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Neighborhood food environment role in modifying psychosocial stress-diet relationships

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Abstract

Exposure to highly palatable foods may increase eating in response to stress, but this behavioral response has not been examined in relation to the neighborhood food environment. This study examined whether the neighborhood food environment modified relationships between psychosocial stress and dietary behaviors. Probability-sample survey (n=460) and in-person food environment audit data were used. Dietary behaviors were measured using 17 snack food items and a single eating-out-of-home item. Chronic stress was derived from five subscales; major life events was a count of 9 items. The neighborhood food environment was measured as availability of large grocery stores, small grocery stores, and convenience stores, as well as proportion of restaurants that were fast food. Two-level hierarchical regression models were estimated. Snack food intake was positively associated with convenience store availability and negatively associated with large grocery store availability. The measures of chronic stress and major life events were generally not associated with either dietary behavior overall, although Latinos were less likely to eat out at high levels of major life events than African Americans. Stress-neighborhood food environment interactions were not statistically significant. Important questions remain regarding the role of the neighborhood food environment in the stress-diet relationship that warrant further investigation.

Keywords

Neighborhood; Food environment; Psychosocial stress; Eating out; Fast food; Snack; Diet

Introduction

Experimental and observational evidence in animals and humans suggests that consumption of sweet, high-fat, and perhaps salty foods may increase under stress (Adam & Epel, 2007; Gibson, 2006; Macht, 2008; Oliver, Wardle, & Gibson, 2000; Torres & Nowson, 2007; Torres, Turner, & Nowson, 2010). Much of this research in humans has focused on major

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stress in the form of daily hassles or as experimentally induced in the laboratory. One study found, for example, that more daily hassles were associated with increased consumption of snacks high in fat or sugar (O Connor, Jones, Conner, McMillan, & Ferguson, 2008). Research has also linked non-specific measures of perceived stress to intake of salty snacks (Laugero, Falcon, & Tucker, 2011) and intake of sweet foods among diabetics and overweight individuals (Laugero, Falcon, & Tucker, 2011; Sims et al., 2008). Moreover, several studies have found relationships between negative emotions (e.g., depressive symptoms) or emotional eating (tendency to eat in response to negative emotions) and poorer dietary behaviors, including fast food consumption, soft drink consumption, and sweet energy-dense food intake (Beydoun et al., 2009; Crawford, Khedkar, Flaws, Sorkin, & Gallicchio, 2011; Elfhag, Tholin, & Rasmussen, 2008; Jeffery et al., 2009; Konttinen, Männistö, Sarlio-Lähteenkorva, Silventoinen, & Haukkala, 2010; Macht, 2008). Chronic stress has been the subject of less human research (Torres, Turner, & Nowson, 2010). One study found that chronic stress was positively associated with highly palatable, nutrient poor food intake (e.g., chips, fried foods, burgers, sweetened beverages) (Groesz et al., 2011). Intake of highly palatable foods, such as those high in fat, sugar, or salt, may activate the endogenous opioid (reward) system and reduce the hypothalamic-pituitary-adrenal (HPA) axis stress response, thereby alleviating symptoms of stress (Adam & Epel, 2007; Dallman et al., 2003; Warne, 2009). Highly palatable food intake may also reduce stress via sensory pleasure, distraction or escape, and other nutritional or metabolic effects (Gibson, 2006).

Less is known about relationships between stress and diet in racial/ethnic minority and groups of low socioeconomic status (SES). Understanding stress-diet relationships in these populations may be particularly important because they are disproportionately exposed to stressful living conditions and events, such as under-resourced neighborhoods, discrimination, and economic hardship (Israel et al., 2006; Lantz, House, Mero, & Williams, 2005; Logan, Alba, McNulty, & Fisher, 1996; Thoits, 2010), and are often at increased risk for poor diet and related chronic health conditions, such as obesity (Flegal, Carroll, Kit, & Ogden, 2012). Intake of foods high in sugar, fat, or salt may be an environmentally accessible and relatively inexpensive response to stressful life circumstances or events within these populations (Drewnowski, Darmon, & Briend, 2004; Jackson, Knight, & Rafferty, 2010).

Growing research suggests that the food environment – both access to healthy food products and exposure to energy-dense, nutrient poor foods and beverages – varies across neighborhoods and may influence dietary behaviors. While less consistent in other countries, racial/ethnic minority and low SES populations in the U.S. disproportionately reside in neighborhoods with ubiquitous access to foods high in sugar, fat, and/or salt and few healthy alternatives (Beaulac, Kristjansson, & Cummins, 2009; Larson, Story, & Nelson, 2009). Although the evidence is mixed, some research shows that living in a neighborhood with a wide selection of healthy food products is associated with healthier dietary behaviors (e.g., greater fruit and vegetable intake, higher overall dietary quality) (Caspi, Sorensen, Subramanian, & Kawachi, 2012; Giskes, Van Lenthe, Avendano-Pabon, & Brug, 2010). Other research has found that living in neighborhoods with greater availability of energy-dense nutrient poor food is associated with less healthy dietary behaviors (Larson, Story, & Nelson, 2009). Many of these studies have used outlet type as a proxy for food availability. Supermarkets and large grocery stores generally have more healthy food options than small grocery stores and convenience stores (Farley et al., 2009; Glanz, Sallis, Saelens, & Frank, 2007; Liese, Weis, Pluto, Smith, & Lawson, 2007; Zenk, 2005). While snack foods and sugar-sweetened beverages are often available across store types (Cameron, Thornton, McNaughton, & Crawford, 2012; Farley, Baker, Futrell, & Rice, 2010; Thornton, Cameron, McNaughton, Worsley, & Crawford, 2012), convenience stores predominately carry energy-dense nutrient poor snack foods and beverages (Lucan, Karpyn, & Sherman, 2010; Sharkey,

Dean, & Nalty, 2012). For example, a U.S. study showed that convenience stores, on average, had the highest proportion of shelf space dedicated to salty snacks, candy, and cookies/pastries and among the highest shelf space for carbonated beverages (Farley et al., 2009). This study also showed that small food stores had relatively high availability of snack foods and carbonated beverages. Nonetheless, while high exposure to snacks and sugar-sweetened beverages may entice impulse purchasing, research testing relationships between the neighborhood food environment and consumption of these food products specifically is scarce. However, one study in New Orleans, Louisiana found that greater neighborhood shelf space for snack foods was positively associated with body mass index of local residents (Rose et al., 2009).

Studies have also examined neighborhood restaurant availability and dietary behaviors. Eating out of home, or consumption of food products purchased or prepared out of home such as at a restaurant, is associated with energy-dense food selection, higher fat intake, and cravings for snacks (Bezerra, Curioni, & Sichieri, 2012; Lachat et al., 2012; Orfanos et al., 2007; Siwik & Senf, 2006). Frequenting fast food restaurants as compared to full-service or sit-down restaurants may be particularly deleterious for dietary behaviors and health because of large portion sizes and the high energy-dense profiles of foods (Duffey, Gordon-Larsen, Steffen, Jacobs, & Popkin, 2009; Garber & Lustig, 2011; Larson, Neumark-Sztainer, Laska, & Story, 2011). Yet, research has found no consistent evidence that the availability of healthy food options differs by restaurant type (Saelens, Glanz, Sallis, & Frank, 2007). Research on neighborhood restaurant availability, particularly fast food restaurant availability, and dietary behaviors has been mixed, with recent reviews of the literature noting that some research finds greater availability or a higher ratio of fast food to other restaurants is associated with greater consumption of fast food and poorer dietary intakes and others find no association (Caspi, Sorensen, Subramanian, & Kawachi, 2012; Fleischhacker, Evenson, Rodriguez, & Ammerman, 2011).

The type and variety of foods available and other food cues may alter the stress-diet relationship (Adam & Epel, 2007; Loxton, Dawe, & Cahill, 2011; Torres & Nowson, 2007; Wallis & Hetherington, 2009). Some animal research suggests that stress has larger effects on diet when highly palatable foods are available than when less hedonic foods are present. In a laboratory experiment with humans, one study found that induction of a negative mood was associated with urge to eat when exposed to a desirable food cue (i.e., fast food or confectionary presented in a wrapper and opened by participants) among disinhibited eaters (i.e., those who tend to lose control over eating) (Loxton, Dawe, & Cahill, 2011). In real-world settings, the neighborhood food environment may serve as a cue that alters the stress-diet relationship. Stress may be particularly likely to increase consumption of foods high in sugar, fat, and/or salt when these options are readily accessible and healthy foods are scarce. For example, living in neighborhoods with more convenience stores and restaurants, especially fast food restaurants, and fewer supermarkets or large grocery stores, may trigger or exacerbate effects of psychosocial stress on consumption of foods high in sugar, fat, or salt. These outlets may make these food choices more convenient and healthy alternatives less convenient to purchase for individuals experiencing stress. They may also serve as environmental cues that elicit eating under stress (Cohen & Farley, 2008; Garber & Lustig, 2011). However, the role of the neighborhood food environment in modifying stress-diet relationships has not been tested. In an effort to understand inconsistent relationships between the neighborhood food environment and diet, one study tested whether weekly stressful events moderated the relationship between neighborhood supermarket and grocery store availability and fruit and vegetable intake in African American and Hispanic women, but found no relationship (Ledoux et al., 2012).

The purpose of the present study was to examine the roles of psychosocial stress and the neighborhood food environment in dietary behaviors – specifically intake of highly palatable snack-type food products high in sugar, fat, or salt (snack foods) and eating out of home -- in a multiethnic, relatively low SES urban population. We hypothesized that: (1) stress is positively associated with snack food intake and eating out of home; (2) poorer quality neighborhood food environment (no large grocery store and more small grocery stores, convenience stores, and fast food restaurants) is positively associated with snack food intake and eating out of home; and (3) poorer quality neighborhood food environment exacerbates positive relationships between stress and snack food intake as well as eating out of home.

Methods

Data and Sample

This cross-sectional secondary analysis drew on data from a 2008 community survey and 2008 food environment audit conducted by the Detroit Healthy Environments Partnership (HEP), a community-based participatory research partnership (Schulz, Zenk, Kannan, Israel, & Stokes, 2012; Schulz et al., 2005; Zenk et al., 2012). The 2008 HEP community survey followed up on a 2002 stratified two-stage probability sample of occupied housing units in three areas of Detroit. After providing written informed consent, face-to-face interviews were conducted with adults ages ≥25 years residing in housing units included in the 2002 sample. Thus, the 2008 sample (n=460) includes 2002 survey respondents (n=219) as well as new residents of housing units included in the 2002 sample (n=241). Interviews were completed in English or Spanish with 80% of households in which an eligible respondent was identified. The research was approved by the Institutional Review Boards at the University of Michigan and University of Illinois at Chicago.

Measures

Dietary Behaviors—We measured two dietary behaviors: intake of highly palatable snack-type food products high in sugar, fat, or salt (snack foods) and eating out of home. Daily frequency of snack food intake was calculated using 17 items reported on the 2005 Block semi-quantitative food frequency questionnaire. The items included nine sweet snacks (ice cream, cake, muffins/biscuit/croissant, cookies, pudding, donuts, pie, chocolate candy, other candy), four sugar-sweetened beverages (regular soda, Kool-Aid, Hi-C, sugar-sweetened fruit drink), and four salty snacks (chips, crackers, nuts, French fries). The items are similar to those used in prior studies (Jeffery et al., 2009; Konttinen, Mannisto, Sarlio-Lahteenkorva, Silventoinen, & Haukkala, 2010; Oliver & Wardle, 1999). Reported intake frequencies, ranging from never to everyday, were converted into daily frequencies and then summed across the items. Because food frequency methods are most useful in ranking individuals on dietary intake (Willett, 1998), we dichotomized intake as low or high based on the median of the sample distribution (2.2 snacks per day). Eating out of home was measured with a single item: “On average, how many meals do you eat out, including takeout, in a given week?” on a 4-point scale: none, 1-2, 3-4, and 5 or more. Based on its distribution, eating out of home was dichotomized as low (0-2 times per week) and high (3 or more times per week). We selected snack food intake and eating out of home because research has found more consistent associations between emotional eating and diet for food group-based intake measures (i.e., snack foods) than for energy or macronutrient intake measures (e.g., saturated fat) (Konttinen, Mannisto, Sarlio-Lahteenkorva, Silventoinen, & Haukkala, 2010).

Psychosocial Stress—We measured two types of psychosocial stress: chronic stress and major life events. Building on results from focus groups with residents of the study communities on sources of stress (Israel et al., 2006), we created an index of chronic stress

from five subscales: neighborhood physical environment, neighborhood social environment, safety stress, everyday unfair treatment, and financial vulnerability. Table 1 shows the items, rating scale, and Cronbach's alpha where relevant for each subscale. The composite measure was created by calculating z-scores for each of the five subscales and then taking the mean of these five z-scores. We selected a composite measure because we expected that the cumulative chronic stress burden, rather than individual domains of chronic stress, would be associated with poorer dietary behaviors. Furthermore, computing the mean of the five subscales, rather than the sum of individual items, allowed us to weight the five domains equally. Number of major life events was calculated as the sum of nine items assessing whether an event occurred within the past 12 months (Table 1).

Neighborhood Food Environment—Data on the neighborhood food environment were drawn from a 2008 mapping (based on data from governmental sources and ground observations or ground-truthing) of the locations of food stores and restaurants in the study communities (Zenk et al., 2012). Neighborhood was defined as a 0.5-mile radial buffer from the centroid (geometric center) of respondents' residential census block. Commonly used in prior neighborhood food environment research (Charreire et al., 2010), a 0.5-mile buffer was selected to capture food outlets where food could readily be picked up from home as part of major grocery shopping or in between major shopping trips. Census block centroids are good proxies for locations of respondents' homes due to the small size of census blocks in the sample (median=0.009 square miles).

While the governmental sources provided a list of food outlet names and addresses, they did not provide information useful for classifying outlets by type. Thus, stores were categorized based on ground observations as large grocery stores (grocery stores with fresh meat and 4+ cash registers), small grocery stores (grocery stores with fresh meat and 1-3 cash registers), and convenience or “corner” stores (food stores with or without gas station, no fresh meat, and not a liquor store). While energy-dense snack foods are available across outlet types, we found that availability of healthy food alternatives, specifically fruits and vegetables, followed a gradient by store type (i.e., large grocery stores to convenience stores) in the study communities (Zenk, 2005). Restaurants were classified as fast food restaurants (restaurants in which you order and pay at the counter) or other restaurants.

For large grocery stores and small grocery stores, availability was measured using dichotomous indicators (presence versus absence). Due to the relatively large number of stores per neighborhood, availability was based on a count for convenience stores. Because of the high correlation between numbers of fast food restaurants and other restaurants (r=0.66), we calculated the proportion of neighborhood restaurants that were fast food restaurants.

Covariates—Individual-level covariates included: gender, age, race/ethnicity, four indicators of individual or household SES (education, employment status, per capita annual household income, auto ownership), and length of neighborhood residence.

Data Analysis

In preparation for analysis, though the percentage of missing data was low, multiple imputation procedures derived from Bayesian models were used to impute missing values on the survey. The imputation was performed using the Markov Chain Monte Carlo method with multiple chain option with Imputation and Variance Estimation software (IVEware, Ann Arbor MI) in SAS 9.1 (SAS Institute Inc, Cary NC, 2002-2003). Because measures of the food environment are often correlated, which can cause problems with multicollinearity, we examined bivariate associations among the variables and estimated variance inflation

factors (VIF) based on a series of single-level regression analyses for the neighborhood variables that rotated dependent variables. These analyses showed that the food environment variables were associated, but raised no concerns about multicollinearity, with VIF well below 2.5.

Two-level Bernoulli weighted hierarchical regression models with robust standard errors were estimated using HLM 7 (Scientific Software International, Lincolnwood, IL, 2011). Level 1 was the 460 survey respondents; level 2 was the 130 census blocks in which respondents resided plus 0.5-mile radial buffers. Bivariate associations were first assessed between each independent variable and outcome, as well as between the two stress measures (using linear regression). For both snack food intake and eating out of home, we tested the main effects of stress and the neighborhood food environment, controlling for covariates. We then added cross-level interactions between stress and each neighborhood food environment variable.

Results

Table 2 shows descriptive statistics for the individual- and neighborhood-level variables. A total of 28.1% of respondents reported eating out at least three times per week. The median daily frequency of snack food intake was 2.2. Less than half (45.4%) of neighborhoods had a large grocery store (none of which were chain full-service supermarkets) and 26.9% had a small grocery store. The mean number of convenience stores in the neighborhood was 3.45 (S.D. 2.40). The mean number per neighborhood was 3.56 (S.D. 2.92) for fast food restaurants and 2.05 (S.D. 2.12) for other restaurants. On average, 54.0% of the restaurants in a neighborhood were fast food (S.D. 34.3).

Model 1 in Tables 3 and 4 present bivariate associations between each independent variable and snack food intake and eating out of home, respectively. Model 2 shows main effects. Models 3 and 4 show cross-level interactions between chronic stress and major life events, respectively, and the food environment variables. With regard to main effects of snack food intake, we found that those with a large grocery store in the neighborhood had half the odds of high snack food intake compared to those without a large grocery store ($p=0.02$), controlling for covariates (Model 2, Table 3). Each additional convenience store in the neighborhood was associated with a 14% increase in the odds of high snack food intake ($p=0.03$). Neither chronic stress nor major life events was associated with snack food intake. There were no statistically significant interactions between the neighborhood food environment and either chronic stress (Model 3) or major life events (Model 4).

Neither measure of stress (chronic stress, major life events) nor the neighborhood food environment was associated with eating out of home (Model 2). A higher proportion of restaurants that were fast food was associated with a somewhat lower odds of eating out of home, but it was non-significant ($p=0.05$). Moreover, none of the interactions between the neighborhood food environment and either chronic stress (Model 3) or major life events (Model 4) were statistically significant.

Sensitivity analyses revealed that results were consistent when controlling for population density (at level 2) and census block group median household income (at level 3 of a 3-level model). Substitution of fast food restaurant counts or total restaurant counts for proportion of restaurants that were fast food did not alter results. The non-significant relationships between stress and snack food intake remained when using separate intake measures of sweet snacks, sugar-sweetened beverages, and salty snacks as outcomes. In these models, large grocery store availability was negatively associated with salty snack intake ($p<0.05$) while convenience store availability was positively associated with sugar sweetened

beverage intake ($p<0.05$). None of these alternative diet measures changed stress-food environment interaction results. Substitution of depressive symptoms for stress did not alter results. Relationships between stress and either dietary behavior did not differ by gender, income, or obesity status. However, there was a statistically significant interaction between race/ethnicity and major life events ($p<0.05$). Latinos were less likely to eat out at higher levels of major life events, while the likelihood of eating out was similar at different levels of major life events for African Americans as it was for the sample overall.

Discussion

In this study of a multiethnic, relatively low SES urban sample, we found no support for our hypothesis that the neighborhood food environment triggers or exacerbates the effect of stress on snack food intake or eating out of home. That is, there was no evidence that individuals with higher stress exposure consumed snacks or ate out of home more often if they lived in a neighborhood without a large grocery store or with more small grocery stores, convenience stores, fast food restaurants, or other restaurants. Further, while associations between chronic stress and dietary behaviors were in the expected direction, they were not statistically significant. Associations between major life events and eating out were confined to Latinos, who were less likely to eat out when experiencing more major life events. This may reflect financial constraints or loss of companionship for eating out associated with some of the major life events. A number of substantive and methodological factors are described below that may have contributed to our null findings, and could be examined in future research.

First, effects of consumption of food products high in sugar, fat, or salt on the brain reward system means that pursuit of these foods may become habitual or automatic. Thus, current dietary patterns may reflect historical stress (Epel, Tomiyama, & Dallman, 2012). This may explain the general lack of an association between contemporary stressful life circumstances or events and intake. Second, it is possible that the types of chronic stress or major life events included in this study are appraised as more “challenging” (demanding situations but with adequate resources to cope) than “threatening” (demanding situations for which one does not have adequate resources to cope); threat stress may have stronger effects on cortisol release and thus dietary behaviors (Adam & Epel, 2007). Further, while it includes important sources of chronic stress for racial/ethnic minority and low SES populations, the chronic stress measure utilized in this study may not adequately reflect total chronic stress burden. Third, measurement error in dietary behaviors may have affected results. Use of a food frequency questionnaire in which the most frequent response option was daily intake (versus multiple times per day) may have underestimated snack food intake for some respondents and therefore misclassified some “high” snack food consumers. Additionally, there may have been too much “noise” in the eating out of home measure used in this study, with individuals considering other food sources beyond restaurants (e.g., workplace cafeterias). Fourth, given prior research suggesting that the stress-diet relationship may differ depending on cognitive and physiological factors (e.g., dietary restraint, dietary disinhibition, cortisol reactivity) (Gibson, 2006; Oliver & Wardle, 1999; Torres & Nowson, 2007; Zellner et al., 2006) that were not available in our survey, we may not have been able to detect relationships between stress and dietary behaviors. It is possible that the neighborhood food environment only plays a role in moderating the stress-diet relationships for subgroups vulnerable to the dietary effects of stress (e.g., those high in dietary disinhibition). Fifth, food outlet type may not adequately capture food availability and prices and other aspects of the food environment, such as marketing, that might modify stress-diet relationships. Finally, because this was a cross-sectional study, we were not able to capture potentially dynamic relationships between stress and dietary behaviors and cannot infer causal relationships.

With little prior research testing relationships between the neighborhood food environment and snack food intake, we did find partial support for our hypothesis that the neighborhood food environment is associated with snack food intake. Our results showed that large grocery store availability was associated with less frequent consumption of snack foods, particularly salty snacks, and that more convenience stores in the neighborhood was positively related to snack food intake, particularly sugar sweetened beverages. In these and similar racially/ethnically and economically segregated communities, food outlets that predominately sell energy-dense nutrient poor foods and beverages greatly outnumber outlets carrying healthy alternatives. Our findings support prior research suggesting large grocery stores are potentially important resources for healthy eating, while convenience stores may make energy-dense, nutrient poor snack food intake opportune choices (Larson, Story, & Nelson, 2009). While a source of snack foods (Cameron, Thornton, McNaughton, & Crawford, 2012; Farley, Baker, Futrell, & Rice, 2010; Thornton, Cameron, McNaughton, Worsley, & Crawford, 2012), large grocery stores and supermarkets also provide the widest selection of foods including healthy options (e.g., fresh fruit) (Farley et al., 2009; Glanz, Sallis, Saelens, & Frank, 2007; Liese, Weis, Pluto, Smith, & Lawson, 2007; Zenk, 2005). Having easier spatial access to healthier foods may make individuals less reliant on energy-dense, nutrient-poor snack foods. Prior research suggests individuals living in neighborhoods with no supermarket or large grocery store are more likely to turn to packaged energy-dense foods at local corner and convenience stores at times when they have insufficient resources (e.g., transportation, time, money) to reach supermarkets and large grocery stores outside the neighborhood (Zenk, Odoms-Young et al., 2011).

Furthermore, the study contributes additional evidence that spatial accessibility of fast food or other restaurants to home may not be related to out-of-home eating (Caspi, Sorensen, Subramanian, & Kawachi, 2012; Fleischhacker, Evenson, Rodriguez, & Ammerman, 2011). In addition to non-specificity in the eating-out-of home measure, discussed above, it is possible that relationships are specific to fast food consumption or that restaurant accessibility close to work, other key activity hubs, or along commuting routes are more relevant. We were not able to test these possibilities in this study; they could be examined in future studies using datasets that include measures of availability in key activity areas beyond the residential neighborhood (Zenk, Schulz et al., 2011).

In conclusion, research suggests that stress-induced eating may differ depending on the type and variety of foods available and other food cues. Building on this research, our study raised and addressed novel questions regarding the potential moderating role of the neighborhood food environment in stress-diet relationships that warrant further investigation. Future studies are needed, for example, to examine these relationships in subgroups that are particularly vulnerable to dietary effects of stress, such as those that are high in dietary restraint, dietary disinhibition, or cortisol reactivity. Studies can also test these relationships for other types of stress like daily hassles. Research utilizing more direct measures of the neighborhood food environment such as snack food availability and marketing could also advance this line of research. Despite generally null findings for stress-diet relationships, our results do suggest that reducing access to convenience stores, which almost exclusively sell snack foods, and expanding access to supermarkets and large grocery stores, particularly in racial/ethnic minority and low-income neighborhoods, may help to curb snack food consumption.

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Table 1
Components of the chronic stress index and the major life event index

Scale name and items	Rating scale (Cronbach's alpha)
Chronic Stress	
Neighborhood physical environment (Israel et al., 2006; Schulz, Zenk, Kannan, Israel, & Stokes, 2012)	5-point disagree- agree scale (α=0.69)
1 Houses in my neighborhood are generally well maintained. (reverse-coded)	
2 There is heavy car or truck traffic in my neighborhood.	
3 My neighborhood has a lot of vacant lots or vacant houses.	
4 There is air pollution like diesel from trucks or pollution from factories or incinerators in my neighborhood.	
5 Streets, sidewalks and vacant lots in my neighborhood are kept clean of litter and dumping. (reverse-coded).	
6 There is a lot of loud noise from cars, motorcycles, music, neighbors, or airplanes in my neighborhood.	
7 There is contaminated land in my neighborhood.	
Neighborhood social environment (Israel et al., 2006; Schulz, Zenk, Kannan, Israel, & Stokes, 2012)	5-point disagree-agree scale (α=0.77)
1 Gang activity in your neighborhood.	
2 Drug dealing or drug dealers in your neighborhood	
3 Gunfire or shooting in your neighborhood.	
4 Prostitutes or cars driving through looking for prostitutes in your neighborhood.	
5 People loitering or hanging around on the street in your neighborhood.	
6 Theft, vandalism, or arson in your neighborhood.	
Safety (Israel et al., 2006; Schulz, Zenk, Kannan, Israel, & Stokes, 2012)	5 - point never - always scale (α=0.84)
1 Worry about your safety in your home	
2 Worry about being robbed or having your home broken into	
3 Worry about your safety in your neighborhood	
Everyday unfair treatment (Williams, Yu, Jackson, & Anderson, 1997)	5 - point never - always scale (α=0.77)
1 Treated with less courtesy or respect than other people	
2 Receive poorer service than other people at restaurants or stores	
3 People act as if they think you are not smart	
4 People act as if they are afraid of you	
5 Threatened or harassed	
• **Financial vulnerability** (James, Keenan, Strogatz, Browning, & Garrett, 1992)	5-point scale from > 1 year to <1 month
1 If you lost all your current sources of household income – your wages, public assistance, or other sources of income – how long could you continue to live at your current address and standard of living?	
Major Life Events (Blazer, Hughes, & George, 1987; Schulz, Zenk, Kannan, Israel, & Stokes, 2012)	Happened in last 12 months (yes, no)
1 Had a serious illness or injury that started or got worse	
2 Been a victim of a serious attack or assault	
3 Were robbed or home was burglarized	

Scale name and items		Rating scale (Cronbach's alpha)
4	Lost a loved one due to violence	
5	You or someone in your household lost job or retired when they didn't want to	
6	Someone close to you died	
7	Family member or close friend had a serious illness or injury	
8	Divorce or separation from husband/wife or partner	
9	Had a relative or close friend go to jail	

Table 2

Weighted descriptive statistics for individual- and neighborhood-level variables

Variables	Mean or %	Standard Error
Individual		
Eating out of home, 3+ times weekly (%)	28.1	
Snack food intake, 2.2+ times daily (%)	50.0	
Chronic stress (mean)[a]	0.00	0.04
Major life events (mean)	1.9	0.08
Age, years (mean)	50.4	0.8
Annual household income, per capita $ (mean)	14,969	1,415
Length neighborhood residence, years (mean)	17.7	0.7
Female (%)	57.6	--
Race/Ethnicity (%)		
Non-Hispanic Black	53.6	--
Hispanic	23.6	--
Non-Hispanic White	20.1	--
Non-Hispanic Other	2.7	--
Automobile ownership, Yes (%)	64.2	--
Employment status, Currently employed (%)	33.9	--
Education (%)		
Less than high school diploma or general equivalency diploma (GED)	37.6	--
High school diploma or GED	22.4	--
More than high school diploma or GED	39.9	--
Neighborhood		
Large grocery store availability, Yes (%)	45.4	--
Small grocery store availability, Yes (%)	26.9	--
Convenience store availability, number (mean)	3.45	2.40
Proportion of fast food restaurants (mean)	0.54	0.34

[a]Based on mean of five subscale z-scores. Subscale means (before z-score) on 5-point scale: everyday unfair treatment 1.7, neighborhood physical environment 3.2, neighborhood social environment 3.1, safety stress 2.7, and financial vulnerability 2.1 (4-point scale).

Table 3

Multilevel weighted regression results of snack food intake on stress, neighborhood food environment, and covariates[a,b]

	Model 1 Bivariate[c]			Model 2 Multivariate			Model 3 Multivariate			Model 4 Multivariate		
	O.R.	**95% C.I.**	***p***	**O.R.**	**95% C.I.**	***p***	**O.R.**	**95% C.I.**	***p***	**O.R.**	**95% C.I.**	***p***
Chronic stress	1.11	0.78, 1.58	0.55	1.00	0.69, 1.45	0.91	0.89	0.52, 1.54	0.68	0.97	0.66, 1.42	0.87
Major life events	1.01	0.89, 1.16	0.85	0.97	0.84, 1.12	0.66	0.98	0.85, 1.14	0.84	1.15	0.90, 1.47	0.27
Large grocery store	0.75	0.46, 1.22	0.24	0.51	0.29, 0.90	0.02	0.50	0.28, 0.89	0.01	0.49	0.28, 0.87	0.01
Small grocery store	0.82	0.50, 1.36	0.44	1.16	0.60, 2.28	0.66	1.19	0.58, 2.47	0.63	1.13	0.59, 2.16	0.72
Convenience stores, number	1.02	0.93, 1.12	0.63	1.14	1.01, 1.28	0.03	1.14	1.01, 1.28	0.03	1.14	1.02, 1.28	0.03
Proportion fast food restaurants	1.62	0.71, 3.67	0.65	1.86	0.78, 4.46	0.16	1.91	0.80, 4.57	0.14	2.01	0.85, 4.72	0.11
Chronic stress * large grocery store							1.26	0.44, 4.60	0.66			
Chronic stress * small grocery store							0.88	0.30, 2.52	0.81			
Chronic stress * convenience stores							1.16	0.94, 1.44	0.15			
Chronic stress * proportion fast food restaurants							0.91	0.27, 3.04	0.87			
Major life events * large grocery store										0.71	0.49, 1.05	0.08
Major life events * small grocery store										1.00	0.67, 1.49	0.99
Major life events * convenience stores										1.02	0.95, 1.11	0.54
Major life events * proportion fast food restaurants										1.22	0.72, 2.10	0.45

O.R. = odds ratio, C.I. = confidence interval

[a] All individual-level variables and neighborhood-level continuous variables are grand-mean centered.

[b] Covariates for multivariate models are individual-level age, race/ethnicity, gender, employment, annual household income, education, auto ownership, and length of neighborhood residence

[c] Major life events was positively associated with chronic stress (Coeff. = 0.11, T ratio = 4.80, p<0.001)

Table 4

Multilevel weighted regression results of eating out of home on stress, neighborhood food environment, and covariates[a,b]

	Model 1 Bivariate			Model 2 Multivariate			Model 3 Multivariate			Model 4 Multivariate		
	O.R.	**95% C.I.**	***p***	**O.R.**	**95% C.I.**	***p***	**O.R.**	**95% C.I.**	***p***	**O.R.**	**95% C.I.**	***p***
Chronic stress	1.33	0.92, 1.92	0.13	1.32	0.87, 2.00	0.19	1.51	0.65, 3.53	0.32	1.31	0.85, 2.00	0.22
Major life events	1.03	0.90, 1.18	0.69	0.95	0.79, 1.15	0.62	0.96	0.79, 1.16	0.67	0.86	0.65, 1.14	0.29
Large grocery store	0.59	0.37, 0.95	0.03	0.77	0.38, 1.56	0.45	0.80	0.39, 1.66	0.52	0.79	0.40, 1.58	0.49
Small grocery store	0.83	0.50, 1.40	0.48	1.07	0.49, 2.34	0.86	1.06	0.44, 2.58	0.89	1.13	0.52, 2.46	0.75
Convenience stores, number	0.90	0.81, 1.01	0.07	0.94	0.83, 1.06	0.31	0.94	0.83, 1.06	0.29	0.93	0.82, 1.05	0.22
Proportion fast food restaurants	0.49	0.27, 0.91	0.02	0.46	0.21, 1.00	0.05	0.47	0.22, 1.02	0.06	0.45	0.21, 1.01	0.05
Chronic stress * large grocery store							0.56	0.16, 1.97	0.35			
Chronic stress * small grocery store							1.11	0.35, 3.49	0.85			
Chronic stress * convenience stores							1.08	0.87, 1.35	0.47			
Chronic stress * proportion fast food restaurants							0.61	0.16, 2.29	0.46			
Major life events * large grocery store										1.09	0.70, 1.70	0.70
Major life events * small grocery store										1.21	0.78, 1.86	0.40
Major life events * convenience stores										0.94	0.85, 1.03	0.17
Major life events * proportion fast food restaurants										0.88	0.50, 1.56	0.66

O.R. = odds ratio, C.I. = confidence interval

[a] All individual-level variables and neighborhood-level continuous variables are grand-mean centered.

[b] Covariates for multivariate models are individual-level age, race/ethnicity, gender, employment, annual household income, education, auto ownership, and length of neighborhood residence