000 block group-level measures. Minority predominant if percent of NH Black, NH Asian American, or Hispanic was above the statewide median and percent of NH White was below the statewide median; White predominant if percent of NH White was above the statewide median and percent of NH Black, NH Asian American, and Hispanic was below the statewide median; Mixed otherwise.
[f]Urban/rural status using census-defined Urbanized Areas (population ≥ 50,000) and Urban Clusters (population between 2,500 and 50,000).
[g]Census 2000 block group-level measures, quintiles based on state distributions. Ratio of actual number of street segments to maximum possible number of intersections; a higher ratio indicates more street connectivity.
[h]Total number of recreational facilities that were active during the 3-year window around year of interview within a 1,600-meter network distance.
[i]Total number of parks within a 1,600-meter network distance.
[j]Residential buffer measure within a 1,600-meter network distance: ratio of the average number of fast food restaurants to other restaurants. If denominator = 0 and numerator > 0, classified as REI ≥ 1. P_{trend} did not include No restaurants.
[k]Residential buffer measure within a 1,600-meter network distance: ratio of the average number of convenience stores, liquor stores, and fast food restaurants to supermarkets and farmers' markets. If denominator = 0 and numerator > 0, classified as RFEI ≥ 1. P_{trend} did not include No food outlets.
[l]Vehicle kilometers traveled (VkmT) within a 500-meter distance, quintiles based on sample distribution.

High status and Upper middle-class suburb neighborhoods had the highest MCS [mean 52.1, 95% CI (50.7–53.4); mean 50.4, 95% CI (48.9–52.0)], respectively, in minimally adjusted models (**Table 5**, Model 1), with High status significantly higher than Upper middle-class suburb. Suburban pioneer [mean 48.0, 95% CI (46.4–49.7)] and Inner city neighborhoods (mean, 48.7; 95% CI, 47.1–50.3) had significantly lower MCS. In a multivariable model adjusting for sociodemographic, clinical, and behavioral variables (**Table 5**, Model 2), only High status (mean, 53.4; 95% CI, 51.1–55.7) remained associated with higher MCS compared with Upper middle-class suburb (mean, 51.7; 95% CI, 49.2–54.1).

Table 4. Associations between neighborhood attributes and MCS.

	Model 1: Neighborhood variable only[a] LS Mean MCS (95% CI)	**Model 2: Neighborhood variable+ nSES[a] LS Mean MCS, (95% CI)**	**Model 3: Multivariable model[b] LS Mean MCS, (95% CI)**	**Model 4: Multivariable model + health-related behaviors[c] LS Mean MCS, (95% CI)**
Neighborhood SES (Yost Index)[d]				
Q1: Low SES: −4.3 to −0.90	48.5 (46.7–50.3)			
Q2: −0.90 to −0.31	48.9 (47.3–50.4)			
Q3: −0.31–0.22	49.3 (47.8–50.7)			
Q4: 0.22–0.84	**50.2 (48.8–51.6)**			
Q5: High SES: 0.84–3.5	**51.2 (49.9–52.5)**			
P_{trend}	<**0.001**			
Neighborhood racial/ethnic composition[e]				
Minority predominant	49.4 (48.2–50.6)	49.5 (48.2–50.7)		
Mixed	**50.7 (49.4–52.0)**	49.8 (48.4–51.2)		
White predominant	**51.4 (49.7–53.1)**	50.4 (48.6–52.2)		
Urbanicity[f]				
Metropolitan	48.4 (47.1–49.8)	48.5 (47.1–50.0)		
Suburb	**50.4 (49.2–51.6)**	**49.9 (48.6–51.2)**		
City	**50.6 (49.2–52.0)**	**50.3 (48.8–51.8)**		
Town	52.3 (47.5–57.2)	52.1 (47.3–57.0)		
Rural	**51.3 (48.6–54.1)**	50.9 (48.1–53.7)		
Population density[e]				
Q1: Low population density: 0–0.00073	50.6 (49.0–52.1)	49.9 (48.3–51.6)		
Q2: 0.00073–0.0020	51.1 (49.7–52.4)	50.5 (49.0–51.9)		
Q3: 00020–0.0031	51.0 (49.6–52.3)	50.5 (49.0–51.9)		
Q4: 0.0031–0.0049	49.2 (47.9–50.6)	49.0 (47.6–50.4)		
Q5: High population density: 0.0049–0.067	**49.0 (47.7–50.3)**	49.1 (47.7–50.4)		
P_{trend}	<**0.001**	**0.021**		
Street connectivity/Gamma[g]				
Q1: Low street connectivity: 0.064–0.39	50.5 (49.2–51.9)	49.8 (48.4–51.3)		
Q2: 0.39–0.42	50.9 (49.6–52.3)	50.4 (49.0–51.9)		
Q3: 0.42–0.46	50.4 (49.0–51.8)	50.1 (48.7–51.5)		
Q4: 0.46–0.50	**49.3 (47.9–50.7)**	49.2 (47.8–50.7)		
Q5: High street connectivity: 0.50–1	**48.9 (47.5–50.2)**	48.8 (47.4–50.2)		
P_{trend}	<**0.001**	**0.027**		
Recreational facilities (per 1,000 residents)[h]				
0	50.1 (48.6–51.6)	49.5 (48.0–51.1)		
1–2	50.6 (49.3–52.0)	50.2 (48.8–51.6)		
3–4	50.3 (48.9–51.7)	50.0 (48.5–51.5)		
5+	49.7 (48.5–50.8)	49.3 (48.0–50.5)		
P_{trend}	0.14	0.19		
Parks (per 1,000 residents)[i]				
0	50.7 (49.4–52.0)	50.2 (48.8–51.6)		
1–2	50.1 (49.0–51.3)	49.8 (48.5–51.0)		
3–4	**49.5 (48.2–50.9)**	49.2 (47.8–50.6)		
5+	**48.4 (46.7–50.1)**	**48.1 (46.3–49.9)**		
P_{trend}	**0.002**	**0.006**		
Restaurant Environment Index (REI)[j]				
REI = 0: No unhealthy restaurants	51.0 (49.7–52.4)	50.4 (48.9–51.9)	52.0 (49.6–54.4)	52.4 (50.1–54.8)
REI < 1: Unhealthy < healthy restaurants	**49.7 (48.5–50.9)**	49.5 (48.2–50.7)	51.4 (49.1–53.7)	51.9 (49.6–54.1)
REI ≥ 1: Unhealthy ≥ healthy restaurants	**48.2 (45.6–50.8)**	47.8 (45.2–50.5)	**49.5 (46.2–52.7)**	**49.9 (46.7–53.1)**
P_{trend}	**0.003**	**0.027**	0.090	0.078
No restaurant	51.0 (49.3–52.6)	50.3 (48.5–52.0)	51.7 (49.1–54.2)	52.1 (49.6–54.6)
Retail Food Environment Index (RFEI)[k]				
RFEI = 0: No unhealthy outlets	51.2 (49.4–53.0)	50.4 (48.5–52.3)		
RFEI<1: Unhealthy<Healthy outlets	**49.4 (48.2–50.6)**	49.2 (48.0–50.5)		
RFEI≥1: Unhealthy≥Healthy outlets	50.3 (49.1–51.6)	49.9 (48.6–51.3)		
P_{trend}	0.52	0.59		
No food outlets	51.0 (49.4–52.7)	50.3 (48.5–52.0)		

(Continued on the following page)

Table 4. Associations between neighborhood attributes and MCS. (Cont'd)

	Model 1: Neighborhood variable only[a] LS Mean MCS (95% CI)	Model 2: Neighborhood variable+ nSES[a] LS Mean MCS, (95% CI)	Model 3: Multivariable model[b] LS Mean MCS, (95% CI)	Model 4: Multivariable model + health-related behaviors[c] LS Mean MCS, (95% CI)
Traffic density (vehicle kilometers traveled)[l]				
Q1: Low density: 0–13,073	50.7 (49.4–52.1)	50.1 (48.6–51.6)		
Q2: 13,074–28,617	50.2 (48.8–51.5)	49.7 (48.2–51.1)		
Q3: 28,619–45,171	49.6 (48.3–51.0)	49.4 (48.0–50.9)		
Q4: 45,715–83,642	49.9 (48.6–51.2)	49.6 (48.2–51.1)		
Q5: High density: 83,691–508,873	**49.4 (48.0–50.8)**	49.3 (47.8–50.7)		
P_{trend}	**0.039**	0.24		
Percent crowding (>1 occupant/room)[d]				
Q1: Low crowding: 0–0.026	51.2 (49.8–52.5)	49.9 (48.3–51.4)		
Q2: 0.026–0.067	50.2 (48.8–51.5)	49.2 (47.6–50.7)		
Q3: 0.067–0.14	**49.9 (48.5–51.2)**	49.4 (47.9–50.8)		
Q4: 0.14–0.29	**49.7 (48.3–51.1)**	49.9 (48.4–51.4)		
Q5: High crowding: 0.29–1	**48.9 (47.4–50.4)**	49.7 (48.1–51.4)		
P_{trend}	**<0.001**	0.90		
Percent rental households[d]				
Q1: Low renting: 0–0.15	51.8 (50.5–53.1)	51.2 (49.8–52.6)		
Q2: 0.15–0.28	**50.2 (48.8–51.5)**	**49.9 (48.4–51.3)**		
Q3: 0.28–0.46	**49.6 (48.2–51.0)**	**49.5 (48.0–50.9)**		
Q4: 0.46–0.68	**49.1 (47.7–50.4)**	**49.1 (47.7–50.4)**		
Q5: High renting: 0.68–1	**48.9 (47.4–50.3)**	**48.9 (47.5–50.4)**		
P_{trend}	**<0.001**	**<0.001**		
Percent non–single family units[f]				
Q1: Low non–single family units: 0–0.025	51.2 (49.8–52.5)	50.4 (48.9–51.8)		
Q2: 0.025–0.15	50.6 (49.3–52.0)	50.1 (48.7–51.6)		
Q3: 0.15–0.33	**49.9 (48.6–51.3)**	49.7 (48.3–51.2)		
Q4: 0.33–0.59	**49.5 (48.2–50.9)**	49.5 (48.1–50.9)		
Q5: High non–single family units: 0.59–1	**49.0 (47.6–50.3)**	**48.9 (47.5–50.3)**		
P_{trend}	**<0.001**	**0.013**		

Note: Bold indicates $P < 0.05$ compared with the first category (reference level).
Abbreviation: LS, least square.
[a]Neighborhood variables entered into models separately, minimally adjusted for age at interview (years), and self-reported recurrence, using a three-level model with a random effect for study/region and a random effect for block group nested within study/region.
[b]Same 3-level model as in footnote a. Model included neighborhood attributes that were significantly associated with MCS in a multivariable model, adjusted for patient and clinical characteristics that were associated with both MCS (in a multivariable model) and REI. The model shown here was adjusted for age, race/ethnicity, education, income, marital status, and insurance.
[c]Additionally added to multivariable model in footnote (b) health-related behavior covariates that were associated with both MCS and neighborhood REI: alcohol.
[d]Census 2000 block group-level measures, quintiles based on state distributions.
[e]Census 2000 block group-level measures. Minority predominant if percent of NH Black, NH Asian American, or Hispanic was above the statewide median and percent of NH White was below the statewide median; White predominant if percent of NH White was above the statewide median and percent of NH Black, NH Asian American, and Hispanic were below the statewide median; Mixed otherwise.
[f]Urban/rural status using census-defined Urbanized Areas (population ≥ 50,000) and Urban Clusters (population between 2,500 and 50,000).
[g]Census 2000 block group-level measures, quintiles based on state distributions. Ratio of actual number of street segments to maximum possible number of intersections; a higher ratio indicates more street connectivity.
[h]Total number of recreational facilities that were active during the 3-year window around year of interview within a 1,600-meter network distance.
[i]Total number of parks within a 1,600-meter network distance.
[j]Residential buffer measure within a 1,600-meter network distance: ratio of the average number of fast food restaurants to other restaurants. If denominator = 0 and numerator > 0, classified as REI ≥ 1. P_{trend} did not include No restaurants.
[k]Residential buffer measure within a 1,600-meter network distance: ratio of the average number of convenience stores, liquor stores, and fast food restaurants to supermarkets and farmers' markets. If denominator = 0 and numerator > 0, classified as RFEI ≥ 1. P_{trend} did not include No food outlets.
[l]Vehicle kilometers traveled (VkmT) within a 500-meter distance, quintiles based on sample distribution.

Discussion

Among a diverse cohort of cancer survivors, we found that select neighborhood social and built environmental factors, including low nSES, high minority composition, increased population density, more street connectivity, more unhealthy restaurants, and more non–single family units, were associated with lower PCS and MCS. However, most of the individual neighborhood associations were no longer significant in multivariable models including nSES, with nSES as the only neighborhood attribute remaining significantly associated with PCS, and only restaurant environment index with MCS. This study

Table 5. Associations between neighborhood archetypes and PCS and MCS.

Archetype 9-class CT 2000	Model 1: Minimally adjusted[a] LS Mean (95% CI)	Model 2: Fully adjusted[b] LS Mean (95% CI)
PCS		
Upper middle-class suburb (ref)	45.1 (43.1–47.1)	39.4 (36.1–42.6)
High status	44.8 (42.9–46.7)	39.4 (36.2–42.6)
New urban/pedestrian	43.9 (42.1–45.8)	39.5 (36.3–42.7)
Mixed SES suburb	43.0 (40.2–45.9)	38.9 (35.2–42.7)
Rural/micropolitan	40.2 (35.1–45.3)	35.8 (30.4–41.1)
City pioneer	**42.3 (40.3–44.3)**	38.8 (35.6–42.0)
Suburban pioneer	**40.2 (38.0–42.3)**	**37.3 (34.1–40.6)**
Hispanic small town	**39.9 (36.9–42.9)**	37.1 (33.3–40.9)
Inner city	**39.3 (37.2–41.4)**	**37.3 (34.0–40.6)**
MCS		
Upper middle-class suburb	50.4 (48.9–52.0)	51.7 (49.2–54.1)
High status	**52.1 (50.7–53.4)**	**53.4 (51.1–55.7)**
New urban/pedestrian	50.1 (48.7–51.5)	51.9 (49.6–54.3)
Mixed SES suburb	50.0 (47.7–52.3)	51.9 (48.9–54.8)
Rural/micropolitan	49.2 (44.9–53.5)	51.1 (46.4–55.7)
City pioneer	49.4 (47.9–51.0)	51.9 (49.5–54.3)
Suburban pioneer	**48.0 (46.4–49.7)**	50.6 (48.2–53.1)
Hispanic small town	48.2 (45.7–50.6)	50.9 (47.8–54.0)
Inner city	**48.7 (47.1–50.3)**	52.0 (49.5–54.5)

Note: Bold indicates $P < 0.05$ compared with Upper middle-class suburb (reference level).
Abbreviations: CT, census tract; LS, least square.
[a]PCS: Minimally adjusted for age at interview (years), stage, and self-reported recurrence, using a 3-level model with a random effect for study/region and a random effect for census tract nested within study/region. MCS: Minimally adjusted for age at interview (years) and self-reported recurrence, using a 3-level model with a random effect for study/region and a random effect for census tract nested within study/region.
[b]PCS: Same 3-level model as footnote a. PCS but adjusted for age, stage, recurrence, race/ethnicity, employment, income, marital status, report of ever having depression/anxiety, moderate and strenuous physical activity, smoking, alcohol, and BMI. MCS: Same 3-level model as footnote a. MCS but adjusted for age, race/ethnicity, education, income, marital status, insurance, and alcohol.

highlights the importance of including neighborhood features in studies of HRQOL among cancer survivors and supports the inclusion of neighborhood features under "enabling resources" in a conceptual framework to improve HRQOL for cancer survivors.

This study highlights the consistent negative impact of low neighborhood SES on HRQOL, even after accounting for patient sociodemographic and clinical factors that also impact HRQOL. This finding is consistent with several prior studies across a range of cancer sites. In a retrospective survey of White and African American cancer survivors, patients living in more disadvantaged neighborhoods (based on an index created from prevalence of poverty, mother-only households, home ownership, and prevalence of college-educated individuals living in the area) reported lower physical QOL compared with those in more advantaged places; interestingly, this association was not seen for mental QOL (38). Similarly, Pruitt and colleagues studied female breast cancer survivors, and found that those living in high poverty neighborhoods were more likely to report lower physical functioning (39). A study of adolescent and young adult survivors of leukemia and lymphoma found that low nSES was associated with poorer physical health (40), while a study of African American and Hispanic breast cancer survivors demonstrated that greater neighborhood stress was associated with poorer health, more comorbidities, more depressive symptoms, and more psychologic difficulties (41). In a multiethnic population–based study of breast cancer survivors, Ashing-Giwa and Lim reported that after controlling for demographic and medical characteristics, low SES and high socioecologic stress exacerbate negative QOL (42). Breast cancer survivors who resided in high-foreclosure-risk areas were at increased odds of reporting poorer health status compared to woman who lived in low-foreclosure-risk areas (43). Future interventions to improve HRQOL among cancer survivors should consider nSES.

In addition, one study of residential exposure to traffic noise and HRQOL found that a 10 decibel higher road traffic noise was associated with lower MCS; however PCS was not associated with traffic noise (15). In our analysis, we assessed traffic density and found that it was not associated with either PCS or MCS once we adjusted for nSES. Studies have demonstrated that rural breast cancer survivors had higher overall QOL and reported lower symptom burden compared to urban survivors (44); another study of head and neck cancer survivors concluded that rural survivors had higher physical and emotional QOL compared to urban survivors, but that social and functional QOL did not differ (45). Our results showed similar associations of rural with higher PCS and MCS in minimally adjusted models; however, these associates were attenuated in fully adjusted models for both PCS and MCS. Our findings for traffic density and urbanicity differ from prior studies likely because of varying covariates and neighborhood factors included in fully adjusted models as well as for the different HRQOL domains examined. Finally, while one study reported an association between limited service/fast food restaurants and physical and mental distress in a general population, no studies to date have explored the role of the restaurant environment and HRQOL among cancer survivors (46). Our finding of more unhealthy restaurants being associated with worse MCS needs to be further studied.

Because it is likely that these individual neighborhood attributes do not impact PCS or MCS independently, but rather through the combination of interactions of these attributes, we expanded upon prior work (47) to consider neighborhood archetypes that summarize the combinations of characteristics from the built environment, migration and commuting, socioeconomic composition, and demographics and household composition (Supplementary Table S1). In our study, we found that the Upper middle-class suburb and High status neighborhoods had the highest PCS and MCS. These archetypes tended to have residents of high SES or who were predominantly White, midlife or older, and had low street connectivity and higher proportion of greenspace or recreational facilities. Hispanic small town and Inner city neighborhoods tend to have residents who are lower-middle to low SES, predominantly are Black or Hispanic, and have more rental properties and more unhealthy food options. In our study, residents of these neighborhood archetypes had the lowest PCS and MCS scores. Evaluating neighborhood archetypes may allow us to account for synergistic effects of individual social and built environment attributes and offer insight as to how these attributes in combination may impact HRQOL.

Our study has several limitations. The data for these analyses are cross-sectional so we were not able to assess causality. In addition, behavioral data was based on self-report and therefore subject to potential recall bias, particularly in light of a cancer diagnosis. The data are pooled from studies conducted in California and in English and thus may not be reflective of cancer survivors who live elsewhere and be limited in generalizability for non–English speaking patient populations. The study also used secondary geospatial data to describe neighborhood environments and therefore may not capture how residents perceive and use their environments. However, capturing social and built environment characteristics in this way is commonly done and validated in other studies; moreover, this approach may better reflect objective characterization of neighborhood environments. A sensitivity analysis indicated that the results from our final multivariable models were driven by BA neighborhoods; however, we do not present stratified findings by region due to limited sample size. Finally, our results were mixed in terms of potential minimally important differences in HRQOL. While SF-12 and SF-36 are less commonly used in studies among diverse patients with cancer and across different cancer types, it is unclear what the optimal criteria are for clinically meaningful difference for this population (48). Therefore, future studies should explore the optimal criteria for determining minimal important differences and minimal clinically important differences among cancer survivors using these surveys. The strength of the work outweighs the limitations considering the robust set of multilevel data captured by capitalizing on cancer registry data from a population-based sample of cancer survivors, self-reported data for participants' HRQOL, and neighborhood data.

As the first study to evaluate the independent and joint associations between such a comprehensive suite of social and built environment features on HRQOL in a diverse cohort of cancer survivors, we found that certain neighborhood social and built environmental factors were associated with PCS and MCS. The findings from this study may help inform which types of neighborhoods are at risk for adverse HRQOL among cancer survivors, and thus identify where interventions could be prioritized. Future studies need to prospectively examine the interaction between social and built environment characteristics to elucidate more clearly the pathways through which nSES and neighborhood attributes impact HRQOL, with attention to include diverse and non–English speaking populations. This will help inform targeted multilevel interventions to improve cancer survivorship outcomes in underserved patient populations and ameliorate disparities in cancer outcomes.

Authors' Disclosures

J.N. Chu reports grants from NIH/Health Resources and Services Administration during the conduct of the study. A.J. Canchola reports grants from NCI during the conduct of the study. T.H.M. Keegan reports grants from NCI during the conduct of the study. A.S. Hamilton reports grants from UCSF subcontract and NIH during the conduct of the study. S.L. Gomez reports grants from NCI during the conduct of the study. S. Shariff-Marco reports grants from NCI during the conduct of the study. No disclosures were reported by the other authors.

Disclaimer

The ideas and opinions expressed herein are those of the author(s) and do not necessarily reflect the opinions of the State of California, Department of Public Health, the NCI, and the Centers for Disease Control and Prevention or their Contractors and Subcontractors.

Authors' Contributions

J.N. Chu: Writing–original draft, writing–review and editing. **A.J. Canchola:** Formal analysis, methodology, writing–original draft, writing–review and editing. **T.H.M. Keegan:** Conceptualization, writing–review and editing. **A. Nickell:** Conceptualization, writing–review and editing. **I. Oakley-Girvan:** Conceptualization, resources, writing–review and editing. **A.S. Hamilton:** Conceptualization, resources, writing–review and editing. **R.L. Yu:** Writing–review and editing. **S.L. Gomez:** Conceptualization, resources, writing–review and editing. **S. Shariff-Marco:** Conceptualization, resources, supervision, investigation, methodology, writing–original draft, writing–review and editing.

Acknowledgments

We would like to acknowledge Mr. Andrew Hertz for his support in developing the neighborhood data used from the California Neighborhoods Data System and David O. Nelson for his guidance on the statistical methods. We would also like to acknowledge Ms. Juan Yang for harmonizing the study data and performing preliminary statistical analyses. The collection of self-report data used in this study was supported by the NCI and NIH under contract numbers N01-PC-35136, N01-PC-35139, HHSN 261201100189P. The collection of cancer incidence data used in this study was supported by the California Department of Public Health pursuant to California Health and Safety Code Section 103885; Centers for Disease Control and Prevention's (CDC) National Program of Cancer Registries, under cooperative agreement 5NU58DP006344; the National Cancer Institute's Surveillance, Epidemiology and End Results Program under contract HHSN261201800032I awarded to the University of California, San Francisco, contract HHSN261201800015I awarded to the University of Southern California, and contract HHSN261201800009I awarded to the Public Health Institute, Cancer Registry of Greater California. This study was funded by an NCI grant: R03CA202192 (principal investigator: S. Shariff-Marco), which provided support for all coauthors except J.N. Chu and R.L. Yu. J.N. Chu is supported by NIH National Research Service Award under grant number T32HP19025.

The costs of publication of this article were defrayed in part by the payment of page charges. This article must therefore be hereby marked *advertisement* in accordance with 18 U.S.C. Section 1734 solely to indicate this fact.

Received January 30, 2021; revised May 7, 2021; accepted October 26, 2021; published first November 2, 2021.

References

1. American Cancer Society. Cancer treatment. Survivor facts & figures. Available from: https://www.cancer.org/research/cancer-facts-statistics/survivor-facts-figures.html.
2. de Moor JS, Mariotto AB, Parry C, Alfano CM, Padgett L, Kent EE, et al. Cancer survivors in the United States: prevalence across the survivorship trajectory and implications for care. Cancer Epidemiol Biomarkers Prev 2013;22:561–70.
3. Elena JW, Travis LB, Simonds NI, Ambrosone CB, Ballard-Barbash R, Bhatia S, et al. Leveraging epidemiology and clinical studies of cancer outcomes: recommendations and opportunities for translational research. J Natl Cancer Inst 2013;105:85–94.
4. Lipscomb J, Gotay CC, Snyder C. Outcomes assessment in cancer: measures, methods and applications. Cambridge, United Kingdom: Cambridge University Press; 2004.
5. Weaver KE, Forsythe LP, Reeve BB, Alfano CM, Rodriguez JL, Sabatino SA, et al. Mental and physical health-related quality of life among US Cancer Survivors: population estimates from the 2010 National Health Interview Survey. Cancer Epidemiol Biomarkers Prev 2012;21:2108–17.
6. Bowen DJ, Alfano CM, McGregor BA, Kuniyuki A, Bernstein L, Meeske K, et al. Possible socioeconomic and ethnic disparities in quality of life in a cohort of breast cancer survivors. Breast Cancer Res Treat 2007;106:85–95.
7. Luckett T, Goldstein D, Butow PN, Gebski V, Aldridge LJ, McGrane J, et al. Psychological morbidity and quality of life of ethnic minority patients with cancer: a systematic review and meta-analysis. Lancet Oncol 2011;12:1240–8.
8. Arora NK, Hamilton AS, Potosky AL, Rowland JH, Aziz NM, Bellizzi KM, et al. Population-based survivorship research using cancer registries: a study of non-Hodgkin's Lymphoma survivors. J Cancer Surviv Res Pract 2007;1:49–63.
9. Gomez SL, Shariff-Marco S, De Rouen M, Keegan THM, Yen IH, Mujahid M, et al. The impact of neighborhood social and built environment factors across the cancer continuum: current research, methodologic considerations, and future directions. Cancer 2015;121:2314–30.
10. McCormack GR, Cabaj J, Orpana H, Lukic R, Blackstaffe A, Goopy S, et al. A scoping review on the relations between urban form and health: a focus on Canadian quantitative evidence. Health Promot Chronic Dis Prev Can Res Policy Pract 2019;39:187–200.

11. Rylands J, Lowe D, Rogers SN. Outcomes by area of residence deprivation in a cohort of oral cancer patients: survival, health-related quality of life, and place of death. Oral Oncol 2016;52:30–6.
12. Hao Y, Landrine H, Smith T, Kaw C, Corral I, Stein K. Residential segregation and disparities in health-related quality of life among Black and White cancer survivors. Health Psychol 2011;30:137–44.
13. Leach CR, Vereen RN, Rao AV, Ross K, Diefenbach MA. Impact of individual- and area-level race/ethnicity on illness intrusiveness among cancer survivors. Transl Behav Med 2019;9:1208–15.
14. Mills SD, Fox RS, Bohan S, Roesch SC, Sadler GR, Malcarne VL. Psychosocial and neighborhood correlates of health-related quality of life: a multi-level study among Hispanic adults. Cultur Divers Ethnic Minor Psychol 2020;26:1–10.
15. Roswall N, Høgh V, Envold-Bidstrup P, Raaschou-Nielsen O, Ketzel M, Overvad K, et al. Residential exposure to traffic noise and health-related quality of life—A Population-Based Study. PLoS One 2015;10:e0120199.
16. Arora NK, Reeve BB, Hays RD, Clauser SB, Oakley-Girvan I. Assessment of quality of cancer-related follow-up care from the Cancer Survivor's Perspective. J Clin Oncol 2011;29:1280–9.
17. Bellizzi KM, Rowland JH, Arora NK, Hamilton AS, Miller MF, Aziz NM. Physical activity and quality of life in adult survivors of non-Hodgkin's lymphoma. J Clin Oncol 2009;27:960–6.
18. Weaver KE, Aziz NM, Arora NK, Forsythe LP, Hamilton AS, Oakley-Girvan I, et al. Follow-up care experiences and perceived quality of care among long-term survivors of breast, prostate, colorectal, and gynecologic cancers. J Oncol Pract 2014;10:e231–9.
19. The California Neighborhoods Data System: a new resource for examining the impact of neighborhood characteristics on cancer incidence and outcomes . . . - PubMed - NCBI [Internet]. Available from: https://www.ncbi.nlm.nih.gov/pubmed/21318584.
20. A 12-Item Short-Form Health Survey: construction of scales and preliminary tests of reliability and validity. - PubMed - NCBI [Internet]. Available from: https://www.ncbi.nlm.nih.gov/pubmed/8628042.
21. Ware JEJ. SF-36 health survey update. Spine 2000;25:3130–9.
22. Office UCB public information. Summary File 3 (SF 3): Census 2000 [Internet]. Available from: https://www.census.gov/census2000/sumfile3.html.
23. NAVSTREETS Reference Manual Q3 2011.pdf [Internet]. [cited 2020 Feb 7]. Available from: http://elodie.chaumet.free.fr/NAVSTREETS%20Reference%20Manual%20Q3%202011.pdf.
24. NETS Database description 2008-1.pdf [Internet]. Available from: https://msbfile03.usc.edu/digitalmeasures/cswenson/intellcont/NETS%20Database%20Description2008-1.pdf.
25. CDFA - IS - I&C - Direct marketing program [Internet]. Available from: https://www.cdfa.ca.gov/is/i_&_c/cfm.html.
26. Highway performance monitoring system (HPMS) data. Caltrans [Internet]. Available from: https://dot.ca.gov/programs/research-innovation-system-information/highway-performance-monitoring-system.
27. Yost K, Perkins C, Cohen R, Morris C, Wright W. Socioeconomic status and breast cancer incidence in California for different race/ethnic groups. Cancer Causes Control 2001;12:703–11.
28. Shariff-Marco S, Von Behren J, Reynolds P, Keegan THM, Hertz A, Kwan ML, et al. Impact of social and built environment factors on body size among breast cancer survivors: the Pathways Study. Cancer Epidemiol Biomarkers Prev 2017;26:505–15.
29. Berrigan D, Pickle LW, Dill J. Associations between street connectivity and active transportation. Int J Health Geogr 2010;9:20.
30. Herman L. LFEI Policy Brief_final for web:LFEI Policy Brief. :10.
31. Gunier RB, Hertz A, Von Behren J, Reynolds P. Traffic density in California: socioeconomic and ethnic differences among potentially exposed children. J Expo Anal Environ Epidemiol 2003;13:240–6.
32. DeRouen MC, Weden MM, Yang J, Jain J, Gomez SL, Shariff-Marco S. Neighborhoods and breast cancer survival: the case for an archetype approach. In: Berrigan D, Berger NA, editors. Geospatial approaches energy balance breast cancer [Internet]. Cham: Springer International Publishing; 2019; p. 221–53. Available from: https://doi.org/10.1007/978-3-030-18408-7_10.
33. Neighborhood Archetypes for Population Health Research: Is There No Place Like Home? [Internet]. [cited 2020 Feb 7]. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3085046/.
34. Shariff-Marco S, DeRouen M, Yang J, Jain J, Nelson D, Weden M, et al. Neighborhood archetypes and breast cancer survival in California. Ann Epidemiol 2021;57:22–9.
35. Borenstein M, Hedges L, Rothstein H. Meta-Analysis fixed effect vs. random effects. www.Meta-Analysis.com; 2007.
36. Harrer M. Doing meta-analysis with R: a hands-on guide. First edition. Boca Raton, FL: CRC Press; 2022.
37. Serghiou S, Goodman SN. Random-effects meta-analysis: summarizing evidence with caveats. JAMA 2019;321:301–2.
38. Li C-C, Matthews AK, Asthana A, Shah RC. The impact of neighborhood disadvantage on health-related quality of life among African American and White cancer survivors. Transl Cancer Res 2019;8:S313–22.
39. Pruitt SL, McQueen A, Deshpande AD, Jeffe DB, Schootman M. Mediators of the effect of neighborhood poverty on physical functioning among breast cancer survivors: a longitudinal study. Cancer Causes Control 2012;23:1529–40.
40. Kent EE, Sender LS, Morris RA, Grigsby TJ, Montoya MJ, Ziogas A, et al. Multilevel socioeconomic effects on quality of life in adolescent and young adult survivors of leukemia and lymphoma. Qual Life Res 2013;22:1339–51.
41. Wu C, Ashing KT, Jones VC, Barcelo LThe association of neighborhood context with health outcomes among ethnic minority breast cancer survivors. J Behav Med 2018;41:52–61.
42. Ashing-Giwa KT, Lim J. Examining the impact of socioeconomic status and socioecologic stress on physical and mental health quality of life among breast cancer survivors. Oncol Nurs Forum 2009;36:79–88.
43. Neighborhood foreclosures and self-rated health among breast cancer survivors. - PubMed - NCBI [Internet]. Available from: https://www.ncbi.nlm.nih.gov/pubmed/21590510.
44. Cahir C, Thomas AA, Dombrowski SU, Bennett K, Sharp L. Urban-rural variations in quality-of-life in breast cancer survivors prescribed endocrine therapy. Int J Environ Res Public Health 2017;14:394.
45. Thomas AA, Timmons A, Molcho M, Pearce A, Gallagher P, Butow P, et al. Quality of life in urban and rural settings: a study of head and neck cancer survivors. Oral Oncol 2014;50:676–82.
46. Dwivedi P, Huang D, Yu W, Nguyen Q. Predicting geographical variation in health-related quality of life. Prev Med 2019;126:105742.
47. Weden MM, Bird CE, Escarce JJ, Lurie N. Neighborhood archetypes for population health research: is there no place like home? Health Place 2011;17:289–99.
48. Jayadevappa R, Schwartz JS, Chhatre S, Wein AJ, Malkowicz SB. Association between utility and treatment among patients with prostate cancer. Qual Life Res 2010;19:711–20.