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Multilevel Correlates of Satisfaction with Neighborhood Availability of Fresh Fruits and Vegetables

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Abstract

Background—Little is known about influences on perceptions of neighborhood food environments, despite their relevance for food-shopping behaviors and food choices.

Purpose—This study examined relationships between multilevel factors (neighborhood structure, independently observed neighborhood food environment, individual socioeconomic position) and satisfaction with neighborhood availability of fruits and vegetables.

Methods—The multilevel regression analysis drew on data from a community survey of urban adults, in-person audit and mapping of food stores, and the 2000 Census.

Results—Satisfaction with neighborhood availability of fruits and vegetables was lower in neighborhoods that were further from a supermarket and that had proportionately more African-American residents. Neighborhood poverty and independently observed neighborhood fruit and vegetable characteristics (variety, prices, quality) were not associated with satisfaction. Individual education modified relationships between neighborhood availability of smaller food stores (small grocery stores, convenience stores, liquor stores) and satisfaction.

Conclusions—Individual-level and neighborhood-level factors affect perceptions of neighborhood food environments.

Keywords

Food environment; Neighborhood effects on health; Socioeconomic status; Urban populations; Fruits; Vegetables

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Introduction

Scholars seeking to understand factors that contribute to racial and socioeconomic disparities in obesity and related outcomes have documented systematic inequalities in the retail food environment by neighborhood economic and racial characteristics (1–9). Most of this research has focused on "objective" (independently observed) indicators of the neighborhood food environment {which includes food outlet availability and food characteristics (availability, prices, quality) within outlets (10)}, with relatively little known about factors that affect individual perceptions of the food environment. Evidence that individual perceptions of the food environment may shape food-shopping behaviors and dietary intakes (11–13) substantiates the importance of understanding influences on perceptions. Factors at both the neighborhood level and individual level may be relevant.

Neighborhood structural determinants have been the focus of most extant research of the independently observed food environment, with food outlet availability or spatial accessibility a major concentration. Healthy foods are generally more available, lower priced, and of higher quality in grocery stores as compared with other food stores (e.g., convenience stores) and in larger stores as compared with smaller stores (14–17). In the main, studies have found that lower-income and predominantly African-American neighborhoods have, or are closer to, fewer supermarkets, more liquor stores, and possibly more convenience stores than higher-income and predominantly White neighborhoods, respectively (3,4,6,8,18). Within food outlets, food availability, prices, and quality are among the factors that influence where consumers shop and their food choices (19–21). A smaller but growing number of studies have shown that healthful food availability and quality are inferior in lower-income and African-American neighborhoods, and these disparities are not completely accounted for by differences in the types of stores present (1,2,5,7,9,15). Evidence regarding neighborhood variations in food prices is inconsistent (5,9,22). Some studies have found that neighborhoods that are both low-income and predominately African-American are particularly disadvantaged with respect to food store availability and healthful food options (1,8,9,18).

Perceptions of the neighborhood food environment may reflect independently observed conditions. For example, individual perceptions of supermarket and healthful food availability may correspond with independently observed presence of a supermarket and these foods, respectively. To the extent that individual perceptions are influenced by independently observed conditions and differences in the food environment exist, residents of lower income and African-American neighborhoods may perceive that healthful foods are less available, of lower quality, and possibly higher priced. Because studies have generally focused on the immediate neighborhood, a largely unanswered question – for both perceived and independently observed indicators of the food environment – is the extent to which food options are even more restricted in neighborhoods in which economic disadvantage or African-American resident concentration are high in surrounding neighborhoods.

It is also possible that perceptions of the neighborhood food environment are influenced but not solely determined by independently observed environmental conditions (23). Physical activity research, for example, has revealed that perceived and independently observed indicators of the environment are often weakly associated (24–27). Individual socioeconomic position (SEP) may affect individual perceptions of the neighborhood food environment in two ways. First, SEP may directly affect perceptions. For example, among residents of the same neighborhood, individuals with limited personal transportation may be more reliant on local foods, and therefore view neighborhood foods more negatively than individuals with greater mobility and choices, independent of the independently observed food environment. Second, SEP may moderate the relationship between the objective and perceived neighborhood food

environment. For example, individuals with low incomes may perceive the same priced food as more expensive than higher income individuals.

The purpose of this study was to examine independent and joint contributions of neighborhood structure (racial composition, poverty rate), independently observed indicators of the neighborhood food environment, and individual SEP to individual perceptions of the neighborhood food environment, specifically satisfaction with neighborhood availability of fresh fruits and vegetables. We tested the following alternative hypotheses (H1–H6).

H1. Poverty rate and African-American resident concentration in the immediate residential neighborhood and surrounding neighborhoods are negatively associated with satisfaction.

H2. Neighborhood poverty rate moderates the relationship between neighborhood African-American concentration and satisfaction.

H3. Greater satisfaction is associated with independently observed aspects of the neighborhood food environment: (a) closer proximity to a supermarket, (b) presence of a large grocery store in the neighborhood, and (c) presence of stores in the neighborhood with relatively good variety, quality, and affordability of fresh fruits and vegetables.

H4. Satisfaction is negatively associated with independently-observed (a) presence of a convenience store, (b) greater number of liquor stores, and (c) presence of a small grocery store in the neighborhood.

H5. Satisfaction is lower among individuals of lower SEP.

H6. Individual SEP moderates relationships between the independently observed neighborhood food environment and satisfaction.

Methods

Setting

We tested these hypotheses in three communities in Detroit, Michigan, United States of America: eastside, southwest, and northwest. Racial residential segregation and economic restructuring have shaped contemporary circumstances in Detroit including these communities. Due in part to fears of racial integration that prompted White residents to flee to the suburbs, Detroit lost over half its population between 1950 and 2000 and transitioned from 16% to 81% African-American by 2000 (28,29). During this same time period, good-paying, blue-collar employment opportunities disappeared from Detroit, due in part to deindustrialization and relocation of industries from the city to the suburbs (28,30). Although there have been recent reinvestment efforts, economic divestment has had grave repercussions for not only residents' economic resources, but also multiple aspects of the physical and social environments including the retail food environment (28). For example, despite having a population of approximately 950,000 people, only nine supermarkets (full-service chain grocery stores or supercenters) were located in Detroit in 2002 (8).

Still, these patterns of depopulation and divestment and reinvestment have differentially impacted communities in Detroit, as demonstrated by 2000 census data and its comparison to prior years (31,32). Losing over half of its residents between 1950 and 1980, eastside Detroit was 94% African-American in 2000. Home to the largest concentration of Latinos in metropolitan Detroit, southwest Detroit in 2000 was approximately 58% Latino, 10% African-American. and 29% White. In both eastside and southwest Detroit about one-third of residents were below poverty. Historically one of the most economically stable areas in the city with a relatively high concentration of White residents, northwest Detroit's population fell by 27% between 1990 and 2000 and, in 2000, was 84% African-American and 12% White.

Data and Sample

For individual-level data, we drew upon a 2002–2003 community survey of a stratified proportional probability sample of 919 African-American, Latino, and White adults age ≥25 years residing in the three Detroit communities: eastside, southwest, and northwest (33). The survey sample was designed to achieve adequate representation of all racial/ethnic groups across individual-level SEP. The overall response rate (number of completed interviews from the number of households in sample estimated to have an eligible respondent) was 55% (919 of 1,663). Interviews were completed with 75% of households in which an eligible respondent was identified, and in 90% of the total households in which an eligible respondent was contacted. The 919 survey respondents were nested within 146 census blocks and 69 census block groups. The survey was conducted by the Healthy Environments Partnership, a community-based participatory research partnership comprised of members from community-based organizations, health services organizations, and academic institutions. (See Acknowledgements for a list of partner organizations.)

We derived the neighborhood-level variables from three data sources. The first data source is a 2002 in-person audit of food stores in the study communities (9,34). As part of the audit, observers recorded information on store type, as well as the variety, quality, and price of fresh produce. The second data source is a 2002 mapping of the locations of food stores in the study communities (9) and all supermarkets in metropolitan Detroit (8). The third data source is the 2000 Census from which we derived information on racial and economic characteristics of respondents' census block groups.

Measures

Individual Satisfaction with Neighborhood Availability of Fruits and Vegetables—The dependent variable was satisfaction with neighborhood availability of fresh fruits and vegetables, as measured by the community survey. On a Likert scale ranging from not at all satisfied (1) to very satisfied (4), respondents rated their satisfaction with the “variety,” “quality,” and “cost and affordability” of fresh fruits and vegetables in their neighborhood, defined as a 10–15 minute walk or 5-minute drive from their home. The mean of these three items was used in the analysis (alpha=0.87), with higher scores indicating greater satisfaction.

Neighborhood Structure—For both the immediate residential neighborhood (census block group in which the respondent lived) and surrounding neighborhoods (census block groups sharing a common border or corner with the census block group of residence), we measured two aspects of *neighborhood structure*: racial composition and poverty rate. Data were available for defined geographies (e.g., census block groups, census tracts) from the U.S. Census; therefore, we used the census block group because it is the smallest spatial scale for which poverty data are available. The percentage of individuals in the census block group who self-identified as non-Hispanic African-American or Black measured neighborhood racial composition (2000 Census Summary File 1). The percentage of individuals in the census block group who reported annual family incomes below the federal poverty line measured neighborhood poverty rate (2000 Census Summary File 3). Using SpaceStat 1.91, we calculated spatially lagged variables for the percentage of African-American residents and residents in poverty using a row-standardized “queen” contiguity matrix. These variables are the mean percentages of African-American residents and residents in poverty, respectively, in the surrounding census block groups.

Independently Observed Neighborhood Food Environment—Drawing on prior research (24,35,36) to approximate an area that we thought would correspond most closely with our sample's perceptions of a 10–15 minute walk, we defined the independently observed neighborhood food environment as a 0.5 mile from respondents' homes. Specifically, we used

0.5-mile Euclidean-distance radial buffers from the centroids (geographic centers) of respondents' residential census blocks. Use of radial buffers based on census block centroids served two purposes. First, as compared to census block groups for example, the radial buffers allowed for more consistent measurement of the independently observed food environment across respondents. Second, measuring the independently observed food environment based on census block centroids, rather than survey respondents' home addresses, permitted the inclusion of the measures at level 2 of our multilevel model and thereby helped to account for non-independence of these observations (respondents were nested within 146 census blocks).

For independently observed neighborhood food store availability, we used dichotomous indicators for the presence of large grocery stores (non-chain grocery stores with at least three cash registers), small grocery stores (non-chain grocery stores with one or two cash registers), convenience stores without gasoline stations (food stores with limited capacity for customer check-out), and specialty stores (fruit and vegetable or meat/seafood markets). Due to the large number of liquor stores, we used a count of liquor stores (stores classified as “liquor” store in the telephone directory; had “liquor” or “party” in their name; or had “liquor,” “beer,” or “wine” as the largest sign on the storefront) within the 0.5 mile radial buffer. Because of the small number of supermarkets in Detroit, we measured supermarket availability as the street-network distance in miles from the centroid of the residential census block to the nearest supermarket using ArcGIS Network Analyst 9.1.

An in-person audit of food stores in the study communities resulted in independently observed neighborhood fresh fruit and vegetable characteristics (variety, affordability, and quality) (9). One observer (the first author) assessed fresh produce variety and prices; one of two observers who completed 16 hours of training rated fresh produce quality. *Variety* was a visual count of 80 fresh fruits and vegetables; *affordability* was the mean standardized (z-scored) price of up to 20 fresh fruits and vegetables, based on the lowest priced brands and sizes; and *quality* was the mean quality score (1–4) of up to 20 fresh fruits and vegetables (9,34). Briefly, for each of the 20 produce varieties (e.g., apples, broccoli), we adapted USDA quality standards 37–39 todevelop a unique high-quality description for external appearance and condition that covered the domains of color, texture, form, and damage or defects. Using these high-quality descriptions, for each produce variety, observers estimated the proportion of items at the store that did *not* meet the high-quality standard: excellent (0–4%), good (5–24%), fair (25–49%), or poor (50–100%). Based on data from three stores (one assessed at each of three time points during the five-week data collection: day 1, end of week one, end of week three), Spearman rank correlation coefficients comparing two observers' quality ratings ranged from 0.82 to 0.85.

Price and quality scores were reverse-coded, so that higher scores correspond with lower prices/greater affordability and higher quality, respectively. Because one-fourth of the neighborhoods did not have any store selling fresh produce, we created 3-level variables for fresh produce variety, quality, and affordability for use in the analysis: presence of at least one store selling fresh produce that was in the upper quartile for the characteristic, presence of at least one store selling fresh produce but no store in the upper quartile for the characteristic (reference category), and no store selling fresh produce. The first level of each variable indicates neighborhood presence of a store with relatively good fresh produce variety, quality, or affordability.

Individual Socioeconomic and Demographic Characteristics—We used four indicators of individual or household *SEP*: education [at least some college, high school diploma or general equivalency diploma (GED), less than a high school diploma or GED], employment status (not employed, currently employed), annual household income (≥$35,000, $20,000–34,999, $10,000–19,999, ≤$10,000), and car ownership (does not own car, owns car). Other individual covariates included: gender (male, female), age in years, self-reported race/

ethnicity (African-American, Latino, non-Hispanic White, Other), marital status (not currently married, currently married), home ownership (does not own home, owns home), number of household members, and years of neighborhood residency. The following are the reference categories in the analysis: at least some college, not employed, annual household income ≥ $35,000, does not own car, male, African-American, not currently married, and does not own home. Due to the small number of respondents, regression results are not presented for respondents classified as “other” race/ethnicity (n=16).

Data Analysis

The primary analytic strategy was multilevel regression analysis. Multilevel models allow for the inclusion of multiple levels of data (e.g., individuals, neighborhoods) in one model and account for dependence among individual responses that arises due to shared experiences in the same neighborhood or common ways that individuals were selected into the same neighborhood (40,41). Failure to account for the multilevel structure of data may result in misestimated standard errors (41).

In preparation for multilevel analysis, several analytic steps were undertaken. First, sample weights were calculated and applied at each level (individual, census block, census block group) to adjust for unequal probabilities of selection within strata (due to the complex sampling design), match the sample to Census 2000 population distributions for the study communities, and adjust for non-response at the individual level (33). Second, multiple imputation (MI) procedures derived from Bayesian models were used to impute missing values for the individual-level data (42,43). The imputation was performed using the Markov Chain Monte Carlo (MCMC) method with multiple chain option in IVEware, a program for SAS 9.1.3 (SAS Institute Inc, Cary NC, 2002–2003). Briefly, through the imputation procedure that used an input dataset of all variables, each missing value was replaced with a vector of five plausible values resulting in five datasets. These five datasets were analyzed simultaneously to compute statistics of interest. Overall the marginal distribution of all imputed variables did not change with respect to their original distribution, suggesting no bias was introduced into the datasets due to imputed values. Third, to identify potential problems with multicollinearity in the regression analysis, we examined bivariate associations among the individual-level variables and the neighborhood-level variables (e.g., store availability, poverty rate, African-American resident concentration).

Three-level weighted hierarchical linear regression models were estimated using HLM 6.04 (Scientific Software International, Lincolnwood IL, 2006). Level 1 was the 919 survey respondents; level 2 was the 146 census blocks plus 0.5 mile radial buffers; and level 3 was the 69 census block groups. Most hypotheses (H1, H3–H5) were tested through direct effects of the independent variables. Because store type was associated with independently observed fruit and vegetable characteristics (variety, affordability, quality) and these characteristics were associated with one another, we tested each set of variables in separate regression models. Other hypotheses (H2, H6) involved tests of moderation. H2 was tested using a multiplicative interaction term between percent African-American (centered) and poverty rate (centered). H6 was tested through cross-level interactions between the individual-level SEP indicators and the independently observed food environment indicators (41). Due to overlap in 0.5 mile radial buffers, we tested level-2 regression model residuals for spatial autocorrelation using a global Moran's *I* test and multiple contiguity matrices (e.g., nearest four census block centroids) in GeoDa 0.9.5-i (Luc Anselin, Urbana IL, 2004).

Results

Table 1 shows weighted summary statistics for the individual-level and neighborhood-level variables. About half the sample was female; 56.8% was African-American; 34.0% were

educated beyond high school; 23.0% had an annual household income of more than $35,000; and 64.9% were currently employed. On average, the poverty rate of the residential and surrounding census block groups were 34.6% and 32.7%, respectively. The residential and surrounding census block groups averaged 66.8% and 68.1% African-American residents, respectively. Although the poverty rate of the residential census block group and surrounding census block groups were moderately correlated (r=0.58), the correlation between the percentage of African-American residents in the residential and surrounding census block groups was high (r=0.96). Therefore, we excluded surrounding census block group percentage African-American from the regression analysis. The prevalence of different store types within the 0.5-mile radial buffers ranged from 25.4% (convenience store) to 39.2% (large grocery store). On average, 5.43 liquor stores were located within the 0.5 mile radial buffers, and the street-network distance to the nearest supermarket was 3.27 miles. Approximately 40% of the 0.5-mile radial buffers had at least one store that fell in the upper quartile for fresh FV variety, quality, or affordability.

With respect to the multilevel regression analyses, a fully unconditional model indicated significant variation at both level 2 (census block) (p=0.031) and level 3 (census block group) (p<0.001) (not shown). Our test of H1 revealed that neither the poverty rate of the immediate residential neighborhood nor the mean poverty rate of surrounding neighborhoods was associated with satisfaction with neighborhood availability of fruits and vegetables (Model 1, Table 2). However, consistent with H1, residents of neighborhoods with greater concentration of African-American residents reported lower satisfaction with neighborhood availability of fruits and vegetables (p=0.004). When added to Model 1, the multiplicative interaction term between percent African-American and percent poor was non-significant (p=0.622; not shown). Thus, we cannot reject the null for H2.

Of the food store variables, only distance to the nearest supermarket had a direct, statistically significant association with satisfaction (p=0.018): longer distance to the nearest supermarket was associated with lower satisfaction with neighborhood availability of fruits and vegetables (Model 1, Table 2), after accounting for neighborhood racial composition and poverty. Thus, we reject the null for H3a but not those corresponding with H3b or H4. Results of global Moran's I tests revealed essentially no spatial autocorrelation in level-2 regression model residuals. Our tests of H3c are shown in Models 2–4 (Table 2), which include neighborhood structural characteristics and add, one at a time, independently observed indicators of neighborhood fruit and vegetable characteristics. None of the neighborhood fruit and vegetable characteristics were associated with satisfaction; therefore, we cannot reject the null for H3c.

Table 3 shows results for our tests of H5. Contrary to H5, when compared with those with at least some college education, individuals with less than a high school diploma and a high school degree reported greater satisfaction with neighborhood availability of fruits and vegetables (p=0.017 and 0.040, respectively; Table 3). However, none of the other three indicators of SEP (employment status, car ownership, annual household income) were statistically significantly associated with satisfaction.

Our results were consistent with H6 for education (Table 4), but not the other three SEP indicators (not shown). On average, each additional liquor store in the neighborhood was associated with a greater decrease in satisfaction with neighborhood availability of fruits and vegetables for both those with less than a high school diploma (p=0.027) and high school graduates (p=0.014) when compared with those with at least some college education. Similarly, presence of a convenience store in the neighborhood was associated with lower satisfaction among those with less than a high school education (p=0.002) and high school graduates (p=0.028) relative to those with at least some college education. In addition, when compared

with those with at least some college education, small grocery store availability was associated with lower satisfaction among high school graduates (p=0.009).

Discussion

This is one of the first studies to examine multilevel factors that may affect individual perceptions of the neighborhood food environment, particularly satisfaction with neighborhood availability of fresh fruits and vegetables. In a multiethnic urban sample residing in neighborhoods with restricted food environments, we found that satisfaction with neighborhood availability of fresh fruits and vegetables was lower in neighborhoods with greater concentrations of African-American residents, but was not associated with neighborhood poverty rates. Living farther away from a supermarket was associated with lower satisfaction, above and beyond the effects of neighborhood racial composition. Residents with less education were generally more satisfied with neighborhood availability of fresh fruits and vegetables than those with at least some college education. However, presence of more liquor stores and a convenience store in the neighborhood were more strongly negatively associated with satisfaction among those with less education.

This study adds a new perspective to a growing body of research documenting neighborhood variations in the food environment. Prior U.S. studies using independently observed indicators have found fewer chain supermarkets (3,4,6,44), less availability or variety of healthy foods including fresh produce (2,5,7), and lower quality fresh produce (5,9) in predominantly African-American neighborhoods. In keeping with these findings, we found that residents of neighborhoods with proportionately more African-Americans were less satisfied with local fruits and vegetables, and that this relationship was significant above and beyond the effects of neighborhood poverty. In contrast to other US studies that have found fewer chain supermarkets (3,4,6) and less independently observed availability of healthful foods (15) in low-income neighborhoods, we found no significant association between the economic conditions of the residential or surrounding neighborhoods and satisfaction with the food environment. Further, in contrast to a small number of prior studies using independently observed food environment indicators (1,8,9,18), we found no evidence that the relationship between neighborhood racial composition and satisfaction differed depending on neighborhood economic conditions.

We found that one independently observed neighborhood food environment measure, distance to the nearest supermarket, was associated with satisfaction with neighborhood availability of fruits and vegetables. Moore and colleagues found that residents of areas with lower densities of supermarkets rated healthful food availability 17% lower than those in areas with the highest densities of supermarkets (45). Our findings lend additional support that availability of a supermarket – measured as supermarket proximity in our study – may affect individuals' appraisals of healthful foods in the neighborhood.

We found that independently observed neighborhood fruit and vegetable characteristics (variety, prices, quality) were not associated with satisfaction. In one of the few prior studies to examine relationships between independently observed and perceived food environments using equivalent (in terms of content) measures of food availability and relative prices of “recommended” (e.g., choices lower in fat, salt) and “regular” foods, Giskes and colleagues found fairly high correspondence for food availability, but not relative prices of “recommended” and “regular” foods, in supermarkets where respondents shopped (11). Our findings may differ due to our focus on the neighborhood food environment rather than the supermarket where shopped, for which we might expect greater correspondence.

Several issues related to measurement may also have contributed to our findings of few associations between independently observed neighborhood fruit and vegetable characteristics and satisfaction. First, perceived walking and driving times may vary such that the area that respondents perceived as within a 10–15 minute walk or 5-minute drive may not correspond with the 0.5 mile radial buffer. Second, the independently observed measures of fruit and vegetable variety, quality, and affordability employed in this study may not capture criteria that residents use to judge these characteristics. For example, the number of stores that do *not* offer a wide variety of reasonably priced, high-quality fruits and vegetables or the proportion of items within neighborhood stores that are reasonably priced and of high quality may have stronger influences on satisfaction than the presence of a store with overall relatively good variety, price, or quality. Third, use of perceptual measures that require a global assessment (e.g., variety of fresh fruits and vegetables) rather than those that are anchored to specific foods (e.g., availability of reduced fat milk) (11) may attenuate associations between the independently observed food environment indicators and satisfaction. Fourth, characteristics of preferred fruits and vegetables, rather than of fruits and vegetables in general, may be more influential on individual satisfaction. The observations in our study may suggest that the determinants tend to differ for independently observed neighborhood food environments versus residents' perceptions of, including satisfaction with, neighborhood foods. Further research is needed to understand why.

Partially consistent with our hypothesis (H6), our findings also suggest that although individuals with less education were generally more satisfied with neighborhood availability of fruits and vegetables than individuals educated beyond high school, presence of a convenience store, small grocery store (high school graduates only), and more liquor stores in the neighborhood were associated with a greater *decrease* in their satisfaction. These outlets tend to sell few fresh fruits and vegetables and a wide selection of energy-dense foods. In general, higher educated individuals may be more dissatisfied with neighborhood availability of fruits and vegetables for several reasons. First, individuals with higher levels of education tend to eat more fruits and vegetables than those with less education (46); therefore, they may be less satisfied if local options are limited. Second, the educational process may provide more procedural knowledge and skills regarding how to judge fruits and vegetables. Third, drawing on the literature showing a positive association between education and discrimination (47), higher education may be associated with heightened expectations and more critical appraisal regarding the variety and quality of fruits and vegetables and what prices are reasonable or fair. On the other hand, those with less education may be more sensitive to the presence of liquor stores, convenience stores, and small grocery stores in the neighborhood due to greater reliance on these outlets to meet their food needs including fruits and vegetables.

Study strengths are inclusion of a multiethnic sample of urban adults, incorporation of potential influences at multiple levels including independently assessed neighborhood store availability and fresh fruit and vegetable characteristics, and examination of the contribution of economic conditions in both the residential and surrounding neighborhoods. Nonetheless, this study has limitations. First, our measure of satisfaction is not necessarily equivalent to the independently observed indicators of neighborhood fruit and vegetable variety, quality, or price. Individuals who are not seeking to purchase fruits and vegetables or who shop outside the neighborhood may be satisfied even when neighborhood fruit and vegetable availability is unfavorable. This would reduce the likelihood of identifying associations. Second, although representative of residents' incomes in these three urban communities, the sample is relatively low-income and has limited variability in income. These factors may explain why we did not find associations between individual income and satisfaction, despite some research showing stronger effects of income than education or occupation on food purchasing behaviors (48). Similarly, relatively few economically advantaged neighborhoods are located in these three Detroit communities. As a comparison, in a study examining differences in food store availability in three U.S. sites

(New York, Maryland, North Carolina), the 75th percentile for median neighborhood annual household income by site ranged from $38,446 to $51,149 respectively (3), compared with $33,036 in our study neighborhoods. Thus, limited variability in neighborhood economic conditions may have contributed to our failure to find a significant effect of neighborhood poverty rate on satisfaction. Fourth, the high correlation between percent African-American in the immediate residential and surrounding neighborhoods prevented us from testing independent effects of each. Although the poverty rates of the immediate residential neighborhood and surrounding neighborhood were moderately correlated (which could dampen their independent effects on satisfaction), the immediate residential neighborhood poverty rate was also not associated with satisfaction when excluding the mean poverty rate of the surrounding neighborhoods from the model (not shown). Sixth, due to the cross-sectional nature of the data, it is not possible to establish causality.

Despite these limitations, this study adds to our current understanding of factors at both the individual level and neighborhood level that influence satisfaction with neighborhood availability of fresh fruits and vegetables in multiethnic adults residing in urban neighborhoods with restricted food options. Specifically, it contributes to a growing body of literature that suggests that neighborhood African-American resident concentration is associated with not only independently observed, but also perceptions of, neighborhood availability of fruits and vegetables. In addition, it affirms that access to supermarkets is associated with satisfaction with local fruit and vegetable availability. Finally, it illustrates that individual characteristics, such as education, modify relationships between the independently observed neighborhood food environment (e.g., location of different types of food stores) and individual satisfaction with neighborhood availability of fresh fruits and vegetables.

The findings reported here suggest several areas for future research. These include examining multilevel predictors of individual perceptions of, including satisfaction with, the neighborhood food environment in different populations and settings; testing relationships between independently observed and perceived food environment measures; and exploring dynamic and reciprocal associations among the perceived food environment, food shopping behaviors (e.g., stores frequented, foods purchased), and dietary intakes. In particular, qualitative research could enhance our understanding of factors that affect how individuals perceive the food environment and what aspects of neighborhood food environments influence food shopping behaviors. This understanding would assist in developing independently observed and perceived indicators of the food environment to apply in future research and in designing programs and policies to improve the local food environment.

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Table 1

Weighted summary statistics for variables

	% or Mean	Std. Dev.
Individual variables		
Satisfaction with neighborhood availability of fresh fruits and vegetables, potential and actual range 1–4 (mean)	2.9	(0.03)
Years of residence in neighborhood (mean)	18.7	(0.47)
Age, years (mean)	46.3	(0.84)
Household size (mean)	2.8	(0.01)
Female (%)	52.3	--
Race/Ethnicity (%)		
African-American	56.8	--
Latino	22.2	--
White	18.8	--
Other	2.3	--
Married (%)	26.4	--
Own home (%)	51.5	
Currently employed (%)	64.9	--
Own automobile (%)	67.0	--
Education (%)		
Less than high school	36.9	--
High school degree	29.1	--
At least some college	34.0	--
Annual household income (%)		
<$10,000	27.3	--
$10,000–$19,999	26.0	--
$20,000–$34,999	23.6	--
≥$35,000	23.0	--
Neighborhood variables		
Large grocery store (%)	39.2	--
Specialty store (%)	32.2	--
Convenience store (%)	25.4	--
Small grocery store (%)	33.8	--
Liquor stores (mean)	5.43	(2.68)
Distance to nearest supermarket, miles (mean)	3.27	(0.78)
Fresh produce variety (%)		
No store selling fresh produce	24.4	--
No store in upper quartile for variety	35.7	--
Store in upper quartile for variety	39.9	--
Fresh produce quality (%)		
No store selling fresh produce	24.4	--
No store in upper quartile for quality	36.2	--
Store in upper quartile for quality	39.4	--

	% or Mean	Std. Dev.
Fresh produce affordability (%)		
No store selling fresh produce	24.4	--
No store in upper quartile for affordability	31.3	--
Store in upper quartile for affordability	44.3	--
Residential neighborhood % African-American (mean)	66.8	(36.01)
Surrounding neighborhoods % African-American (mean)	68.1	(32.68)
Residential neighborhood % poor (mean)	34.6	(12.56)
Surrounding neighborhoods % poor (mean)	32.7	(7.72)

Table 2

Satisfaction with neighborhood availability of fresh fruits and vegetables regressed on individual characteristics, neighborhood structure, and independently observed indicators of the neighborhood food environment[a,b]

	Model 1			Model 2			Model 3			Model 4		
	Coeff.[c]	SE	p-value	Coeff.	SE	p-value	Coeff.	SE	p-value	Coeff.	SE	p-value
Intercept	2.786	(0.054)	<0.001	2.810	(0.049)	<0.001	2.800	(0.046)	<0.001	2.744	(0.039)	<0.001
Residential neighborhood % Black	−0.004	(0.001)	0.004	−0.004	(0.001)	<0.001	−0.004	(0.001)	<0.001	−0.004	(0.001)	<0.001
Residential neighborhood % poor	<0.001	(0.003)	0.999	<0.001	(0.003)	0.996	<0.001	(0.003)	0.645	<0.001	(0.003)	0.993
Surrounding neighborhood % poor	−0.006	(0.006)	0.352	−0.010	(0.006)	0.105	−0.010	(0.006)	0.110	−0.011	(0.006)	0.060
Large grocery store	−0.062	(0.047)	0.227									
Specialty store	0.065	(0.059)	0.270									
Convenience store	0.028	(0.050)	0.576									
Liquor stores, #	0.004	(0.015)	0.811									
Small grocery store	0.040	(0.083)	0.631									
Distance to nearest supermarket	−0.161	(0.067)	0.018									
Observed FV variety (Ref: No store in upper quartile)												
No store selling fresh FV				0.093	(0.093)	0.320						
Store present in upper quartile				−0.044	(0.061)	0.468						
Observed FV quality (Ref: No store in upper quartile)												
No store selling fresh FV							0.103	(0.094)	0.275			
Store present in upper quartile							−0.024	(0.049)	0.623			
Observed FV affordability (Ref: No store in upper quartile)												
No store selling fresh FV										0.155	(0.091)	0.089
Store present in upper quartile										0.087	(0.057)	0.125
Individual variance	0.535			0.534			0.534			0.534		
Census block (level 2) variance	0.003		0.009	0.007		0.006	0.010		0.006	0.010		0.006
Census block group (level 3) variance	<0.001		0.287	0.005		0.106	0.005		0.152	0.003		0.195

SE = Standard error

[a]All models include these individual-level (level-1) covariates: age, household size, years of neighborhood residence, gender, race/ethnicity, marital status, home ownership, employment status, car ownership, education, and annual household income.

[b] All individual-level covariates, residential neighborhood percent African-American, residential and surrounding neighborhood percent poor, distance to the nearest supermarket, and number of liquor stores were grand-mean centered. Therefore, the coefficients are interpreted as the average effect of a one unit change from the grand mean (across neighborhoods) for that variable.

[c] Coeff. = Unstandardized coefficient

Table 3

Satisfaction with neighborhood availability of fresh fruits and vegetables regressed on individual characteristics[a,b]

	Coeff.[c]	SE	p-value
Intercept	2.820	(0.033)	<0.001
Age, years	0.006	(0.003)	0.049
Household size, # members	0.033	(0.020)	0.087
Years of residence in neighborhood	0.001	(0.003)	0.664
Female (Ref: Male)	−0.078	(0.052)	0.139
Race/ethnicity (Ref: African-American)			
Latino	0.190	(0.143)	0.184
White	−0.080	(0.088)	0.366
Currently married (Ref: Not married)	−0.004	(0.098)	0.968
Own home (Ref: Does not own home)	0.172	0.077	0.025
Currently employed (Ref: Not employed)	0.066	(0.086)	0.445
Own car (Ref: Does not own car)	−0.051	(0.057)	0.371
Education (Ref: At least some college)			
Less than high school	0.255	(0.107)	0.017
High school degree	0.198	(0.096)	0.040
Annual household income (Ref: ≥$35,000)			
<$10,000	−0.026	(0.126)	0.833
$10,000–$19,999	0.058	(0.137)	0.671
$20,000–$34,999	−0.001	(0.091)	0.989
Individual variance	0.533		
Census block (level 2) variance	0.012		0.007
Census block group (level 3) variance	<0.001		0.082

SE = Standard error

[a] All individual-level independent variables were group-mean centered. Therefore, the coefficients are interpreted as the average effect of a one unit change from the block group mean for that variable and compare residents of the same block group.

[b] The grand-mean centered aggregate of each individual-level variable was included at level 3.

[c] Coeff. = Unstandardized coefficient

Table 4

Cross-level interactions between individual education and neighborhood food store availability (Dependent variable: Satisfaction with neighborhood availability of fresh fruits and vegetables) [a,b,c]

	Coeff.[d]	SE	p-value
Intercept	2.738	(0.048)	<0.001
Education (Ref: At least some college)			
Less than high school	0.375	(0.114)	0.001
High school degree	0.330	(0.118)	0.006
Large grocery store	−0.062	(0.055)	0.262
Specialty store	0.093	(0.072)	0.197
Convenience store	0.090	(0.054)	0.094
Liquor stores, #	0.001	(0.015)	0.930
Small grocery store	0.116	(0.089)	0.193
Distance to nearest supermarket, miles	−0.133	(0.059)	0.026
Less than high school * large grocery store	0.189	(0.161)	0.241
Less than high school * specialty store	0.168	(0.200)	0.404
Less than high school * convenience store	−0.498	(0.153)	0.002
Less than high school * liquor stores	−0.075	(0.034)	0.027
Less than high school * small grocery store	−0.266	(0.190)	0.162
Less than high school * distance to nearest supermarket	0.158	(0.118)	0.180
High school degree * large grocery store	0.135	(0.159)	0.397
High school degree * specialty store	0.187	(0.194)	0.335
High school degree * convenience store	−0.350	(0.159)	0.028
High school degree * liquor stores	−0.064	(0.026)	0.014
High school degree * small grocery store	−0.455	(0.173)	0.009
High school degree * distance to nearest supermarket	0.075	(0.085)	0.377
Individual variance	0.512		
Census block (level 2) variance	0.001		0.001
Census block group (level 3) variance	0.007		0.159

SE = Standard error

[a] Individual-level covariates include age, household size, years of neighborhood residence, gender, race/ethnicity, marital status, home ownership, employment status, car ownership, and annual household income.

[b] All individual-level covariates were group-mean centered; distance to the nearest supermarket and number of liquor stores were grand-mean centered.

[c] The grand-mean centered aggregate of each individual-level variable was included at level 3.

[d] Coeff. = Unstandardized coefficient