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Visual cues of the built environment and perceived stress among a cohort of black breast cancer survivors

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Abstract

We investigated relationships between independently observed, visual cues of residential environments and subsequent participant-reported stress within a population-based cohort of Black breast cancer survivors (n = 476). Greater visual cues of engagement – presence of team sports, yard decorations, outdoor seating – (compared to less engagement) was marginally associated with lower perceived stress in univariate models, but attenuated towards null with adjustment for socio-demographic, behavioral, and health-related covariates. Similarly, physical disorder and perceived stress were not associated in adjusted models. Relationships between observed built environment characteristics and perceived stress might be influenced by socioeconomic and health behavior factors, which longitudinal studies should investigate.

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Author contributions

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Declaration of competing interest

All authors report no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.healthplace.2020.102498.

Keywords

Built environment; Neighborhood audit; Perceived stress; Breast cancer survivors; Black women

1. Introduction

Breast cancer is the second leading cause of cancer death among women in the United States (U.S.) despite decreases in mortality over time (DeSantis et al., 2016). Advancements have not been equally distributed, however, as women who self-identify as African American or Black (hereafter, 'Black women') have higher breast cancer mortality rates compared to White women. Moreover, this Black-White breast cancer survival disparity remains after accounting for various demographic, tumor, treatment, healthcare access, and neighborhood social factors (Iqbal et al., 2015; Jemal et al., 2018; Ellis et al., 2018). The persistent racial disparity has led to a greater focus on the potential role of psychosocial stress which might be involved in pathways leading to adverse breast cancer survival outcomes. (Williams et al., 2016; Saini et al., 2019; Krieger, 2013).

Perceived stress is an important predictor of health-related quality of life outcomes among breast cancer survivors (Golden-Kreutz et al., 2005; McDonough et al., 2014; Low et al., 2006). A recent review of patient-reported mental health outcomes among female breast cancer survivors found that lower socioeconomic status (SES) was associated with greater perceived stress (Syrowatka et al., 2017). Furthermore, the prevalence of unhealthy behaviors (high fat diet, tobacco use, physical inactivity) is higher among women of lower SES and greater psychosocial stress (Syrowatka et al., 2017; Ezzati et al., 2014; Ng and Jeffery, 2003; Hedgeman et al., 2018), suggesting that SES-induced stress influence breast cancer morbidity through health behaviors. SES disparities by race could be one explanation for the disproportionately high burden of psychosocial stress and adverse breast cancer outcomes among Black compared to White women (Hedgeman et al., 2018; Statistics and Health, 2019; DeSantis et al., 2019; Bailey et al., 2017). Additional explanations motivated by socio-ecologic theoretical frameworks point to less studied but important racialized social factors that might influence psychosocial stress disparities by race (Saini et al., 2019; Gomez et al., 2015; Warnecke et al., 2008; Lynch and Rebbeck, 2013).

Historical and current structural racist practices and policies have been linked to individual socioeconomic disparities by race as well as disparities in social and built environmental characteristics including residential physical disorder (Rugh et al., 2015; Sampson and Sharkey, 2008). Mortgage lending and housing discrimination has contributed to a disproportionate number of Black residents residing in neighborhoods of lower socioeconomic composition (Rugh et al., 2015; Sampson and Sharkey, 2008). These same discriminatory processes have influenced racial and geographic disparities in public and private disinvestment within communities. For example, the early 21st century housing crisis partially brought on by targeted marketing of subprime mortgages to Black home-buyers, resulted in a greater proportion of foreclosed and real estate owned homes in neighborhoods with a greater proportion of Black residents (Rugh et al., 2015; Kim and Cho, 2016). Foreclosed and real estate owned homes are not as well-maintained compared to owneroccupied homes, and the proportion of these homes in a neighborhood is associated with lower perceived neighborhood quality, lower property value of nearby homes, and higher violent crime (Immergluck and Smith, 2006; Immergluck, 2015; Leonard and Murdoch, 2009; Li and Walter, 2013).

Previous, mostly cross-sectional, studies have found that participant-perceived residential physical disorder indicators - lower aesthetic appeal, presence of garbage, graffiti, and poor building conditions - have been associated with participant-reported stress, alcohol consumption, tobacco use, physical activity, and various health outcomes (Latkin and Curry, 2003; Mayne et al., 2018; Theall et al., 2013; Giurgescu et al., 2015; Plascak et al., 2018; O'Brien et al., 2019). Despite their importance investigating relationships between perceived environmental stressors and health outcomes, these studies are limited by the potential of same-source bias (Chum et al., 2019). Neighborhood audits of residential environmental characteristics made by independent raters overcomes this bias but require additional protocols and resources for data collection which has contributed to their limited use. Accordingly associations between objective visual cues of the neighborhood environment and participant-reported measures have been rarely studied (Kruger et al., 2007; Epstein et al., 2014; Giurgescu et al., 2012), with only one recent study among cancer survivors (Schootman et al., 2020). Potentially due to a small sample size of 215, the study found no evidence of an association between the presence of independently-assessed garbage or graffiti and a variety of participant-reported quality of life outcomes. Nonetheless, numerous reports have noted how measurements from such ubiquitous data sources as Google Street View have the potential to explore theoretically influential but empirically understudied relationships between built environment factors and health outcomes (Gomez et al., 2015; Schootman et al., 2016, 2017).

To fill the aforementioned knowledge gaps, this study investigated associations between independently audited residential physical disorder factors and perceived stress in the Women's Circle of Health Follow-up Study (WCHFS) of breast cancer survivors self-identifying as Black. Specifically, this study uses previously-studied neighborhood audit data to investigate whether physical disorder factors measured at baseline are associated with participant-reported stress measured approximately 1 year later, while controlling for numerous covariates.

2. Methods

2.1. Study population and data

The WCHFS is a population-based cohort of Black breast cancer survivors, described in detail elsewhere (Xing et al., 2019; Bandera et al., 2020; Qin et al., 2018). Briefly, potential participants were identified through rapid case ascertainment by the New Jersey State Cancer Registry in 10 counties in New Jersey. Black women diagnosed with histologically-confirmed ductal carcinoma in-situ or invasive breast cancer at age 20–75 years, who could read and speak English, and without prior cancer history (besides non-melanomatous skin cancer) were eligible to participate. The present analysis was limited to WCHFS participants diagnosed with invasive breast cancer.

Questionnaire data were collected by trained interviewers during two in-person home visits: at baseline (within 12 months of diagnosis) and at follow-up 1 (approximately 24 months after diagnosis). Baseline questionnaires included questions on demographics (i.e., age, marital status, health insurance, education, income) as well as known or suspected risk factors for breast cancer (e.g., alcohol, physical activity, smoking, reproductive factors) one year before diagnosis. Physical activity was measured as metabolic equivalents derived using from Godin and Shephard (1985) from questions based on the Black Women's Health Study (Carter-Nolan et al., 2006). Alcohol consumption was estimated in grams/day derived from a food frequency questionnaire, modified from the Black Women's Health Study (Block et al., 1986; Genkinger et al., 2013). Body mass index was calculated as kg/m^2 from interviewer measured height and weight following standardized protocols (Qin et al., 2018; Bandera et al., 2013). Household income poverty levels were calculated from annually reported federal guidelines based on the median of income range categories, people supported by the income, and year of baseline questionnaire (Services, 2019).

The follow-up questionnaire included questions on perceived stress using the 10-item version of Cohen's perceived stress (PSS-10) (Cohen et al., 1983). The PSS-10 prompts participants to recall past month frequencies ('never', 'almost never', 'sometimes', 'fairly often', 'very often') of stress-related feelings and perceptions. PSS-10 item responses were summed upon finding good internal consistency ($\alpha = 0.85$). This sum score was subsequently used as a continuous variable with higher values indicating higher perceived stress. The only other variable analyzed from follow-up was survey date. Interval between dates of cancer diagnosis and follow-up interview was calculated and considered as a potential confounder.

Information on age at diagnosis, diagnosis date, cancer stage at diagnosis, geocoded residential address, and geocode certainty was obtained through linkage with cancer registry files. Residential address at diagnosis was geocoded by the cancer registry and provided as an exact point-location (latitude and longitude), which was subsequently spatially joined to census tract-level Census data and neighborhood audit data (below). Data were limited to geocodes of most certainty (based on complete and valid street address, 95.5% of sample).

2.2. Audited neighborhood engagement and physical disorder

Virtual neighborhood auditing, a method to observe and rate neighborhood characteristics virtually through online mapping programs, was conducted at 29,017 locations across New Jersey to create observable measures of neighborhood physical disorder and engagement (Plascak et al., 2020a). Locations were randomly selected along non-highway roads across the study region. The auditing platform, CANVAS, was used to assess the 360° view within Google Street View scenes at each location for the following nine characteristics: garbage/litter (yes/no), graffiti (yes/no), boarded up or burned out buildings (yes/no), large dumpsters (none, 1–2, >2), building conditions (very good, moderate, fair, poor), yard conditions (very good, moderate, fair, poor), team sports equipment in public spaces (yes/no), yard decorations (yes/no), and outdoor seating (yes/no) (Bader et al., 2015; Mooney et al., 2014). Assessments were conducted by four trained auditors, following a standardized protocol, resulted in maximum test-retest agreement reliability that was at least ‘substantial’ ($\kappa \geq 0.61$) for all nine items (Plascak et al., 2020a).

Similar to previous work, item response theory was used to investigate audit item response pattern correlations and the presence of latent neighborhood factors (Mayne et al., 2018; Mooney et al., 2014). As results indicated variation by urbanicity – 2010 Rural-Urban Commuting Area <2 ‘Metropolitan area core’ vs ≥ 2 (less urban) – subsequent analyses were limited to Rural-Urban Commuting Area <2 (n = 23,276, 80.3%). Results from item response theory models of non-missing, audit item response patterns indicated a best-fitting, two-factor model: ‘Physical disorder’ indicated by garbage/litter, graffiti, boarded up or burned buildings, dumpsters, building conditions, and yard conditions ($\alpha = 0.65$); and ‘Engagement’ indicated by team sports equipment in public spaces, yard decorations, and outdoor seating ($\alpha = 0.33$). Despite low internal consistency of each resulting factor, the two-factor model demonstrated better fit (BIC = 110,565) over a single factor model (BIC = 111,066).

Separate Universal Kriging (UK), spatial models were built to predict continuous spatial surfaces of neighborhood physical disorder and engagement across the study region based on factor sum scores (Mooney et al., 2014; Plascak et al., 2020b). Physical disorder and engagement values were assigned to each WCHFS participant by extracting the resulting UK-predicted surface values based on geocoded address at cancer diagnosis (see Figs. 1 and 2). Google Street View scene image dates of the analytic dataset ranged from August 2007 to September 2018 (59.4% scene dates < 2014).

2.3. Neighborhood census-based variables

Census tract-level Black residential segregation was estimated by the Gini and Isolation indices calculated from 2010 decennial Census data gathered from the National Historical Geographic Information System database (Bureau, 2011; Manson et al., 2019). Gini is a common measure of segregation ‘evenness’ and Isolation a measure of ‘exposure’. With these measures, evenness refers to the variability in block-level proportions of Black residents within census tracts and exposure is meant to estimate the extent of potential contact that a Black resident might have with other Black residents (Massey and Denton, 1988). As previous studies have also operationalized segregation using informal measures of racial-ethic density (White and Borrell, 2011), we also calculated % Black within each census tract. Neighborhood SES was estimated by census tract-level Yost Index and provided by previous researchers (Kish et al., 2014; Yu et al., 2014). We linked the 2010 Yost Index to each study participant’s census tract at diagnosis for consistency with other Census-based measures.

2.4. Statistical analysis

Geographic distributions of physical disorder and engagement factors overlaid by study participants’ residential address (randomly jittered within zip code of residence) were explored through maps. Example images of high and low neighborhood engagement within rated Google Street View scenes were displayed to demonstrate observed visual cues of engagement values potentially experienced by WCHFS participants. Demographic, socioeconomic, tumor, health behavior, perceived stress, and neighborhood factors were summarized (mean/N, standard deviation/%) for the study sample. Neighborhood audit variables were z-scored and alcohol consumption and physical activity metabolic equivalents were log-transformed prior to correlational analyses. Relationships between covariates were explored in a correlation matrix. Multilevel linear regression models with census tract random intercepts were built to test associations between perceived stress and covariates and account for potential clustering of WCHFS participant PSS-10 values within census tracts (Goldstein, 2003). Two multivariable models were built: 1) an adjusted model which included all covariates except the audited neighborhood factors), and 2) all covariates including the audited neighborhood factors. Regression coefficients were calculated by multiple imputation due to missingness >1.0% of potential confounding (income = 4.9%, household size = 1.4%, tumor stage = 6.6%, Yost index = 3.1%) and mediating (alcohol consumption 6.8%) variables. A total of 485 participants met the above eligibility criteria, with 476 providing complete data after imputation (n = 2 missing PSS-10, n = 4 missing health insurance, n = 1 missing education, n = 2 body mass index).

We assessed bias by non-participation by comparing distributions of our major variables of interest for women completing the baseline visit, those completing the follow-up visit, and all potential eligible participants in the 10 counties in the study according to 2008–2013 cancer registry data (no evidence of bias, Supplement Table 1) (Kulkarni et al., 2019). Post-hoc analyses were conducted to explore the change in associations of built environment factors and perceived stress as a function of various models. Three additional models were sequentially built based on correlations of groups of variables beginning with models of those variables least correlated with built environment factors and perceived stress (demographic and cancer covariates), and ending with those most correlated (socioeconomic covariates) (Fig. 3). Recruitment of WCHFS participants began in 2012 and in this analysis, we included women diagnosed with invasive breast cancer up to July 2018. Neighborhood audit data were collected between November 2017 and June 2019. Analyses were conducted using SAS v. 9.4 and ArcGIS v. 10.6.

3. Results

The geographic distributions of predicted neighborhood physical disorder and engagement are shown in Figs. 1 and 2. Greater neighborhood physical disorder values (red shade) appear to concentrate towards the Northeast and Southwest borders of the study region, which coincide with major cities including Newark (Northeast), Trenton (Central-Southwest), and Camden (Southwest) (Fig. 1). Neighborhood engagement displays greater geographic variability throughout the study region compared to physical disorder, which exhibited broader patterns across space (Fig. 2). As better visualized by the inset in Fig. 2, a seemingly large proportion of study participants' residential locations appear to coincide with pockets of greater neighborhood engagement (blue shade) in the North-Central study region. Similar to physical disorder patterns, border regions to the Central-Southwest appear to be characterized as less engaged neighborhoods.

The mean age at diagnosis was 55 years, approximately one third of participants were married/partnered, 34.9% had no more than a high school diploma, 18.5% had income-household size combinations determined to be below the federal poverty level, 49.4% were diagnosed with a stage I tumor, nearly 40% reported current or former smoking status, the mean body mass index was 32.1 kg/m^2, and the mean PSS-10 score was 15.5 (Table 1).

Average residential census tract Black density, Black Gini segregation, and Black Isolation segregation measures were similar (44.5, 57.4, 51.2, respectively), indicating a moderate-to -high racial residential segregation environment. WCHFS participants appear to reside in neighborhoods characterized by higher physical disorder (average = 0.50) compared to physical disorder of all areas analyzed (average = 0.02). This relationship was not true for neighborhood engagement as average values were nearly identical when comparing WCHFS participants to all areas assessed in the study region (0.02).

Fig. 3 indicates that physical disorder displays weak negative correlations (light red colors) with engagement; moderate-strong negative correlations (darker red) with neighborhood socioeconomic composition, individual educational attainment, and household income-to-poverty ratio; weak positive correlations with Black segregation as measured by the Gini index, body mass index, and perceived stress; and moderate positive correlations (medium blue) with Black segregation as measured by the Isolation index and % Black. Engagement exhibits weak negative correlations with Black segregation (Gini and Isolation indices), % Black, and perceived stress. Perceived stress showed weak negative correlations with neighborhood socioeconomic composition, individual educational attainment, age, and menopause; moderate negative correlations with household income-to-poverty ratio; and weak positive correlations with physical activity and alcohol consumption.

Unadjusted models of PSS-10 indicated that perceived stress decreased by 0.60 points (95% CI: −1.23, −0.03, $p = 0.061$) for each standard deviation increase in neighborhood engagement, and increased by 0.56 (95% CI: −0.07, 1.19, $p = 0.079$) for each standard deviation increase in neighborhood physical disorder. Adjustment for covariates (Table 2, Model 2) attenuated associations involving neighborhood engagement and physical disorder; $\beta = -0.47$ (95% CI: −1.10, 0.16, $p = 0.141$) and $\beta = 0.25$ (95% CI: −1.69, 1.19, $p = 0.599$), respectively. Post-hoc analyses of sequentially built models indicated that associations between perceived stress and physical disorder and engagement were both substantially attenuated towards null comparing models adjusted for demographic, anthropometric, and cancer covariates only to a model that also included health behaviors – alcohol consumption, physical activity, and tobacco use; $\beta_{\text{physical disorder| demographic, anthropometric, and cancer covariates}}$ (95% CI): 0.55 (−0.08,1.18), $\beta_{\text{physical disorder| demographic, anthropometric, cancer, and health behavior covariates}}$ (95% CI): 0.20 (−0.45,0.85), $\beta_{\text{engagement| demographic, anthropometric, and cancer covariates}}$ (95% CI): −0.58 (−1.2,0.04), $\beta_{\text{engagement| demographic, anthropometric, cancer, and health behavior covariates}}$ (95% CI): −0.46 (−1.1,0.19) (Supplement Table 2).

Two Google Street View scenes observed and rated by auditors, and which were representative of the 10th (lower) and 90th (higher) percentiles of neighborhood engagement for WCHFS participants are displayed in Fig. 4a and b, respectively. The 10th percentile is approximately equal to neighborhood engagement values where the Google Street View scene is absent of any engagement indicators or only has team sports equipment in a public space (Fig. 4a). Alternatively, the 90th percentile is approximated by engagement values where the Google Street View scene contains outdoor seating only, or team sports equipment + yard decorations (Fig. 4b) or team sports equipment + outdoor seating. It is important to note that these Google Street View scenes are best related to the unadjusted models; no attempts were made to choose scenes with engagement values that were also at the average values of other modeled factors (e.g., average racial segregation, average individual income of the study region, etc.).

4. Discussion

Findings from this study showed that associations between participant-reported perceived stress at follow-up and independently observed neighborhood physical disorder and engagement at baseline were substantially attenuated towards null after adjustment for baseline demographic, socioeconomic, tumor, health behavioral, and neighborhood factors among a cohort of Black breast cancer survivors. In models with mutual adjustment for built environment factors only, greater perceived stress was marginally associated with residence in areas of greater physical disorder and lower engagement. Sensitivity analyses that involved constructing models sequentially by adding groups of covariates suggested that inclusion of health behaviors – physical activity, alcohol consumption, and tobacco use – led to the largest attenuation of estimated associations. Potential explanations of these results follow.

Receiving a cancer diagnosis and living as a cancer survivor is recognized as a stressful experience that can adversely affect quality of life and survival outcomes (Golden-Kreutz et al., 2005; Golden-Kreutz and Andersen, 2004; Andersen et al., 2017; Harris et al., 2017). The greater number of social stressors experienced by Black women has been hypothesized to influence breast cancer survival disparities through psychosocial stress and related physiologic effects (Williams et al., 2016; Saini et al., 2019; Coughlin, 2019). Studies of stress among breast cancer survivors, however, have found little evidence of associations involving social factors, including race/ethnicity and socioeconomic status (Golden-Kreutz et al., 2005; Syrowatka et al., 2017; Stanton et al., 2015; Vazquez et al., 2020). For example, Golden-Kreutz et al., found no correlation between race, educational attainment, or household income and perceived stress among women surgically treated for breast cancer. Similarly, a longitudinal study of recently diagnosed female breast cancer patients found little evidence of a relationship between a measure of physical quality of life and race or education (Harris et al., 2017). The same study did find, however, that women who reported greater stress had worse quality of life. Both of these studies were comprised predominantly of White women who were of higher SES, limiting comparison to the current study comprised of Black breast cancer survivors. (Golden-Kreutz et al., 2005; Harris et al., 2017).

Our findings of associations between indicators of lower socioeconomic status and greater perceived stress might be due to the larger statistical power afforded by this study's exclusive enrollment of Black participants. Alternatively, associations between socioeconomic indicators and perceived stress could depend on race due to the inequitable distribution of adverse social factors by race. For example, less education might not be associated with greater stress among women who are white and who might also have access to more stress buffers such as social support and social capital compared to Black women (Pinheiro et al., 2017; Paladino et al., 2019).

The current study is among the few to investigate associations between visually observed built environment factors and any participant-reported outcomes (Kruger et al., 2007; Epstein et al., 2014; Giurgescu et al., 2012), with only one known study among cancer survivors (Schootman et al., 2020). A recent study among African American breast cancer survivors found that among various virtually audited built environment factors, only sidewalk quality was associated with patient-reported, longitudinal measures of emotional well-being and pain (Schootman et al., 2020). While longitudinal quality of life measurement is a notable strength, this previous study was limited by a smaller sample size (n = 215 at baseline) and collection of few built environment features.

The relationships between physical disorder-related built environment factors and perceived stress have been studied more often among non-cancer populations. One early study among diverse, community-dwelling survey respondents within Flint Michigan, reported an association between presence of residential building deterioration and greater stress (Kruger et al., 2007). Similar to the current study, the estimated building deterioration–stress relationship was partially explained by race, education and additional sociodemographic factors. A more recent study among pregnant women identifying as Black similarly reported no association between observed physical disorder (i. e., vacant lots, vacant buildings, abandoned buildings) and psychological distress. In general, the observed attenuation of associations between physical disorder-related built environment factors and health outcomes with covariate adjustment or stratification might be due to various processes including.: sociodemographic-based selection into or out of neighborhoods based on physical disorder (Sampson and Sharkey, 2008), or involvement of additional psychosocial perceptions (e.g., fear, distrust) and health behaviors in pathways between built environment factors and health (O'Brien et al., 2019; Kruger et al., 2007; Epstein et al., 2014; Giurgescu et al., 2012; Franzini et al., 2008). Moreover, participant perceptions of independently observed built environment visual cues and reporting of stress might vary across socioeconomic or health behavior characteristics, which could influence variation in results based on study population composition. For example, a study of urban-dwelling, racial-ethnically diverse adults with elementary school aged-children found that perceptions of residential physical disorder were lower among participants who were Black, moved more often, and of higher education (Franzini et al., 2008). Interestingly, these associations were reported from models of perceived physical disorder that also accounted for the positive association between physical disorder observed through audits, neighborhood poverty rates, and rates of violent crimes. The potential influence of additional factors and processes suggests that future studies should more comprehensively measure objective and perceived neighborhood environment characteristics, psychosocial predictors of behavior such as fear and social retreat, health behaviors, and residential mobility.

While this is the first known study of the relationship between neighborhood engagement and perceived stress, related studies of residential natural aesthetics have reported similar findings with patient-reported stress and mental health outcomes (van den Berg et al., 2010; Gascon et al., 2015). Similar to studies of physical disorder and health related factors and outcomes, it is likely that the relationships involving visually observed neighborhood engagement involve additional behaviors and social factors. One neighborhood audit study found that greater neighborhood engagement, partially indicated by presence of decorations, was associated with greater perceived collective efficacy (McDonell and Waters, 2011). In another study visually assessed yard maintenance was associated with greater neighborhood social cohesion (Krusky et al., 2015). These results suggest that positive, visual cues of neighborhood engagement might convey a general sense of community and well-being, a confidence in personal and property safety, and desire to visually and socially interact within one's immediate residential surroundings. As it relates to stress, it is possible that visual indicators of engaged neighborhoods have stress-reducing qualities, or that individuals who have lower stress for other reasons (e.g., high income) have the capacity and resources to decorate their residence, engage in team sports, or enjoy their neighborhood while sitting outside. Attempts were made to account for the latter in this study by controlling for potential confounders, but should be more carefully investigated in larger longitudinal studies with repeated measures.

Strengths of this study include the study design and the use of multimodal data sources. The design of the WCHFS ensured that baseline (≤12 months post-diagnosis) demographic, socioeconomic, tumor-related, anthropometric, and other potential confounding factors were assessed prior to participant-reported levels of stress at the first follow-up (approximately 24 months post-diagnosis). This represents an important criterion for bias control and temporality of relationships. Although the sample size was not very large, we tested and found no evidence that participants at baseline or follow-up differed from each other or the target population (i.e., Black Breast cancer survivors within the 10 county study region) with respect to several key variables, including the exposures of interest, indicative of no selection bias due to differential participation, missing data, or loss to follow-up. We integrated data between a novel virtual neighborhood audit and high-quality, longitudinal cohort of Black breast cancer survivors in attempt to better understand the disproportionate burden of breast cancer morbidity experienced by Black women (Bandera et al., 2020; Plascak et al., 2020a). Strengths of these virtual neighborhood audit data include the innovative collection protocol which enabled a large number of data points, verified audit item agreement reliability, investigation of audit item internal consistency and data reduction techniques, and application of spatial statistical estimation to enable linkage to the WCHFS (Plascak, 2020a,b). A final and substantial strength is the measurement and subsequent testing of independently observed, modifiable, visual cues of the environment for relationships with perceived stress – an important contributor to breast cancer morbidity, mortality, and potential disparity by race.

Several notable qualities of this study limit the results and should be addressed in future work. The WCHFS was not designed as a study of stress and the potential stress-inducing roles of residential built environment factors. The stress measurement available in the WCHFS is a global measure of perceived stress and is non-specific to the residential stressors (safety, social norms, law enforcement activity, noise, smells, traffic, etc.) that might be more strongly associated with residential physical disorder and engagement (Cohen et al., 1983). Despite its innovations, the virtual neighborhood audit data is collected from Google, Inc., which itself retains largely opaque data collection protocols. This limits the research potential of these data mainly because of the multiple, potential sources of measurement error arising from use of Google Street View images, as has been cited elsewhere (Plascak et al., 2020a; Rzotkiewicz et al., 2018). Relevant to this study is the potential for exposure misclassification due to the inability to choose the exact date of Google Street View scenes. Although this cohort study design guaranteed that all baseline covariates as well as residential address at diagnosis occurred prior to patient reported perceived stress, the Google Street View scene used in the calculation of neighborhood physical disorder and engagement might have indeed been dated after stress data were collected. This potential leaves open the possibility for a reversal of associations; lower stress individuals visually signaling neighborhood engagement via yard decorations, team sports equipment, and outdoor seating. However, 59% of all Google Street View image scenes were dated prior to 2014, which preceded any follow-up survey dates when stress was collected. Future neighborhood audit work should explore the potential of estimating spatio-temporal models of item responses to further minimize this potential bias.

5. Conclusion

Visually observed indicators of neighborhood engagement could be important built environment factors that can be modified to reduce breast cancer survivors' reported levels of stress. Visual built environment characteristics are novel social factors that should be further investigated in larger studies.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

Andersen BL, et al., 2017. Trajectories of stress, depressive symptoms, and immunity in cancer survivors: diagnosis to 5 years. Clin. Canc. Res 23 (1), 52–61.

Bader MDM, et al., 2015. Development and deployment of the computer assisted neighborhood visual assessment System (CANVAS) to measure health-related neighborhood conditions. Health Place 31, 163–172. [PubMed: 25545769]

Bailey ZD, et al., 2017. Structural racism and health inequities in the USA: evidence and interventions. Lancet 389 (10077), 1453–1463. [PubMed: 28402827]

Bandera EV, et al., 2013. Body fatness and breast cancer risk in women of African ancestry. BMC Canc 13 (1), 475.

Bandera EV, et al., 2020. The Women's Circle of Health Follow-Up Study: a population-based longitudinal study of Black breast cancer survivors in New Jersey. J. Canc. Survivorship 1–16.

Block G, et al., 1986. A data-based approach to diet questionnaire design and testing. Am. J. Epidemiol 124 (3), 453–469. [PubMed: 3740045]

Bureau USC, 2011. 2010 Census of population and. housing, Summary File 1 2010 U. S. Census Bureau, Washington, DC.

Carter-Nolan PL, et al., 2006. Validation of physical activity instruments: black women's health study. Ethn. Dis 16 (4), 943–947. [PubMed: 17061751]

Chum A, et al., 2019. Evaluating same-source bias in the association between neighbourhood characteristics and depression in a community sample from Toronto, Canada. Soc. Psychiatr. Psychiatr. Epidemiol 54 (10), 1177–1187.

Cohen S, Kamarck T, Mermelstein R, 1983. A global measure of perceived stress. J. Health Social Behav 24 (4), 385–396.

Coughlin SS, 2019. Social determinants of breast cancer risk, stage, and survival. Breast Canc. Res. Treat 177 (3), 537–548.

DeSantis CE, et al., 2016. Breast cancer statistics, 2015: convergence of incidence rates between black and white women. CA: Canc. J. Clinicians 66 (1), 31–42.

DeSantis CE, et al., 2019. Cancer statistics for african Americans, 2019. CA Canc. J. Clin 69 (3), 211–233.

Ellis L, et al., 2018. Racial and ethnic disparities in cancer survival: the contribution of tumor, sociodemographic, institutional, and neighborhood characteristics. J. Clin. Oncol 36 (1), 25–+. [PubMed: 29035642]

Epstein DH, et al., 2014. Real-time tracking of neighborhood surroundings and mood in urban drug misusers: application of a new method to study behavior in its geographical context. Drug Alcohol Depend 134, 22–29. [PubMed: 24332365]

Ezzati A, et al., 2014. Validation of the perceived stress scale in a community sample of older adults. Int. J. Geriatr. Psychiatr 29 (6), 645–652.

Franzini L, et al., 2008. Perceptions of disorder: Contributions of neighborhood characteristics to subjective perceptions of disorder. J. Environ. Psychol 28 (1), 83–93.

Gascon M, et al., 2015. Mental health benefits of long-term exposure to residential green and blue spaces: a systematic review. Int. J. Environ. Res. Publ. Health 12 (4), 4354–4379.

Genkinger JM, et al., 2013. Consumption of dairy and meat in relation to breast cancer risk in the Black Women's Health Study. Canc. Causes Contrl 24 (4), 675–684.

Giurgescu C, et al., 2012. Relationships among neighborhood environment, racial discrimination, psychological distress, and preterm birth in african American women. Jognn J. Obstetric Gynecol. Neonatal Nursing 41 (6), E51–E61.

Giurgescu C, et al., 2015. The impact of neighborhood quality, perceived stress, and social support on depressive symptoms during pregnancy in African American women. Soc. Sci. Med 130, 172–180. [PubMed: 25703670]

Godin G, Shephard RJ, 1985. A simple method to assess exercise behavior in the community. Can. J. Appl. Sport Sci 10 (3), 141–146. [PubMed: 4053261]

Golden-Kreutz DM, Andersen BL, 2004. Depressive symptoms after breast cancer surgery: relationships with global, cancer-related, and life event stress. Psycho Oncol 13 (3), 211–220.

Golden-Kreutz DM, et al., 2005. Traumatic stress, perceived global stress, and life events: prospectively predicting quality of life in breast cancer patients. Health Psychol. : Off. J. Div. Health Psychol. Am. Psychol. Assoc 24 (3), 288–296.

Goldstein H, 2003. Multilevel Statistical Models. Kendall's Library of Statistics, vol. 3. Arnold, London, p. 253.

Gomez SL, et al., 2015. The impact of neighborhood social and built environment factors across the cancer continuum: current research, methodological considerations, and future directions. Cancer 121 (14), 2314–2330. [PubMed: 25847484]

Harris LN, et al., 2017. Chronic and episodic stress predict physical symptom bother following breast cancer diagnosis. J. Behav. Med 40 (6), 875–885. [PubMed: 28528393]

Hedgeman E, et al., 2018. Perceived stress across the midlife: longitudinal changes among a diverse sample of women, the Study of Women's health across the Nation (SWAN). Womens Midlife Health 4.

Immergluck D, 2015. A look back: what we now know about the causes of the US mortgage crisis. Int. J. Unity Sci 19 (3), 269–285.

Immergluck D, Smith G, 2006. The impact of single-family mortgage foreclosures on neighborhood crime. Hous. Stud 21 (6), 851–866.

Iqbal J, et al., 2015. Differences in breast cancer stage at diagnosis and cancer-specific survival by race and ethnicity in the United States. Jama 313 (2), 165–173. [PubMed: 25585328]

Jemal A, et al., 2018. Factors that contributed to black-white disparities in survival among nonelderly women with breast cancer between 2004 and 2013. J. Clin. Oncol 36 (1), 14–+. [PubMed: 29035645]

Kim J, Cho G-H, 2016. Unending foreclosure crisis: uneven housing tenure trajectories of post-REO properties. Appl. Geogr 70, 49–58.

Kish JK, et al., 2014. Racial and ethnic disparities in cancer survival by neighborhood socioeconomic status in Surveillance, Epidemiology, and End Results (SEER) Registries. J. Natl. Cancer Inst. Monogr 2014 (49), 236–243. [PubMed: 25417237]

Krieger N, 2013. History, biology, and health inequities: emergent embodied phenotypes and the illustrative case of the breast cancer estrogen receptor. Am. J. Public Health 103 (1), 22–27. [PubMed: 23153126]

Kruger DJ, Reischl TM, Gee GC, 2007. Neighborhood social conditions mediate the association between physical deterioration and mental health. Am. J. Community Psychol 40 (3–4), 261–271. [PubMed: 17924185]

Krusky AM, et al., 2015. The effects of produce gardens on neighborhoods: a test of the greening hypothesis in a post-industrial city. Landsc. Urban Plann 136, 68–75.

Kulkarni A, et al., 2019. Breast Cancer Incidence and Mortality by Molecular Subtype: Statewide Age and Racial/Ethnic Disparities in New Jersey, vol. 3. Cancer health disparities, p. e1.

Latkin CA, Curry AD, 2003. Stressful neighborhoods and depression: a prospective study of the impact of neighborhood disorder. J. Health Social Behav 34–44.

Leonard T, Murdoch JC, 2009. The neighborhood effects of foreclosure. J. Geogr. Syst 11 (4), 317–332.

Li YM, Walter R, 2013. Single-Family housing market segmentation, post-foreclosure resale duration, and neighborhood attributes. Housing Policy Debate 23 (4), 643–665.

Low CA, et al., 2006. Contextual life stress and coping strategies as predictors of adjustment to breast cancer survivorship. Ann. Behav. Med 32 (3), 235–244. [PubMed: 17107297]

Lynch SM, Rebbeck TR, 2013. Bridging the gap between biologic, individual, and macro environmental factors in cancer: a multilevel approach. Cancer epidemiology, biomarkers & prevention : a publication of the American Association for CancCosponsored Am. Soc. Preventive Oncol.er Research. cosponsored by the American Society of Preventive Oncology 22 (4), 485–495.

Manson S, et al., 2019. IPUMS National Historical Geographic Information System: Version 14.0 [Database] IPUMS, Minneapolis, MN.

Massey DS, Denton NA, 1988. The dimensions of residential segregation. Soc. Forces 67 (2), 281–315.

Mayne SL, et al., 2018. Neighborhood disorder and obesity-related outcomes among women in chicago. Int. J. Environ. Res. Publ. Health 15 (7).

McDonell JR, Waters TJ, 2011. Construction and validation of an observational scale of neighborhood characteristics. Soc. Indicat. Res 104 (3), 439–457.

McDonough MH, Sabiston CM, Wrosch C, 2014. Predicting changes in posttraumatic growth and subjective well-being among breast cancer survivors: the role of social support and stress. Psycho Oncol 23 (1), 114–120.

Mooney SJ, et al., 2014. Validity of an econometric neighborhood physical disorder measure constructed by virtual street audit. Am. J. Epidemiol, kwu180

Ng DM, Jeffery RW, 2003. Relationships between perceived stress and health behaviors in a sample of working adults. Health Psychol 22 (6), 638–642. [PubMed: 14640862]

O'Brien DT, Farrell C, Welsh BC, 2019. Broken (windows) theory: a meta-analysis of the evidence for the pathways from neighborhood disorder to resident health outcomes and behaviors. Soc. Sci. Med 228, 272–292. [PubMed: 30885673]

Paladino AJ, et al., 2019. A qualitative exploration of race-based differences in social support needs of diverse women with breast cancer on adjuvant therapy. Psycho Oncol 28 (3), 570–576.

Pinheiro LC, et al., 2017. Understanding racial differences in health-related quality of life in a diverse, population-based cohort of breast cancer survivors in North Carolina. Cancer Epidemiol. Biomark. Prev 26 (2).

Plascak JJ, et al., 2018. Perceived neighborhood disorder, racial-ethnic discrimination and leading risk factors for chronic disease among women: California Behavioral Risk Factor Surveillance System, 2013. Ssm-Population Health 5, 227–238. [PubMed: 30094318]

Plascak JJ, et al., 2020a. Drop-and-Spin virtual neighborhood auditing: assessing built environment for linkage to health studies. Am. J. Prev. Med 58 (1), 152–160. [PubMed: 31862100]

Plascak JJ, et al., 2020b. Spatial predictive properties of built environment characteristics assessed by drop-and-spin virtual neighborhood auditing. Int. J. Health Geogr 19 (1), 21. [PubMed: 32471502]

Qin B, et al., 2018. Validity of self-reported weight, height, and body mass index among African American breast cancer survivors. J. Canc. Survivorship 12 (4), 460–468.

Rugh JS, Albright L, Massey DS, 2015. Race, space, and cumulative disadvantage: a case study of the subprime lending collapse. Soc. Probl 62 (2), 186–218. [PubMed: 27478254]

Rzotkiewicz A, et al., 2018. Systematic review of the use of Google Street View in health research: major themes, strengths, weaknesses and possibilities for future research. Health Place 52, 240–246. [PubMed: 30015181]

Saini G, et al., 2019. Disadvantaged neighborhoods and racial disparity in breast cancer outcomes: the biological link. Canc. Causes Contrl 30 (7), 677–686.

Sampson RJ, Sharkey P, 2008. Neighborhood selection and the social reproduction of concentrated racial inequality. Demography 45 (1), 1–29. [PubMed: 18390289]

Schootman M, et al., 2016. Emerging technologies to measure neighborhood conditions in public health: implications for interventions and next steps. Int. J. Health Geogr 15 (1), 20. [PubMed: 27339260]

Schootman M, et al., 2017. Geospatial approaches to cancer control and population sciences. Cancer Epidemiol. Biomark. Prev 26 (4), 472–475.

Schootman M, et al., 2020. Influence of built environment on quality of life changes in African-American patients with non-metastatic breast cancer. Health Place 63, 102333. [PubMed: 32543424]

Services, U.D.o.H.H., 2019. Prior HHS Poverty Guidelines and Federal Register References. 1 11 2019 [cited 2019 October 31]; Available from: https://aspe.hhs.gov/prior-hhs-poverty-guidelines-and-federal-register-references.

Stanton AL, et al., 2015. Depressive episodes, symptoms, and trajectories in women recently diagnosed with breast cancer. Breast Canc. Res. Treat 154 (1), 105–115.

Statistics, Health, N.C.f.H., 2019. United States, 2018 [cited 2019 December 4].

Syrowatka A, et al., 2017. Predictors of distress in female breast cancer survivors: a systematic review. Breast Canc. Res. Treat 165 (2), 229–245.

Theall KP, et al., 2013. Neighborhood disorder and telomeres: connecting children's exposure to community level stress and cellular response. Soc. Sci. Med 85, 50–58. [PubMed: 23540366]

van den Berg AE, et al., 2010. Green space as a buffer between stressful life events and health. Soc. Sci. Med 70 (8), 1203–1210. [PubMed: 20163905]

Vazquez D, et al., 2020. Posttraumatic stress in breast cancer survivors diagnosed at a young age. Psycho Oncol 29 (8), 1312–1320.

Warnecke RB, et al., 2008. Approaching health disparities from a population perspective: the national institutes of health Centers for population health and health disparities. Am. J. Public Health 98 (9), 1608–1615. [PubMed: 18633099]

White K, Borrell LN, 2011. Racial/ethnic residential segregation: framing the context of health risk and health disparities. Health Place 17 (2), 438–448. [PubMed: 21236721]

Williams DR, Mohammed SA, Shields AE, 2016. Understanding and Effectively Addressing Breast Cancer in African American Women: Unpacking the Social Context. Cancer.

Xing CY, et al., 2019. Prediagnostic Allostatic Load as a Predictor of Poorly Differentiated and Larger Sized Breast Cancers Among Black Women in the Women's Circle of Health Follow-Up Study. Cancer Epidemiology and Prevention Biomarkers.

Yu MD, et al., 2014. Using a composite index of socioeconomic status to investigate health disparities while protecting the confidentiality of cancer registry data. Canc. Causes Contrl 25 (1), 81–92.

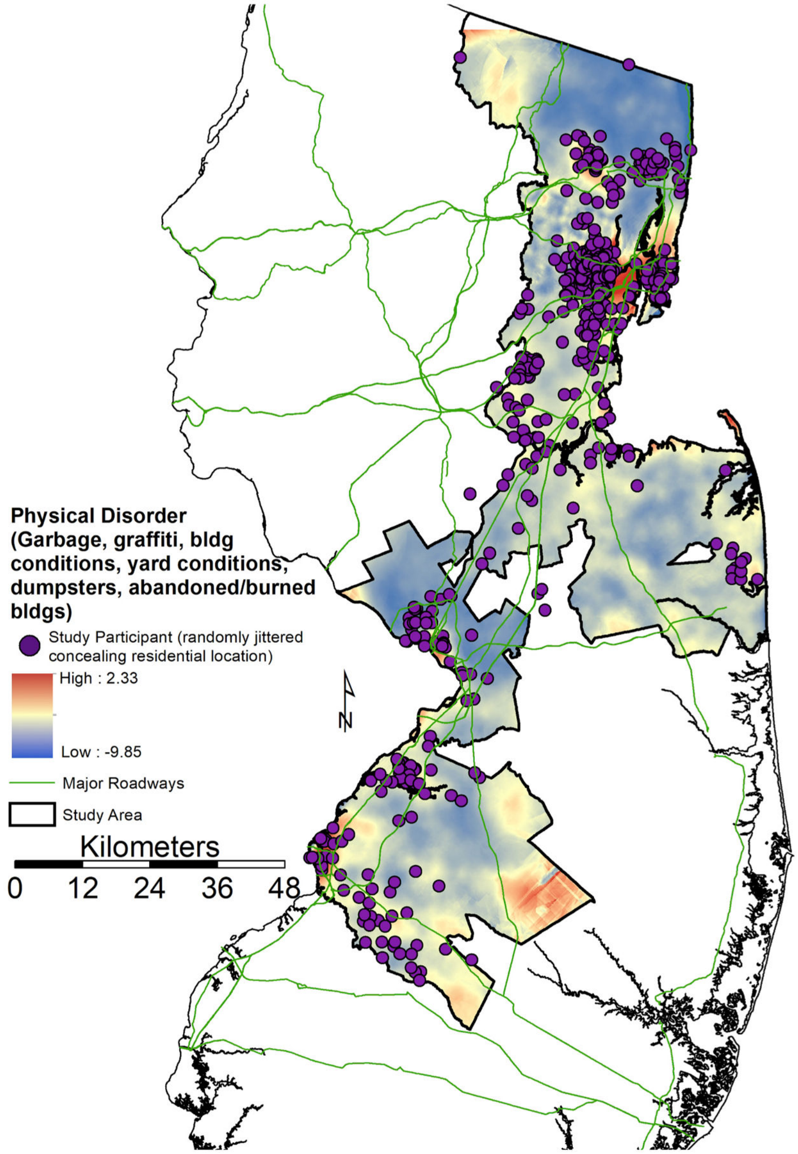

Fig. 1.

Estimated built environment physical disorder and WCHFS follow-up participants, restricted to New Jersey urban regions and WCHFS counties.

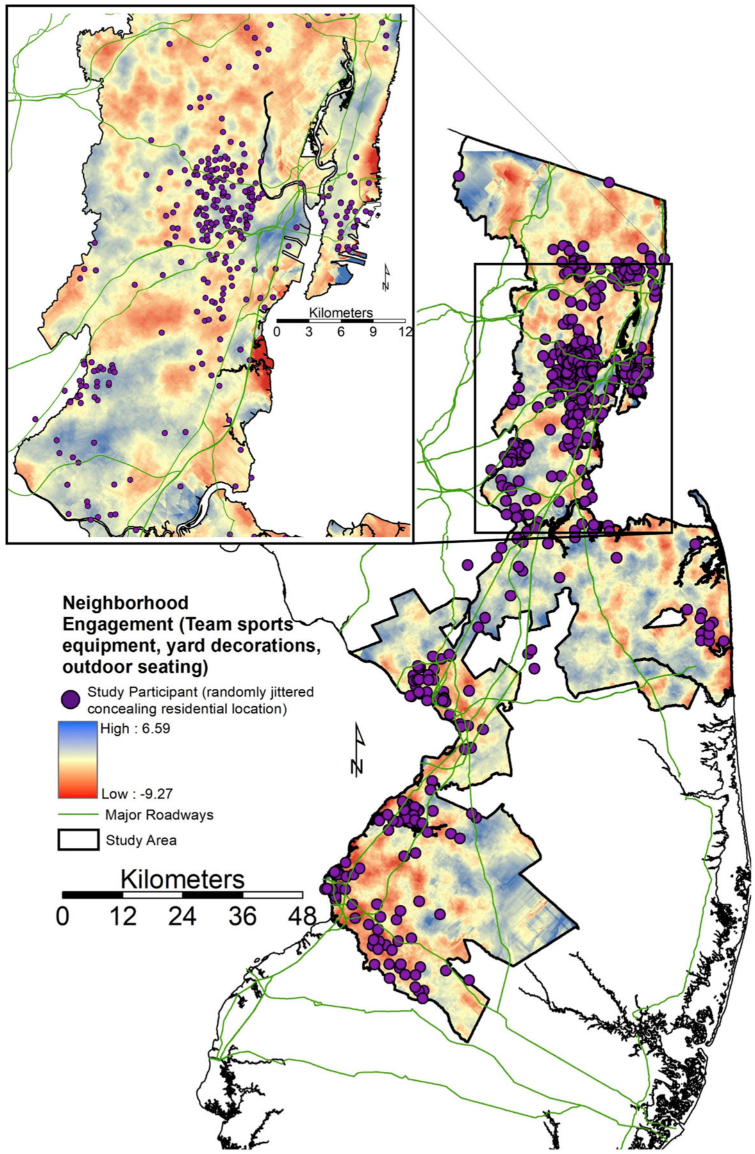

Fig. 2.

Estimated built environment engagement and WCHFS follow-up participants, restricted to New Jersey urban regions and WCHFS counties.

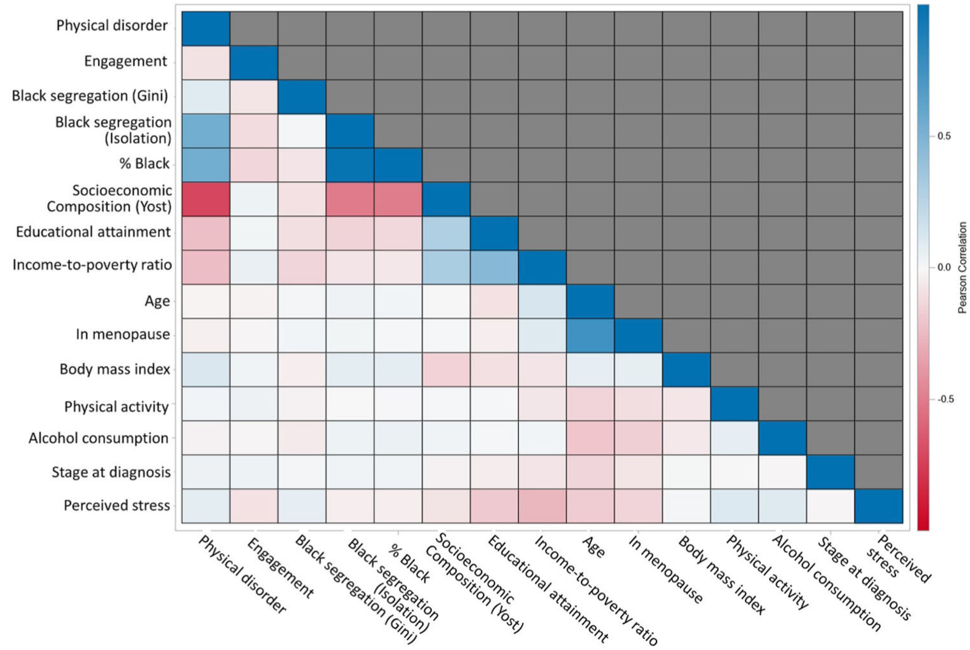

Fig. 3.

Correlation matrix of sociodemographic, anthropometric, health behavior, cancer, audited built environment, neighborhood factors, and perceived stress.

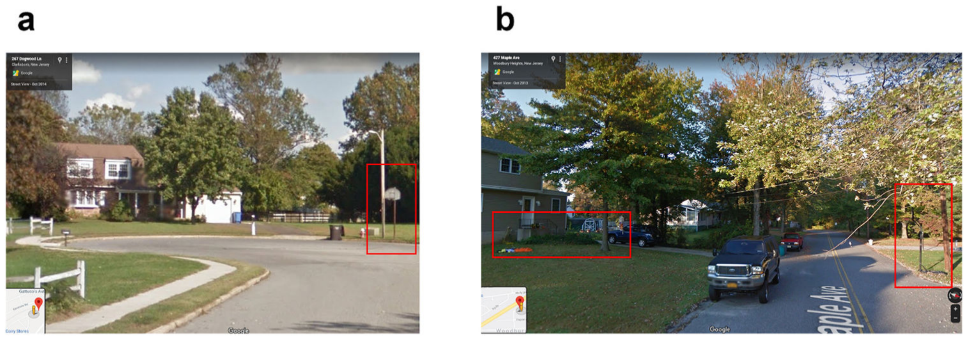

Fig. 4.

Example Google Street View scenes representative of neighborhood engagement among a) lower, and b) higher values of WCHFS study participants.[1].

[1]‘Lower’ here represents approximately the 10th percentile of study participants and is defined as absence of any engagement indicators or only presence of team sports equipment (red box above); ‘higher’ represents approximately the 90th percentile of study participants and is defined as presence of outdoor seating only or team sports equipment + yard decorations (red boxes above) or team sports equipment + outdoor seating.

Table 1

Distributions of sociodemographic, anthropometric, health behavior, cancer, audited built environment, neighborhood factors, and perceived stress[a], WCHFS, n = 476.

Variable	Mean or N (sd or %)
Neighborhood Physical Disorder[b]	0.50 (0.58)
Neighborhood Engagement[c]	0.03 (0.26)
Age (year)	54.7 (11.0)
Marital Status	
Single/never married	147 (30.9)
Widowed/Divorced/Separated	168 (35.3)
Married/Partnered	161 (33.8)
Education	
>4-year diploma	58 (12.2)
4-year diploma	89 (18.7)
Some college	163 (34.2)
≤ High school diploma	166 (34.9)
Household Income, $	50,704 (33,214)
Household Income Poverty	
≥100% Federal Poverty Level	370 (81.5)
<100% Federal Poverty Level	84 (18.5)
Health Insurance	
Private	253 (53.1)
Medicare	85 (17.9)
Medicaid	65 (13.7)
Uninsured	49 (10.3)
Other	24 (5.0)
AJCC Stage at diagnosis	
I	220 (49.4)
II	174 (39.1)
III	40 (9.0)
IV	11 (2.5)
Menopause	
No	164 (34.4)
Yes	312 (65.5)
Time from cancer diagnosis to follow-up, months	23.1 (4.4)
Alcohol Consumption (g/day)	2.9 (8.7)
Smoking Status	
Never	285 (59.9)
Former	108 (22.7)
Current	83 (17.4)
Physical Activity (metabolic equivalents)	55.9 (55.8)

Variable	Mean or N (sd or %)
Body Mass Index (kg/m^2)	32.1 (6.9)
Year of Follow-up Interview	
2014	92 (19.3)
2015	137 (28.8)
2016	76 (16.0)
2017	52 (10.9)
2018	92 (19.3)
2019	27 (5.7)
Perceived stress (PSS-10)	15.5 (7.0)
Census-based Neighborhood Factors	
Black Residential Segregation (Gini), 0–100	57.4 (14.7)
Black Residential Segregation (Isolation), 0–100	51.2 (27.2)
% Black	44.5 (30.2)
Socioeconomic composition (Yost Avg. Vigintile)	9.6 (5.4)

[a] sd = standard deviation.

[b] Neighborhood physical disorder scores from IRT models had a mean of 0.02 (sd = 0.80) and were proportional to greater physical disorder (i.e., presence of garbage/litter, graffiti, poor building and yard conditions, etc.).

[c] Neighborhood engagement scores from IRT models had a mean of 0.02 (sd = 0.60) and were proportional to greater engagement (i.e., presence of team sports in public spaces, yard decorations, and outdoor seating).

Table 2

Estimated perceived stress at follow-up by baseline demographic, socioeconomic, tumor, health behavioral, audited built environment, and neighborhood factors, WCHFS, n = 476.

	β (95% CI)[a]	
Variable	**Model 1**[b]	**Model 2**[c]
Neighborhood Physical Disorder, per 1 SD		0.25 (−0.69,1.19)
Neighborhood Engagement, per 1 SD		−0.47 (−1.10,0.16)
Age, per 5 yr	−0.47 (−0.95,0.01)[d]	−0.47 (−0.95,0.01)[d]
Marital Status		
Single/never married	Reference	Reference
Widowed/Divorced/Separated	0.42 (−1.26,2.1)	0.40 (−1.28,2.07)
Married/Partnered	1.09 (−0.55,2.73)	1.13 (−0.51,2.76)
Education		
> 4-year diploma	Reference	Reference
4-year diploma	0.82 (−1.45,3.09)	0.86 (−1.41,3.12)
Some college	3.36 (1.26,5.45)[e]	3.41 (1.32,5.50)[e]
≤ High school diploma	3.08 (0.88,5.28)[e]	3.14 (0.94,5.33)[e]
Household Income Poverty		
≥ 100% Federal Poverty Level	Reference	Reference
< 100% Federal Poverty Level	2.61 (0.54,4.68)[e]	2.65 (0.58,4.72)[e]
Health Insurance		
Private	Reference	Reference
Medicare	−1.16 (−3.46,1.15)	−0.55 (−2.49,1.39)
Medicaid	−0.55 (−2.5,1.39)	−1.32 (−3.63,0.99)
Uninsured	2.55 (0.31,4.79)[e]	2.40 (0.15,4.64)[e]
Other	0.44 (−2.31,3.18)	0.63 (−2.12,3.38)
AJCC Stage at diagnosis		
I	Reference	Reference
II	−1.44 (−2.78,−0.1)[e]	−1.38 (−2.72,−0.04)[e]
III	−0.34 (−2.58,1.89)	−0.25 (−2.48,1.98)
IV	−2.54 (−6.6,1.51)	−2.64 (−6.69,1.40)
Menopause		
No	Reference	Reference
Yes	−0.07 (−2.00,1.87)	−0.06 (−1.99,1.87)
Time between diagnosis and follow-up, per 1 mo.	−0.04 (−0.18,0.10)	−0.04 (−0.18,0.10)
Alcohol Consumption, per (log) 1 g / day	0.20 (−0.00,0.39)[d]	0.20 (−0.00,0.39)[d]
Smoking Status		
Never	Reference	Reference
Former	−1.30 (−2.84,0.24)[d]	−1.19 (−2.74,0.35)

Variable	β (95% CI)[a]	
	Model 1[b]	Model 2[c]
Current	−0.39 (−2.17,1.38)	−0.35 (−2.13,1.42)
Physical Activity, per (log) 100 weekly metabolic equivalents	0.49 (−0.22,1.20)	0.50 (−0.20,1.21)
Body Mass Index, per 1 unit (m^2 / kg)	0.00 (−0.09,0.09)	0.01 (−0.09,0.10)
Census-based Neighborhood Factors		
Black Residential Segregation (Gini), per 1 SD	1.80 (−2.90,6.51)	1.00 (−3.80,5.80)
Black Residential Segregation (Isolation), per 1 SD	−2.11 (−15.07,10.85)	−0.22 (−13.36,12.92)
% Black, per 1 SD	−0.01 (−0.13,0.11)	−0.03 (−0.15,0.09)
Socioeconomic composition (Yost), per 1 quantile	−0.11 (−0.25,0.03)	−0.09 (−0.26,0.09)

[a] Estimated within multiple imputation framework from 25 imputed datasets.

[b] Model 1: includes all covariates with coefficients within Model 1 column.

[c] Model 2: includes all covariates with coefficients within Model 2.

[d] $0.10 \geq p \geq 0.05$.

[e] $p < 0.05$.