Preventive Medicine xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

The neighborhood environment and obesity: Understanding variation by race/ethnicity

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ARTICLE INFO

Keywords:
Obesity
Resident characteristics
Health status disparities
Minority health

ABSTRACT

Neighborhood characteristics have been associated with obesity, but less is known whether relationships vary by race/ethnicity. This study examined the relationship between soda consumption – a behavior strongly associated with obesity – and weight status with neighborhood sociodemographic, social, and built environments by race/ethnicity. We merged data on adults from the 2011–2013 California Health Interview Survey, U.S. Census data, and InfoUSA (n = 62,396). Dependent variables were soda consumption and weight status outcomes (body mass index and obesity status). Main independent variables were measures of three neighborhood environments: social (social cohesion and safety), sociodemographic (neighborhood socioeconomic status, educational attainment, percent Asian, percent Hispanic, and percent black), and built environments (number of grocery stores, convenience stores, fast food restaurants, and gyms in neighborhood). We fit multi-level linear and logistic regression models, stratified by individual race/ethnicity (NH (non-Hispanic) Whites, NH African Americans, Hispanics, and NH Asians) controlling for individual-level characteristics, to estimate neighborhood contextual effects on study outcomes. Lower neighborhood educational attainment was associated with higher odds of obesity and soda consumption in all racial/ethnic groups. We found fewer associations between study outcomes and the neighborhood, especially the built environment, among NH African Americans and NH Asians. While improvements to neighborhood environment may be promising to reduce obesity, null associations among minority subgroups suggest that changes, particularly to the built environment, may alone be insufficient to address obesity in these groups.

1. Introduction

Although obesity prevalence is stabilizing in the United States (Flegal et al., 2012), non-Hispanic (NH) African Americans and Hispanics remain disproportionately affected (Ogden et al., 2014) and the rate of obesity continues to increase among NH Asians, especially in younger generations (Nam, 2013). Obesity outcomes have been associated with characteristics of the built, sociodemographic and social environments (Carroll-Scott et al., 2013; Feng et al., 2010; Kimbro and Denney, 2013; Kirby et al., 2012; Li et al., 2014; Powell-Wiley et al., 2014; Suglia et al., 2016). Within the built environment (e.g., grocery stores, parks), findings are mixed (Carroll-Scott et al., 2013; Feng et al., 2010). Sociodemographic environment, including neighborhood socioeconomic status (SES) (Kimbro and Denney, 2013; Powell-Wiley et al., 2014) and racial/ethnic composition, has been more consistently associated with obesity (Kirby et al., 2012; Li et al., 2014). Social environment, defined as the relationships, groups, and social processes within a neighborhood (Carroll-Scott et al., 2013), is less well studied, but higher social cohesion and social capital have been associated with lower obesity prevalence (Carroll-Scott et al., 2013; Suglia et al., 2016).

Neighborhood environment may contribute to observed differences in obesity prevalence across racial/ethnic subgroups. It is possible that the relationship between obesity and neighborhood characteristics vary by race/ethnicity; some neighborhood characteristics may matter for some subgroups. For example, among recent immigrants, particularly Asians and Hispanics, evidence suggests that traditional eating

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https://doi.org/10.1016/j.ypmed.2017.11.029
Received 17 July 2017; Received in revised form 13 October 2017; Accepted 26 November 2017
0091-7435/ Published by Elsevier Inc.

practices (Guendelman and Abrams, 1995; Wang et al., 2011) may buffer against negative neighborhood influences. In contrast, NH African Americans may be more susceptible to neighborhood influences because they, on average, have fewer individual-level socioeconomic resources in comparison to NH Whites (Pew Research Center, 2016). However, few studies have considered racial/ethnic variation in the associations between obesity and the neighborhood environment. Failure to examine these relationships by race/ethnicity could hinder the identification of effective interventions or policies for addressing persistent disparities in obesity and reducing population obesity. Of the studies that examined relationships between neighborhood and obesity by race/ethnicity (Lovasi et al., 2009a), most have focused on neighborhood racial/ethnic composition or food environment (Jones-Smith et al., 2013; Morland et al., 2002; Powell et al., 2007; Yi et al., 2014). To our knowledge, few studies have considered race/ethnic variations for other built and sociodemographic characteristics (Kirby et al., 2012; Zeigler-Johnson et al., 2013), and none for the social environment.

This study examined the associations between soda consumption – given the strong link between soda consumption and obesity risk (Hu, 2013) – and weight status with characteristics of the built, socioeconomic, and social environments by individual race/ethnicity.

We hypothesized that neighborhoods with high social support, high neighborhood socioeconomic status, and protective built environment characteristics would be associated with positive outcomes for all groups (Carroll-Scott et al., 2013; Feng et al., 2010; Powell-Wiley et al., 2014), and that more of these positive neighborhood characteristics would be associated with obesity outcomes for NH Whites and NH African Americans. We further hypothesized that living among others from the same ethnic group would be associated with better obesity outcomes among NH Asians and Hispanics (since 'ethnic enclaves' have previously been associated with better diet for these populations (Osypuk et al., 2009)), but worse outcomes among NH African Americans (since institutional racism against African Americans, such as the process of redlining, has led to highly segregated, mostly urban neighborhoods which have been associated with negative health outcomes (Williams and Collins, 2001)).

2. Materials and methods

2.1. Data and sample

Individual-level and social environment data were obtained from the 2011–2013 California Health Interview Survey (CHIS) (California Health Interview Survey, 2014). The CHIS, representative of California's non-institutionalized population, was designed to provide population estimates for California's major race/ethnic groups. Our study sample included adults, aged ≥ 18 (n = 62,396), excluding pregnant women, underweight individuals, and individuals in the "other" race/ethnicity category (n = 3285).

Neighborhoods were defined by census tracts. We merged data from 2011 to 2013 InfoUSA (InfoUSA, 2015), and 2009–2013 5-year U.S. Census's American Community Survey (U.S. Census Bureau, 2009–2013) to the CHIS though census tract identifiers to provide information about the built and sociodemographic environments, respectively. InfoUSA is a commercially available database commonly used in this area of research that obtains data about businesses, including type and location, from a variety of sources, such as Yellow Page directories, business filings, and corporate websites (InfoUSA, 2015).

2.2. Measures

2.2.1. Dependent variables

The outcomes were soda consumption and weight status. Soda consumption was based on self-report and dichotomized into any soda (i.e., 1 or more) in the previous week vs. none, which is consistent with prior research that characterizes consumption of at least 1 soda per week as "frequent" consumption (Ma et al., 2016).

Weight status outcomes included a continuous measure of body mass index (BMI) – calculated from self-reported height and weight – and a dichotomized indicator of obese or non-obese using WHO definitions (World Health Organization, 2016).

2.2.2. Main independent variables

Neighborhood sociodemographic, social, and built environments are represented by three different, non-overlapping sets of variables. The sociodemographic environment is represented by census-tract level measures of neighborhood SES (median household income, and educational attainment (percent with a high school degree or less)) and racial/ethnic composition (percent Hispanic, black, and Asian). All sociodemographic environment variables were modeled as continuous measures. Median household income was scaled by $10,000 increments. Other sociodemographic measures were scaled by 10 percentage point increments.

A neighborhood's social environment was assessed by 4 CHIS questions asked of all adult respondents. Through factor analyses, we identified two distinct neighborhood social environment measures – social cohesion and safety – which corresponded with the theoretical understanding of the neighborhood social environment (Diez Roux and Mair, 2010). Social cohesion was based on three questions: whether respondents perceived their neighbors as willing to help each other out, trustworthy, and watching out for the safety of children in the neighborhood. Responses to each of these questions were on a 4-point scale of strongly disagree, disagree, agree, or strongly agree. We summed the responses across the 3 questions to create a single continuous measure ranging from 0 (low social cohesion) to 9 (high social cohesion). Neighborhood safety was based on a single question of how often (all, most, some, and none of the time) respondents felt safe in their neighborhood, and dichotomized into safe (all the time) vs. not safe (< all of the time).

For the built environment, we included separate measures of the number of convenience stores, supermarkets/grocery stores, fast food outlets (limited service restaurants and pizza restaurants), and fitness and recreational sports centers within each census tract. These businesses were identified through the North American industry Classification System (NAICS) codes.

Additional information on each of these measures is available in appendix Table A1.

2.2.3. Potential confounding variables

We controlled for potential individual-level confounders, including demographic characteristics (age, gender, education), health behaviors (current smoking status), residential characteristics (urban/rural, years at current residential address), and acculturation. Acculturation was assessed by a measure of English proficiency and a 5-level composite variable of nativity/generational status/time in U.S.: U.S. born, both parents born in the U.S.; U.S. born, one parent born in the U.S., U.S. born, neither parent born in the U.S.; foreign born, > 15 years in the U.S.; and foreign born, or < 15 years in the U.S.

2.3. Statistical analysis

We accounted for CHIS's complex survey design to calculate summary statistics for all variables of interest stratified by the following racial/ethnic groups: NH White, NH African American, Hispanics, and NH Asians.

The data are hierarchical with persons (level-1 units) nested within census tract (level-2 units). To assess the relationship between soda consumption and weight status with the neighborhood environments for NH White, Hispanic, NH African American, and NH Asian subgroups, multi-level linear and logistic regression models were fit separately for each neighborhood environment, stratified by race/ethnicity

subgroup. The models included a random intercept to account for the potential within-neighborhood correlation of study outcomes (Diggle, 2002). We used linear random intercept models for BMI, and logistic random intercept models for obesity prevalence and soda consumption. We included the CHIS survey weights to account for the complex survey design. Level 1 weights were scaled to the cluster sample size within each race/ethnicity group.

For each outcome, we built separate regression models for each of the three neighborhood environments that adjusted for a priori selected *potential* individual-level and census tract-level confounding variables. For the sociodemographic environment, we included only the individual-level potential confounding variables. For the built and social environments, in addition to individual-level potential confounders, we also included 2 measures of neighborhood SES (median household income and percent in the census tract with a high school degree or less) since neighborhood SES may be a confounder of the relationship between obesity behavioral and weight status and neighborhood built and social environments (Cubbin et al., 2008; Estabrooks et al., 2003).

2.3.1. Sensitivity analysis

We conducted a sensitivity analyses for the built environment measures by including stores within a 1) 0.5 mile and 2) 1 mile radius buffer around of the census tract.

All analyses were conducted using Stata 14 (College Station, TX). The Johns Hopkins School of Public Health Institutional Review Board reviewed and determined that this project was non-human subjects research.

3. Results

3.1. Sample characteristics

The weighted sample represents 27,066,497 adults (age ≥ 18) of which 45.4, 35.1, 5.8, and 13.7% identified as NH White, Hispanic, NH African American and NH Asian, respectively (Table 1). Hispanics were least likely to have a college degree. > 80% of each subgroup lived in an urban area. Hispanics and NH Asians were more likely to be foreign born and were less likely to speak only English.

Hispanics and NH African Americans lived in neighborhoods with lower median household income, fewer high school graduates, and had a larger proportion of Hispanics (Table 1). Social cohesion was similar for all groups. NH Whites were more likely to report high levels of safety. Hispanics lived in neighborhoods with the highest number of grocery stores/supermarkets, but the fewest number of fitness centers. The number of neighborhood convenience stores and fast food outlets available was similar across all subgroups.

Table 2 summarizes the outcomes for each race/ethnicity subgroup. A larger proportion of Hispanics and NH African Americans reported consuming any soda (56.1% and 48.3%, respectively) compared to NH Asians and NH Whites (34.2% and 33.3%, respectively). BMI was highest for NH African Americans (29.3 kg/m^2) and lowest for NH Asians (24.8 kg/m^2). Among respondents, 22% of NH Whites, 33% of Hispanics, 37% of NH African Americans, and 10% of NH Asians were obese.

Table 3 presents adjusted associations between each of the neighborhood environments and study outcomes by race/ethnicity.

3.1.1. NH Whites

In adjusted models, all outcomes were associated with all three neighborhood environments. In the sociodemographic domain, lower neighborhood educational attainment i.e., % with a high school degree or less) was associated with higher odds of soda consumption (OR: 1.13, 95%CI: 1.07, 1.18), higher BMI (0.55, 95% CI: 0.45, 0.65), and higher odds of obesity (OR: 1.27, 95%CI: 1.21, 1.33). Neighborhoods with a higher proportion of Asians were associated with higher BMI (0.09, 95%CI: 0.02, 0.15). In the social environment, higher neighborhood social cohesion was associated with lower odds of soda consumption (OR: 0.95, 95%CI: 0.93, 0.98), lower BMI (−0.17, 95%CI: −0.22, −0.12), and lower odds of obesity (OR: 0.93, 95%CI: 0.91, 0.96). Safer neighborhoods were also associated with reduced odds of obesity (OR: 0.89, 95%CI: 0.82, 0.97). In the built environment, grocery stores were associated with lower BMI (−0.11, 95%CI: −0.17, −0.05), and lower odds of obesity (OR: 0.94, 95%CI: 0.92, 0.97), and fitness centers with lower soda consumption (OR: 0.96, 95%CI: 0.93, 1.00), and lower BMI (−0.07, 95%CI: −0.13, −0.01). Conversely, fast food restaurants were associated with higher soda consumption (OR: 1.02, 95%CI: 1.01, 1.04), and higher BMI (0.03, 95%CI: 0.00, 0.06).

3.1.2. Hispanics

Some characteristics from all three neighborhood environments were associated with weight status. In the sociodemographic domain, lower educational attainment was associated with higher BMI (0.28, 95%CI: 0.10, 0.46) and higher odds of obesity (OR: 1.08, 95%CI: 1.01, 1.16). In the social environment, social cohesion was associated with lower BMI (−0.10, 95%CI: −0.20, −0.00). In the built environment, only fitness centers were associated lower BMI (−0.16, 95%CI: −0.27, −0.04).

3.1.3. NH African Americans

Both the sociodemographic and social environments were associated with soda consumption and weight status for NH African Americans. In the sociodemographic environment, lower educational attainment was associated with increased soda consumption (OR: 1.14, 95%CI: 1.00, 1.31). In the social environment, safe neighborhoods were associated with lower BMI (−0.59 (95% CI: −1.13, −0.06). Outcomes were not associated with the built environment.

3.1.4. NH Asians

Aspects of the sociodemographic and built environments were associated with soda consumption and weight status. In the sociodemographic environment, lower neighborhood educational attainment was associated with higher BMI (OR: 0.23, 95%CI: 0.04, 0.43), while a high proportion of Asians in the neighborhood was associated with lower odds of obesity (OR: 0.87, 95%CI: 0.79, 0.96). In the built environment, fitness centers were also associated with lower BMI (−0.10, 95%CI: −0.20, −0.00).

3.1.5. Sensitivity Analysis

Results from both sensitivity analyses of the neighborhood boundaries of the built environment were largely similar with a few notable differences among NH Asians and Hispanics (Appendix Table A2). Contrary to the main analysis, for NH Asians, fitness centers were associated with lower odds of soda consumption for the 1-mile buffer. Among Hispanics, we found additional associations between grocery stores/supermarkets with reduced odds of obesity for both buffer distances, and with BMI for the 1-mile buffer. Fitness centers were associated with reduced odds of obesity at the 0.5-mile buffer, and fast food restaurants were associated with higher BMI at the 1-mile buffer.

4. Discussion

We found that a greater number of neighborhood sociodemographic, social, and built environment characteristics were associated with soda consumption and weight status – in the expected direction – for NH Whites compared to other subgroups. Fewer built environment characteristics were associated with soda consumption and weight status in the other race/ethnicity subgroups.

Lower neighborhood educational attainment was associated with higher soda consumption and weight status in all race/ethnicity groups. This is consistent with evidence demonstrating that neighborhood deprivation is associated with obesity-related behaviors and weight status (Kimbro and Denney, 2013; Powell-Wiley et al., 2014). While prior

Table 1
Descriptive statistics of sample respondent-level and neighborhood environment characteristics.

	NH White (n = 38,466)	Hispanic (n = 13,466)	NH African American (n = 2943)	NH Asian (n = 5499)
Respondent-level				
Demographic characteristics				
Gender, %				
Female	50.5	49.8	53.4	52.0
Age, years (SD)	50.4 (21.8)	40.5 (12.4)	46.6 (16.1)	43.0 (13.9)
Education, %				
Less than HS	4.9	34.4	10.0	8.4
HS degree	37.8	42.3	48.8	28.7
College degree or beyond	57.3	23.4	41.2	62.8
Heath behaviors				
Current smoker, %	14.5	11.9	20.3	10.4
Residential characteristics				
Urban/rural, %				
Urban	82.1	89.5	96.3	96.3
Time at residential address, year (SD)	12.5 (14.7)	8.7 (7.3)	9.6 (10.7)	9.0 (7.6)
US acculturation characteristics				
Nativity, generational status/time in US, %				
US born, both parents US born	78.8	16.9	87.1	4.4
US born, one parent US born	7.8	9	2.3	3.1
US born, no parent US born	3.6	19.3	1.8	21.8
Foreign born, ≥ 15 years in US	7.2	38.6	5.3	45.4
Foreign born, < 15 years in US	2.5	16.1	3.2	25.4
English proficiency, %				
Speaks only English	88.0	19.6	90.6	24.3
Speaks English very well/well	11.7	43.7	9.1	57.5
Not well/not at all	0.3	36.8	0.3	18.2
Neighborhood environment				
Sociodemographic environment				
Median household income, $ (SD)	74,938 (37,772)	54,960 (18,974)	57,087 (23,875)	76,468 (27,225)
High school graduate or less, %	31.6	52.8	45.3	34.5
Hispanic, %	25.5	55.2	40.3	28.5
Black, %	4.0	6.1	19.5	5.3
Asia, %	11.1	10.3	11.6	27.7
Social environment				
Social cohesion[a], mean (SD)	6.4 (2.0)	5.6 (1.4)	5.6 (1.7)	6.0 (1.2)
Perceived safety, %				
All the time	93.53	79.29	81.31	85.95
< all the time	6.47	20.71	18.69	14.05
Built environment[b]				
Grocery stores/supermarkets	1.4 (2.0)	1.9 (1.6)	1.7 (1.7)	1.6 (1.5)
Convenience stores	0.5 (0.9)	0.5 (0.6)	0.5 (0.7)	0.4 (0.6)
Fast food outlets	2.6 (4.1)	2.4 (2.6)	2.4 (3.1)	2.7 (2.9)
Fitness centers	1.1 (1.9)	0.7 (1.0)	0.8 (1.3)	1.0 (1.3)

Notes: Data from 2011 to 2013 CHIS; Study sample: Adults, age ≥ 18, excluding pregnant and underweight individuals.
[a] Scale from 0 (low) to 9 (high).
[b] Count/census tract.

Table 2
Descriptive statistics of sample outcomes.

	NH White	Hispanic	NH African American	NH Asian
Soda (≥ 1/week), %	33.3	56.1	48.3	34.2
BMI, kg/m^2 (SD)	26.9 (6.4)	28.8 (5.4)	29.3 (5.8)	24.8 (4.0)
Obese[a], %	22.1	32.8	37.3	9.6

Note: Data from 2011 to 2013 CHIS.
Study sample: Adults, age ≥ 18, excluding pregnant and underweight individuals.
[a] BMI ≥ 30.

studies have assessed neighborhood deprivation through both income and education, we found few subgroup associations with neighborhood income. This suggests that neighborhood education may be more relevant to obesity outcomes.

Social environment characteristic, such as cohesion, were associated with better outcomes among NH Whites, Hispanics, and NH African Americans. These findings build upon the growing evidence of the importance of the neighborhood social environment on obesity outcomes, and further suggest that the social environment is important for both NH White and minority groups. However, it is important to note that the exact relationships differed by race/ethnicity suggesting that there may be racial/ethnic differences in how the social environment influences obesity outcomes, and there was a more consistent association among NH Whites.

For NH Whites, multiple measures from all three neighborhood environments were significantly associated with both soda consumption and weight status. Most of these associations were consistent with prior reports that higher neighborhood SES, greater social cohesion, and safety are associated with improved obesity outcomes (Powell-Wiley et al., 2014; Suglia et al., 2016; Yu and Lippert, 2016). We also found several associations between the built environment characteristics (fast food outlets, grocery stores, and fitness center) and obesity outcomes for NH Whites. There were fewer associations between obesity outcomes and built environment characteristics in other racial/ethnic groups.

For Hispanics, social cohesion was associated with lower BMI. This is consistent with existing evidence of obesity-related benefits of more cohesive neighborhoods beyond neighborhood SES (Suglia et al., 2016). Social cohesion may encourage more culturally traditional, healthful diets, resulting in lower BMI (Suglia et al., 2016). Among built environment measures, only fitness centers were associated with better obesity outcomes.

For NH Asians, our finding that living among a higher concentration

Table 3
Adjusted associations between soda consumption and weight status outcomes (BMI and obesity) with neighborhood sociodemographic, social, and built environments.

	Soda consumption (≥ 1/week)		BMI		Obese[a]	
	OR	95% CI	Estimate	95% CI	OR	95% CI
Neighborhood sociodemographic environment[b]						
Median HH income[c]						
NH White	0.99	(0.97, 1.01)	0.00	(−0.03, 0.03)	1.00	(0.98, 1.02)
Hispanic	0.97	(0.94, 1.00)	−0.09	(−0.19, −0.00)	0.98	(0.94, 1.01)
NH African American	1.03	(0.97, 1.09)	0.00	(−0.12, 0.13)	0.99	(0.93, 1.06)
NH Asian	0.98	(0.94, 1.03)	0.04	(−0.03, 0.11)	1.01	(0.95 1.08)
% with HS degree or less[d]						
NH White	1.13	(1.07, 1.18)	0.55	(0.45, 0.65)	1.27	(1.21, 1.33)
Hispanic	1.06	(0.97, 1.12)	0.28	(0.10, 0.46)	1.08	(1.01, 1.16)
NH African American	1.14	(1.00, 1.31)	0.30	(−0.01, 0.61)	1.12	(0.97, 1.30)
NH Asian	1.03	(0.91, 1.16)	0.23	(0.04, 0.43)	1.14	(0.96, 1.36)
% Hispanic[c]						
NH White	1.00	(0.97, 1.04)	−0.04	(−0.11, 0.03)	0.97	(0.94, 1.00)
Hispanic	1.03	(0.98, 1.08)	−0.02	(−0.13, 0.10)	1.02	(0.97, 1.07)
NH African American	0.98	(0.88, 1.08)	−0.5	(−0.27, 0.18)	0.97	(0.87, 1.08)
NH Asian	1.01	(0.92, 1.11)	0.03	(−0.10, 0.16)	1.01	(0.88, 1.15)
% Black[c]						
NH White	0.97	(0.90, 1.05)	0.12	(−0.03, 0.27)	1.06	(0.99, 1.13)
Hispanic	1.06	(0.99, 1.14)	0.10	(−0.08, 0.27)	1.04	(0.98, 1.11)
NH African American	1.04	(0.97, 1.11)	0.04	(−0.12, 0.21)	0.99	(0.92, 1.07)
NH Asian	1.05	(0.90, 1.23)	−0.01	(−0.10, 0.16)	0.97	(0.79, 1.19)
% Asian[c]						
NH White	1.00	(0.97, 1.04)	0.09	(0.02, 0.15)	1.06	(1.00, 1.07)
Hispanic	1.00	(0.95, 1.05)	0.08	(−0.06, 0.22)	0.99	(0.94, 1.04)
NH African American	1.06	(0.96, 1.17)	−0.13	(−0.34, 0.08)	0.94	(0.85, 1.05)
NH Asian	0.94	(0.88, 1.00)	−0.08	(−0.17, 0.00)	0.87	(0.79, 0.96)
Neighborhood social environment[e]						
Social cohesion						
NH White	0.95	(0.93, 0.98)	−0.17	(−0.22, −0.12)	0.93	(0.91, 0.96)
Hispanic	0.99	(0.94, 1.03)	−0.10	(−0.20, −0.00)	0.97	(0.94, 1.01)
NH African American	1.04	(0.97, 1.11)	−0.01	(−0.16, 0.14)	0.97	(0.90, 1.04)
NH Asian	0.98	(0.90, 1.06)	0.08	(−0.02, 0.18)	1.01	(0.90, 1.14)
Safety						
NH White	0.95	(0.87, 1.03)	−0.20	(−0.36, −0.04)	0.89	(0.82, 0.97)
Hispanic	0.96	(0.85, 1.09)	0.23	(−0.09, 0.55)	1.10	(0.97, 1.25)
NH African American	0.79	(0.61, 1.01)	−0.59	(−1.13, −0.06)	0.82	(0.64, 1.07)
NH Asian	1.00	(0.78, 1.23)	0.16	(−0.23, 0.46)	1.11	(0.78, 1.59)
Neighborhood built environment[e]						
Grocery stores/supermarkets						
NH White	1.00	(0.96. 1.03)	−0.11	(−0.17, −0.05)	0.94	(0.92, 0.97)
Hispanic	0.99	(0.95, 1.02)	−0.00	(−0.09, 0.08)	0.99	(0.95, 1.02)
NH African American	0.99	(0.93, 1.06)	0.03	(−0.14, 0.21)	1.03	(0.95, 1.10)
NH Asian	1.05	(0.98, 1.13)	−0.03	(−0.12, 0.06)	0.93	(0.84, 1.02)
Convenience stores						
NH White	0.97	(0.92, 1.04)	0.10	(−0.04, 0.23)	1.02	(0.96, 1.08)
Hispanic	0.98	(0.91, 1.06)	0.08	(−0.12, 0.28)	1.03	(0.95, 1.11)
NH African American	0.99	(0.85, 1.16)	0.14	(−0.24, 0.52)	1.06	(0.90, 1.24)
NH Asian	1.05	(0.89, 1.23)	0.12	(−0.12, 0.35)	0.92	(0.73, 1.16)
Fast food restaurants						
NH White	1.02	(1.01, 1.04)	0.03	(0.00, 0.06)	1.01	(1.00, 1.03)
Hispanic	0.99	(0.97, 1.01)	0.05	(−0.00, 0.11)	1.01	(0.99, 1.03)
NH African American	1.00	(0.95, 1.04)	0.06	(−0.05, 0.17)	1.04	(0.99, 1.08)
NH Asian	0.97	(0.94, 1.01)	0.03	(−0.02, 0.08)	1.06	(1.00, 1.12)
Fitness centers						
NH White	0.96	(0.93, 1.00)	−0.07	(−0.13, −0.01)	0.98	(0.95, 1.01)
Hispanic	1.00	(0.95, 1.05)	−0.16	(−0.27, −0.04)	0.96	(0.91, 1.03)
NH African American	0.97	(0.88, 1.07)	−0.13	(−0.37, 0.11)	0.91	(0.82, 1.01)
NH Asian	0.97	(0.90, 1.06)	−0.10	(−0.20, −0.00)	0.93	(0.83, 1.05)

Note: Data from 2011 to 2013 CHIS.
Results for soda consumption and obesity were obtained from multivariate logistic regression; results for BMI were obtained from multivariate linear regression.
Study sample: Adults, age ≥ 18, excluding pregnant and underweight individuals.

[a] BMI ≥ 30.
[b] Controlled for respondent-level confounders (gender, age, education, current smoking status, urban/rural, time at residential address, nativity, English proficiency).
[c] Per $10,000 change.
[d] Per 10% change.
[e] Controlled for respondent-level confounders (gender, age, education, current smoking status, urban/rural, time at residential address, nativity, English proficiency) and neighborhood SES (household income and % ≤ HS degree).

of Asians was associated with reduced obesity prevalence is consistent with research that found that Asians living in “ethnic enclaves” had better diet (Osypuk et al., 2009). Interestingly though, the social environment was not associated with outcomes. While we might expect a higher concentration of Asians might improve social cohesion, these findings suggest other mechanisms linking Asian neighborhood

concentration to obesity. Fitness centers were the only built environment feature associated with better obesity outcomes. We believe that this is the first study to assess the relationship between fitness centers and obesity among NH Asians.

Among, NH African Americans, neighborhood safety was associated with lower BMI. Neighborhood safety may be particularly important to this subgroup because they are more likely to live in neighborhoods perceived as unsafe (Clark et al., 2009). The only built characteristic associated with obesity-related behaviors was fast food restaurant availability. Our study is the first to find an association between more fast food outlets and worse diet among NH African Americans. We did not find an association with grocery stores/supermarkets, which were found in some (Morland et al., 2002; Powell et al., 2007), but not all, prior studies (Jones-Smith et al., 2013).

In our sensitivity analyses of the neighborhood boundaries, we found a few key differences: for Hispanics, extending the boundaries to both 0.5 and 1-mile buffers around the census tract resulted in additional associations – all in the hypothesized directions – between weight status and several built environment features (grocery stores/supermarkets, fitness centers, and fast food). It is possible that relevant neighborhood boundaries might vary by race/ethnicity, as prior research suggest that neighborhood boundaries differ by individual-level characteristics (Lyseen et al., 2015). Larger neighborhood boundaries might be more appropriate for Hispanics, particularly if they live in rural, agricultural communities and may have to travel further to Hispanic grocery stores.

Our findings have several implications for policy and research. Recently, there has been significant interest in built environment interventions to reduce obesity prevalence and address persistent disparities by race/ethnicity. For example, policies to improve the built food environment, such as Pennsylvania's Fresh Food Financing Initiative, have provided financial incentives for supermarkets to open in low-income neighborhoods (Dubowitz et al., 2013). Prior studies have found that NH African Americans tend to live in neighborhoods with fewer healthy food stores, such as supermarkets (Bower et al., 2014), suggesting that increasing the number of these stores in African American communities may help reduce disparities in obesity outcomes between Whites and African Americans. However, numerous null associations between the built environment and obesity among minority subgroups in our study suggest that changes to the built environment alone may be insufficient for improving obesity outcomes in these groups. If changes to the built environment disproportionately benefit NH Whites, they could unintentionally exacerbate persistent race/ethnic disparities in obesity. Minority race/ethnic groups may face numerous barriers – at the individual and the neighborhood-level – that may hinder them from getting hypothesized benefits of built environment improvements to reduce obesity (Lovasi et al., 2009b). For example, neighborhoods may be unsafe, lack social cohesion, and lack grocery stores, or individuals may have limited financial resources that preclude them from taking advantage of changes to their built environment. Reducing race/ethnic disparities in obesity, particularly in high-risk minority groups, may require a more tailored approach that addresses multiple neighborhood and individual-level factors and a better understanding of what these factors are for each subgroup.

We did, though, find that higher neighborhood educational attainment was associated with better obesity outcomes in all race/ethnicity groups. Greater investment in the educational system to increase individual and neighborhood educational attainment, and policies that promote mixed income communities, which would improve neighborhood educational attainment for low-SES individual, could yield both economic (Chetty et al., 2016) and health benefits (e.g., lower obesity) for all race/ethnicity groups. We also found associations between the social environment and obesity in Hispanics and NH African Americans, who are both disproportionally affected by obesity. Social environment interventions are potentially promising, but will require efforts tailored to specific subgroups. Future research should examine how other neighborhood social environment characteristics, such as social capital (e.g., civic responsibility and engagement) or collective efficacy (e.g., social control, ability to count on neighbors to address community issues), relate to obesity by race/ethnicity. Our analysis suggests that relationships vary by racial/ethnic group, but there may also be differences within these groups. For example, additional research could explore whether the relationships vary within Hispanic and NH Asian subgroups (e.g., differences between Chinese, Vietnamese, and Koreans). In addition, future research should examine the role of physical activity-related built environment characteristics (e.g., parks, walkability) by race/ethnicity as this analysis primarily focused on food environment. Also, the sensitivity analyses results for Hispanics highlight the need for additional research on how the relevant neighborhood boundaries might vary by race/ethnicity.

This study had several limitations. Using cross-sectional data limited our ability to infer causality. This analysis, though exploratory, identified the relevance of less studied neighborhood characteristics, such as social cohesion, for obesity outcomes and can inform future studies. Future studies could assess causality between neighborhood educational attainment and obesity-related behaviors and weight status within minority subgroups. Our study relied on self-reported height and weight, which likely underestimates BMI (Rowland, 1990). We defined neighborhoods by census tracts, but it is possible that this may not accurately capture neighborhood boundaries relevant to obesity and dietary behaviors. There was less variation among built environment characteristics at the census tract-level (available upon request), which might limit our ability to detect significant differences. Because car ownership is high in California, the neighborhood definition for the built environment may extend beyond census tracts. Our sensitivity analyses suggest that larger boundaries might be appropriate for Hispanics but not NH African Americans. We used a commercial database to create our built environment measures, but there may be issues with data accuracy (Liese et al., 2010).

5. Conclusion

Our study findings suggest that associations between neighborhood environment characteristics and obesity-related behaviors and outcomes vary by race/ethnicity. Efforts to intervene on neighborhood built environments might not benefit all racial/ethnic subgroups equally. Future research should explore potential pathways to better understand the relationship between obesity outcomes and the neighborhood environment in different race/ethnicity groups, particularly in high-risk minority groups.

Funding

Dr. Wong was supported by the Agency for Healthcare Research and Quality [Award Number #T32HS000029], National Institute Of Diabetes And Digestive And Kidney Diseases of the National Institutes of Health [Award Number T32DK062707], and the VA Office of Academic Affiliations through the Health Services Research & Development Postdoctoral fellowship. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health, Agency for Healthcare Research and Quality, the U.S. Department of Veterans Affairs or the United States Government.

Conflicts of interest

None.

Transparency document

The Transparency document associated with this article can be found, in online version.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2017.11.029.

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