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Neighborhood Retail Food Environment and Fruit and Vegetable Intake in a Multiethnic Urban Population

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Abstract

Purpose—To examine relationships between the neighborhood food environment and fruit and vegetable intake in a multiethnic urban population.

Design—Analysis of cross-sectional survey and observational data.

Setting—146 neighborhoods within three large geographic communities of Detroit, Michigan.

Subjects—Probability sample of 919 African-American, Latino, and White adults.

Measures—The dependent variable was mean daily fruit and vegetable servings measured using a modified Block 98 food frequency questionnaire. Independent variables included the neighborhood food environment: store availability (large grocery, specialty, convenience, liquor, small grocery), supermarket proximity (street-network distance to nearest chain grocer), and perceived and observed neighborhood fresh fruit and vegetable supply (availability, variety, quality, affordability).

Analysis—Weighted multilevel regression.

Results—Presence of a large grocery store in the neighborhood was associated with, on average, 0.69 more daily fruit and vegetable servings in the full sample. Relationships between the food environment and fruit and vegetable intake did not differ between Whites and African-Americans. However, Latinos compared with African-Americans with a large grocery store in their neighborhood consumed 2.20 more daily servings of fruits and vegetables. Presence of a convenience store in the neighborhood was associated with 1.84 fewer daily fruit and vegetable servings among Latinos than African-Americans.

Conclusion—The neighborhood food environment influences fruit and vegetable intake, and the size of this relationship may vary for different racial/ethnic subpopulations.

Keywords

African Americans; Diet; Hispanic Americans; Residence Characteristics; Urban Population

Indexing Key Words

Format: Research; Purpose: Modeling/relationship testing; Design: Non-experimental; Outcome: Behavioral; Setting: Local community; Health focus: Nutrition; Strategy: Built environment; Age: Adults; Population circumstances: Range of education and income levels, 3 geographic communities in Detroit, Michigan, African-Americans, Latinos, and non-Hispanic Whites

INTRODUCTION

Understanding contributions of the retail food environment to fruit and vegetable intake is of growing interest.[1] The neighborhood fruit and vegetable supply, specifically a wide variety of reasonably priced, high-quality fruits and vegetables, may promote fruit and vegetable intake by facilitating their purchase during major shopping trips or in between major shopping excursions as home stocks run low, or by serving as visual cues that prompt their purchase.[2] In contrast, stores that predominately sell energy-dense foods (e.g., convenience stores, corner/liquor stores) may negatively affect fruit and vegetable consumption through disproportionate promotion of unhealthy foods, lower food costs per kilocalorie,[3, 4] shifts in social norms around food, or changes in food preferences.

An increasing number of studies have examined relationships between aspects of the neighborhood food environment and fruit and vegetable intake in adults. One study conducted in four areas of the U.S. found that the presence of a supermarket in the residential census tract was associated with an increased likelihood of meeting dietary guidelines for fruit and vegetable intake in African-Americans.[5] No significant associations were found for the presence of grocery stores, and associations were weaker in Whites. In a study of 1,347 women in 45 neighborhoods in Melbourne, Australia, neighborhood density of supermarkets and fruit and vegetable markets were not associated with fruit or vegetable intake.[6] A study of 102 households in four New Orleans census tracts found a positive association between the amount of shelf space for vegetables within 100 meters of home and vegetable intake, with each additional meter of shelf space associated with a 0.35 daily serving increase in intake.[7] Fresh fruit shelf space was not associated with fruit intake, and having a small food store within 100 meters was not related to fruit or vegetable consumption. Quasi-experimental studies in the United Kingdom have found inconsistent results of the impact of the opening of a supermarket in the neighborhood on fruit and vegetable intake.[8, 9]

Though not specifically focused on the neighborhood retail food environment, other studies have found that the type, proximity, and fruit and vegetable supply (selection, quality) of

stores where people shop are associated with fruit and vegetable intake.[10, 11] A study of low-income U.S. households found that those living within a mile of the primary store at which they shopped, on average, consumed more fruit, but not vegetables, than those living more than five miles from the primary store.[10] Moreover, the same study found that having "easy access" to supermarkets (i.e., buying most of food at a supermarket and either owning a car or having a round-trip travel time of less than 30 minutes to the supermarket at which they shopped) was associated with greater fruit, but not vegetable, intake than those with "little access" to supermarkets (i.e., buying most of food from a store other than a supermarket). A United Kingdom study found that neither distance to the nearest supermarket where respondents shopped, nor the price of 9 fruits and vegetables at supermarkets where they shopped was associated with fruit or vegetable consumption.[12] In a sample of urban African-American women, those who shopped at a supermarket or specialty store (vs. independent grocer) and those who rated that selection and quality of fresh produce at their primary store higher consumed fruits and vegetables more often.[11]

Thus, extant research suggests that the retail food environment may play a role in fruit and vegetable consumption, but has several limitations. First, most studies have relied solely on store type – primarily supermarkets (large chain grocers) -- as a proxy of the fruit and vegetable supply,[5, 10] despite research showing neighborhood differences in the food supply after accounting for store type.[13–16] Second, even among studies that have examined fruit and vegetable supply characteristics, studies have generally focused on one aspect of the fruit and vegetable supply (e.g., prices),[7, 12] and few have examined the effects of fruit and vegetable quality on intake.[11] Further, we identified no study that included both perceived and observed measures of the fruit and vegetable supply. Third, little is known about whether the neighborhood retail food environment differentially impacts fruit and vegetable intake in multiethnic urban populations depending on individual resources and characteristics. For example, the neighborhood food environment may be particularly influential for residents who do not own a car and thus are possibly more reliant on local outlets and foods.

PURPOSE

The purpose of this study was to examine relationships between multiple aspects of the residential neighborhood retail food environment and fruit and vegetable intake in a multiethnic urban population. We tested the following alternative hypotheses:

1. Availability of a large grocery store and specialty store in the neighborhood and closer proximity to a supermarket are positively associated with fruit and vegetable intake.
2. Availability of a convenience store and a greater number of liquor stores are negatively associated with fruit and vegetable intake.
3. Availability of more stores selling fresh produce in the neighborhood is positively associated with fruit and vegetable intake.
4. Greater variety, quality, and affordability (lower prices) of fresh produce in neighborhood stores are positively associated with fruit and vegetable intake.

We also explored whether individual demographic and socioeconomic characteristics moderate associations between the neighborhood retail food environment and fruit and vegetable intake.

METHODS

Design

This study used a cross-sectional analysis based on three data sources. The first data source is a 2002–2003 community survey of urban adults who resided in one of three large geographic communities.[17] The second data source is a 2002 in-person audit of food stores located in the study communities.[16] Food stores located within a mile of participants' residential census blocks were visited once in the fall season by a team of two observers. The third data source is a 2002 mapping of the locations of supermarkets in metropolitan Detroit.[18]

Sample

The community survey sample is a stratified proportional probability sample of 919 African-American, Latino, and non-Hispanic White adults age ≥25 years living in three large geographic communities in Detroit: eastside, southwest, and northwest (response rate 55%).[17] Households were selected to attain approximately equal representation across racial/ethnic groups and by socioeconomic status (SES). Survey respondents provided written informed consent. The survey was conducted by the Healthy Environments Partnership (HEP), a community-based participatory research partnership with academic, health service, and community members, and approved by the University of Michigan Institutional Review Board.

Measures

Fruit and Vegetable Intake—The dependent variable was fruit and vegetable intake, which was measured using an interviewer-administered modified Block 98 semi-quantitative Food Frequency Questionnaire (Berkeley Nutrition Services, Berkeley, California). Daily servings of fruits and vegetables were calculated by multiplying the frequency of reported intake for each item by its portion size. In the analysis, we used the mean daily fruit and vegetable servings (minus fried potatoes and other white potatoes).

Neighborhood Retail Food Environment

Food Store Availability and Proximity: The independent variables included the neighborhood retail food environment and individual sociodemographic characteristics. *Food store availability* was measured as a count of food stores, by type, located in the residential neighborhood, defined as a 0.5-mile Euclidean distance buffer from the centroid of the residential census block. In the analysis, we used dichotomous indicators for large grocery stores (grocery stores with at least three cash registers), small grocery stores (grocery stores with one or two cash registers), convenience stores without gasoline stations (food stores with limited capacity for check-out), and specialty stores (fruit and vegetable or meat/seafood markets).[16] 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 main sign in front of the store) in the neighborhood.

In 2002, only 9 supermarkets (full-service chain grocery stores or supercenters) were located in Detroit,[18] and only one of these supermarkets was located in our study neighborhoods. Thus, we measured *supermarket proximity* 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 (Environmental Systems Research Institute, Redlands, CA).

Fruit and Vegetable Supply: Using an in-person audit of food stores, we assessed four aspects of the neighborhood retail fruit and vegetable supply: availability, variety, quality, and affordability.[16] Fresh produce availability was assessed based on whether or not the store sold any fresh produce. Among stores that sold fresh fruit and vegetables, *variety* was evaluated using a visual count of 80 fruits and vegetables. Regardless of the number of brands (e.g., Red Delicious, Gala), sizes (large, small), forms (e.g., organic, non-organic), or packaging (e.g., sold in bags or individually), each produce type (e.g., apples, oranges, iceberg lettuce, spinach) was counted only once.

Quality and cost were assessed for a subset of 20 fruits and vegetables based on the lowest cost (non-organic) brand and size. For each of the 20 types, we specified beforehand whether the cost and quality assessment should be based on individual items (e.g., apples, grapefruit, oranges) or bags (e.g., carrots, white potatoes). To assess *quality*, for each of the 20 types, we developed a unique quality description of external physical appearance and condition, drawing on information provided by the United States Department of Agriculture.[19–21] Based on the estimated percentage of items at the store that did *not* meet high-quality standards, one of two trained observers evaluated quality of each available produce type on a 4-point scale, ranging from 1 (0–4%) to 4 (50–100%). Inter-rater reliability ranged from 0.82 to 0.92 during the field period. We reverse-coded the quality scores so that higher scores correspond with higher quality and then calculated for each store the mean score for up to 20 types. An observer also assessed prices for the 20 fruits and vegetables. Prices were generally assessed per pound, with the exceptions of cantaloupe, heads of lettuce, and mangos for which price per item was recorded. *Affordability* was calculated as the mean standardized (z-scored) price of up to 20 fruits and vegetables. These scores were also reverse-coded, so that higher scores correspond with lower prices and greater affordability.

In the analysis, fresh produce availability was determined by the number of food stores in the neighborhood that sold fresh produce. Because 23% of the neighborhoods did not have any store selling fruit and vegetables, 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), and no store selling fresh produce. The first level of each variable indicates presence of a store with relatively good fresh produce variety, quality, or affordability.

We also measured survey respondents' perceptions of the neighborhood retail fruit and vegetable supply. On a 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 produce in their neighborhood, defined as a 10–15 minute walk or 5 minute drive from their home. The mean of the three items was used in the analysis, with higher scores indicating greater satisfaction (alpha=0.87).

Individual Sociodemographic Characteristics—Individual sociodemographic variables included: age in years, number of household members, number of years of neighborhood residency, gender (male, female), self-reported race/ethnicity (African-American, Latino, non-Hispanic White, Other), marital status (not currently married, currently married), annual household income (≥$35,000, $20,000–34,999, $10,000–19,999, ≤$10,000), education (at least some college, high school diploma or GED, less than high school), employment status (not employed, currently employed), and car ownership (no car, owns or leases car). Male, African-American, not currently married, annual household income ≥$35,000, at least some college, and no car were the reference categories in the

analysis. Due to the small number of respondents, regression results are not presented for respondents classified as “other” race/ethnicity.

Data Analysis

Two-level weighted hierarchical linear regression models were estimated using full maximum likelihood (HLM 6.04, Scientific Software International, Lincolnwood IL, 2006). Level-1 was the 919 survey participants; Level-2 was the 146 census blocks in which they lived. The number of participants per census block averaged 6.3 and ranged from 1 to 29. Given the clustering of participants in census blocks and relatively high intraclass correlation for daily fruit and vegetable intake (reported in Results), multilevel modeling was employed in order to obtain more robust standard error estimates.[22, 23] All Level-1 independent variables and continuous Level-2 variables were grand-mean centered in the analysis.[23] Multiple imputation (MI) procedures derived from Bayesian models were used to impute missing values for the individual-level data.[24, 25] The imputation was performed using the IMPUTE routine that is available in the SAS add-in IVEware software. Because of the complex sampling design, created to achieve adequate representation of all racial and ethnic groups across SES, sample weights were calculated and applied at each level to adjust for probabilities of selection within strata and to match the sample to Census 2000 population distributions for the study communities (and to adjust for non-response at the individual level).[17]

RESULTS

Table 1 shows weighted summary statistics for the individual- and neighborhood-level variables. Respondents’ fruit and vegetable intake averaged 3.38 daily servings. About half the sample was female; the majority was African-American; approximately a third had more than a high school education; less than one-fourth had an annual household income of more than $35,000; and almost two-thirds were currently employed. The prevalence of the different store types per neighborhood ranged from 25.4% (convenience store) to 36.6% (small grocery store). On average, the neighborhoods had 5.43 liquor stores, and the street-network distance to the nearest supermarket was 3.27 miles.

Table 2 shows the multilevel regression results. Model 1 is a fully unconditional model that indicates significant variation in daily fruit and vegetable servings at the neighborhood level ($p < 0.001$). Based on the intraclass correlation (neighborhood variance divided by the sum of the neighborhood and individual variances), 11.4% of the variance in daily fruit and vegetable servings was between neighborhoods. Model 2 added individual sociodemographic variables. Adjusting for compositional differences between neighborhoods in Model 2, 3.8% of the variance in daily fruit and vegetable servings remained at the neighborhood level ($p=0.013$).

To test hypotheses 1 and 2, Model 3 added neighborhood store availability and proximity (Table 2). Adjusting for individual sociodemographic characteristics, presence of a large grocery store in the neighborhood was associated with an average of 0.69 more daily fruit and vegetable servings ($p=0.002$). The association between distance to the nearest supermarket and daily fruit and vegetable servings was non-significant. Our findings are consistent with the hypothesis that presence of a large grocery store in the immediate neighborhood, but not distance to the nearest supermarket, is associated with fruit and vegetable intake. Our test of the second hypothesis found that presence of other store types in the neighborhood (specialty, convenience, liquor, small grocery) were negatively, but not significantly, associated with fruit and vegetable intake. Based on these findings, we cannot reject the null hypothesis that presence of other store types is not associated with fruit and

vegetable intake. Adjusting for store availability and proximity reduced the neighborhood variance in daily fruit and vegetable servings to marginal statistical significance (p=0.064).

To test hypotheses 3 and 4, Models 4–8 included, one at a time, perceived and observed measures of the neighborhood fruit and vegetable supply, along with the individual-level covariates. Neither satisfaction with the neighborhood fruit and vegetable supply (Model 4; Table 2) nor observed characteristics of the neighborhood fruit and vegetable supply (availability, variety, quality, price; Models 5–8, respectively, Table 3) were significantly associated with fruit and vegetable intake. While coefficients for perceptions of the neighborhood fruit and vegetable supply and having a store in the upper quartile for variety and quality were in the expected direction, based on these findings we cannot reject the null hypotheses that perceived or observed indicators of the neighborhood food environment are not associated with fruit and vegetable intake.

We also tested whether individual sociodemographic characteristics moderated the relationship between the neighborhood food environment and fruit and vegetable intake. We found some evidence for a moderating effect of individual race/ethnicity (Table 4). On average across all neighborhoods, the relationships between the food environment and fruit and vegetable intake were similar for African-Americans and Whites. However, Latinos who had a large grocery store in their neighborhood consumed 2.20 more daily fruit and vegetable servings than African-Americans with a large grocery store in their neighborhood (p=0.010) (Model 1; Table 4). Presence of a convenience store in the neighborhood was associated with 1.84 fewer daily fruit and vegetable servings in Latinos than African-Americans (p=0.016). Neighborhood variance in fruit and vegetable intake was no longer significant after the addition of these cross-level interactions (p=0.216). Furthermore, on average across all neighborhoods, each additional store selling fresh produce was associated with a 0.35 daily serving increase in fruit and vegetable intake in Latinos relative to African-Americans (p=0.053) (Model 2; Table 4). We found no other evidence of effect modification.

To test the sensitivity of the results to a different definition of neighborhood, we examined relationships between fruit and vegetable intake and measures of the neighborhood retail food environment using 1-mile Euclidean distance buffers to define participants' neighborhoods. Results for neighborhood food store availability and the observed fruit and vegetable supply measures were similar. However, though the coefficients were in the same direction, presence of a large grocery store within one mile was not significantly associated with fruit and vegetable consumption.

DISCUSSION

We found that the presence of a large grocery store within 0.5 mile was positively related to fruit and vegetable consumption, and that individual race/ethnicity moderated relationships between neighborhood store availability and fruit and vegetable intake. Neighborhood store availability accounted for the between-neighborhood variation in fruit and vegetable intake.

Our findings suggest that availability of large non-chain grocery stores, particularly at a small spatial scale, may facilitate the purchase and consumption of fruit and vegetable by residents. We found no relationship between supermarket proximity and fruit and vegetable consumption. Prior research, using a wide variety of designs and store definitions, is inconsistent regarding relationships between fruit and vegetable consumption and supermarket proximity.[5, 8–10, 12] Given the sensitivity to distance suggested by our finding that large grocery store availability within 0.5 mile but not one mile influences fruit and vegetable intake, supermarkets may have been located too far away to facilitate fruit and

vegetable intake in our sample, with the nearest supermarket, on average, over 3 miles from respondents' residential census blocks. Studies examining the distribution of different store types across neighborhoods and the effects of store availability on dietary intake have generally classified grocery stores as chain ("supermarkets") or non-chain,[5, 11, 26, 27] with few distinguishing between large and small non-chain grocery stores.[7, 28] As a result, little is known about the potential contributions of large versus small non-chain grocery stores to fruit and vegetable intake or other dietary behaviors. Our findings suggest that this is an important direction for future research. If research evidence amasses showing that large non-chain grocers are nutritional resources, cultivating these store types in underserved urban neighborhoods, not just chain supermarkets, may be an effective community change strategy.

Because large food stores (e.g., supermarkets) generally have greater varieties, lower prices, and possibly higher quality foods for sale than smaller food stores (e.g., convenience stores),[29–31] store type is often used as a proxy for the food supply. Yet, we found no direct associations between the observed or perceived neighborhood fruit and vegetable supply (availability, variety, quality, price) and consumption. One potential explanation is that stocks of canned, frozen, or dried fruits and vegetables, which we did not measure, at large grocery stores may promote higher fruit and vegetable consumption. It is also possible (as suggested below under Limitations) that there was insufficient variation in the neighborhood fruit and vegetable supply to detect effects or that our observed and perceived measures do not capture aspects of the neighborhood fresh fruit and vegetable supply that are influential. Indeed, in the limited number of studies that have directly tested relationships between fruit and vegetable intake and aspects of the fruit and vegetable supply in either the residential neighborhood or stores where people shop, results are inconsistent. Studies are needed to develop reliable and valid measures of the neighborhood fruit and vegetable supply, which are grounded in residents' understandings and experiences, for use in both observational and experimental research on the food environment.

Presence of a large grocery store was associated with a greater increase in average daily fruit and vegetable servings among Latinos compared with African-Americans. Presence of a convenience store was negatively related to fruit and vegetable intake while more stores selling fresh produce was positively related to consumption among Latinos, but not African-Americans. Relationships between the food environment and intake did not differ between African-Americans and Whites. Extant studies of primarily African-American and White samples have been inconsistent regarding whether individual race/ethnicity moderates relationships between store availability or proximity and dietary intake.[5, 32] More specifically, a North Carolina study found no difference in relationships between store proximity and dietary quality by race in a predominately African-American and White sample of pregnant women,[32] whereas another study with a primarily Southern population showed stronger associations between store availability and fruit and vegetable consumption among African-Americans than Whites.[5] Our study differs from these studies in its inclusion of a substantial number of Latinos and focus on a midwestern U.S. urban population.

Several potential explanations may account for the stronger effect of the food environment on Latinos compared with African-Americans. First, because 60% of our Latino sample was first-generation immigrants (born outside the U.S.) and immigrants' dietary quality is generally than that of those who have been in the U.S. for two or more generations or who are more acculturated,[33, 34] exposure to less expensive, energy-dense foods in neighborhood convenience stores may have a stronger negative effect on their fruit and vegetable consumption, whereas large grocers and more stores selling fresh produce may facilitate food choices from their home countries including higher fruit and vegetable intake. Indeed, having inadequate physical access to high-quality fruits and vegetables that were commonly

available in their home countries or that their parents served or prepared has been found to be a barrier to fruit and vegetable consumption among some Latinos.[35] It is possible that the large grocery stores located near our Latino respondents offer these more familiar and sought-after fruits and vegetables. Second, drawing on research suggesting that first-generation urban Mexican immigrants conduct their lives mostly in their residential neighborhood,[36] Latinos in our sample may be more reliant upon and thus their food choices potentially influenced by neighborhood stores than African-Americans who may have larger activity spaces and greater exposure to food sources outside the neighborhood. Third and related, given the pervasive and persistent deficiencies in the retail food environment (e.g., few supermarkets, poor quality produce) of neighborhoods where they live,[13, 16, 18, 26–28, 37] African-Americans may have developed strategies (e.g., ride-sharing) for purchasing foods outside their neighborhoods. Fourth, inadequate family economic resources and unsupportive retail food environments during childhood and thus insufficient opportunities to develop a preference or "taste" for fruits and vegetables may result in African-Americans being less sensitive to the neighborhood food environment compared to Latinos.[38–40] If supported by other studies, research to better understand the nature of the stronger relationships between the neighborhood food environment and fruit and vegetable consumption among urban Latinos might inform approaches to create supportive food environments for Latinos and other racial/ethnic subpopulations.

A major strength of this study is inclusion of multiple aspects of the neighborhood retail food environment, including availability of or proximity to a range of store types as well as perceived and observed measures of the fruit and vegetable supply (availability, variety, quality, price). However, the study has limitations. First, the study is cross-sectional. Therefore, we cannot determine whether the neighborhood food environment affected residents' fruit and vegetable consumption or their fruit and vegetable intake and thus demand shaped the neighborhood food environment. Second, neighborhoods were not sampled to achieve maximum variation in the retail food environment; therefore, there may be insufficient variation to detect environmental effects. Third, this study did not include gas station convenience stores or food service places (e.g., restaurants), and therefore may underestimate the role of the neighborhood food environment in fruit and vegetable intake. Fourth, because store listings in business databases were incomplete, we relied primarily on data collected during in-person observations of stores to classify stores by type. Though our approach increased the comprehensiveness and accuracy of store locations, we were not able to classify stores by type using Standard Industry Classification (SIC) or North American Industrial Classification System (NAICS) codes, as has been done in some prior work. Fifth, our observed and perceived measures of the neighborhood fruit and vegetable supply only included "fresh" options, not frozen, canned, or dried. Sixth, we assessed neighborhood fruit and vegetable supply based on a single observation in a single season, the validity of which for characterizing the fruit and vegetable supply within season or across the year is unknown. Seventh, the relatively small average number of survey respondents per census block may have resulted in underestimated standard errors and thus greater risk of a Type I error (rejecting a null hypothesis when it is true).

In conclusion, rigorous research is needed to guide the development of effective evidence-based interventions and policies to create environments supportive of healthful dietary intakes, including fruits and vegetables.[41] Adding to a growing body of evidence that disparities in the retail food environment may play a role in shaping dietary intakes in the U.S.,[42, 43] we found that the neighborhood food environment may influence fruit and vegetable intake of Latinos to a greater extent than African-Americans and Whites, perhaps due to differences in historical and contemporary circumstances. Our results suggest that increasing the availability of large non-chain grocery stores and fresh produce at stores may be effective strategies to promote fruit and vegetable intake in urban racial/ethnic

subpopulations, particularly Latinos. Because fruits and vegetables must compete with cheaper energy dense foods for consumers' food dollars, taxation policies to alter the price structure of foods by subsidizing the costs of fruits and vegetables and raising prices of energy-dense foods has also been proposed, particularly for low-income consumers.[3] However, further research is needed to examine whether effects of the neighborhood food environment on fruit and vegetable intake and other dietary behaviors depend on individual characteristics and resources. This research, particularly if it actively engages communities according to community-based participatory research principles, may be informative for identifying and instigating necessary changes at multiple levels to improve not only neighborhood food environments, but also individual material, attitudinal, or motivational resources.[44–46].

SO WHAT?

We found that aspects of the neighborhood food environment influence fruit and vegetable intake, and the size of these relationships may vary for different racial/ethnic urban subpopulations. Large non-chain grocery stores and stores selling fresh fruits and vegetables may serve as nutritional resources for multiethnic urban populations, particularly Latinos. More research is needed to understand how these and potentially other aspects of the neighborhood food environment affect fruit and vegetable intake and other dietary behaviors among diverse racial/ethnic urban subpopulations, including Latinos of different generational status and length of U.S. residence. Moreover, studies are needed to develop observational and perceptual measures of the neighborhood fruit and vegetable supply with established reliability and validity. The findings suggest that efforts of practitioners in partnership with community members aimed at attracting and sustaining large grocery stores in urban communities may positively impact fruit and vegetable intake among multiethnic urban populations. Further, working with local store owners to increase the availability of fresh produce may be an effective strategy for promoting fruit and vegetable intake in urban Latino subpopulations.

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Table 1

Weighted summary statistics for the individual- and neighborhood-level variables

	% or Mean	Standard Error
Individual-level variables		
Daily servings of fruit and vegetable (mean)	3.38	(0.11)
Satisfaction with neighborhood fruit and vegetable supply, 1–4 (mean)	2.87	(0.03)
Years of residence in neighborhood (mean)	18.52	(0.67)
Age, years (mean)	46.28	(0.84)
Household size (mean)	2.79	(0.01)
Female, %	52.3	--
Race/Ethnicity, %		
African-American	56.8	--
Latino	22.2	--
White	18.8	--
Other	2.3	--
Education, %		
Less than 12 years	36.9	--
12 years	29.1	--
More than 12 years	34.1	--
Annual household income, %		
<$10,000	27.3	--
$10,000–$19,999	26.0	--
$20,000–$34,999	23.6	--
≥$35,000	23.0	--
Married, %	26.4	
Currently employed, %	64.9	--
Own automobile, %	67.0	--
Neighborhood-level variables		
Large grocery store, %	28.9	--
Specialty store, %	32.2	--
Convenience store, %	25.4	--
Small grocery store, %	36.6	--
Liquor stores (mean)	5.43	(0.28)
Distance to nearest supermarket, miles (mean)	3.27	(0.07)
Number stores with fresh produce (mean)	2.33	(0.19)
Fresh produce variety, %		
No store selling fresh produce	23.0	--
No store in upper quartile for variety	37.1	--
Store in upper quartile for variety	39.9	--
Fresh produce quality, %		
No store selling fresh produce	23.0	--
No store in upper quartile for quality	37.6	--

	% or Mean	Standard Error
Store in upper quartile for quality	39.4	--
Fresh produce affordability, %		
No store selling fresh produce	23.0	--
No store in upper quartile for affordability	32.7	--
Store in upper quartile for affordability	44.3	--

Table 2

Mean daily fruit and vegetable servings regressed on individual variables, neighborhood store availability, and perceived neighborhood fruit and vegetable supply*

	Model 1: Fully unconditional			Model 2: Individual co-variates			Model 3: Food store availability			Model 4: Perceived fruit and vegetable supply		
	Estimate	SE	p-value	Estimate	SE	p-value	Estimate	SE	p-value	Estimate	SE	p-value
Intercept	3.362	0.144	<0.001	3.333	0.103	<0.001	3.269	0.178	<0.001	3.333	0.103	<0.001
Age, years				<0.001	0.007	0.960	0.001	0.007	0.857	<0.001	0.007	0.972
Household size, # members				0.021	0.087	0.812	0.020	0.087	0.821	0.019	0.087	0.827
Years of residence in neighborhood				−0.012	0.008	0.137	−0.014	0.008	0.097	−0.012	0.008	0.134
Female (Ref: Male)				−0.237	0.251	0.345	−0.225	0.254	0.375	−0.230	0.254	0.365
Currently married (Ref: Not married)				0.681	0.296	0.021	0.693	0.294	0.019	0.674	0.288	0.020
Race/ethnicity (Ref: African-American)												
Latino				1.707	0.360	<0.001	1.730	0.381	<0.001	1.678	0.357	<0.001
White				−0.361	0.217	0.096	−0.300	0.206	0.145	−0.371	0.218	0.089
Education (Ref: At least some college)												
Less than high school				0.102	0.316	0.748	0.159	0.313	0.611	0.075	0.310	0.810
High school diploma or GED				−0.434	0.310	0.162	−0.455	0.298	0.127	−0.453	0.299	0.130
Annual income (Ref: ≥$35,000)												
<$10,000				0.123	0.322	0.696	0.146	0.316	0.644	0.133	0.320	0.677
$10,000–$19,999				0.385	0.456	0.399	0.378	0.446	0.397	0.383	0.464	0.409
$20,000–$34,999				−0.168	0.283	0.552	−0.132	0.285	0.644	−0.168	0.284	0.553
Currently employed (Ref: Not employed)				0.297	0.309	0.338	0.281	0.314	0.372	0.292	0.312	0.349
Owns car (Ref: Does not own car)				−0.143	0.261	0.584	−0.157	0.258	0.542	−0.140	0.260	0.591
Large grocery store							0.691	0.210	0.002			
Specialty store							−0.030	0.230	0.896			
Convenience store							−0.110	0.238	0.643			
Liquor stores, #							−0.041	0.046	0.376			
Small grocery store							−0.289	0.193	0.136			
Distance to nearest supermarket, miles							0.056	0.120	0.638			

	Model 1: Fully unconditional			Model 2: Individual co-variates			Model 3: Food store availability			Model 4: Perceived fruit and vegetable supply		
	Estimate	**SE**	**p-value**	**Estimate**	**SE**	**p-value**	**Estimate**	**SE**	**p-value**	**Estimate**	**SE**	**p-value**
Satisfaction neighborhood fruit and vegetable supply										0.099	0.150	0.500
Neighborhood variance	0.930		<0.001	0.271		0.013	0.058		0.065	0.266		0.014
Individual variance	7.210			6.791			6.875			6.789		

* All individual-level independent variables, distance to the nearest supermarket, and number of liquor stores were grand-mean centered.

Table 3

Mean daily fruit and vegetable servings regressed on individual variables and observed neighborhood fruit and vegetable supply*

	Model 5: Observed fruit and vegetable availability			Model 6: Observed fruit and vegetable variety			Model 7: Observed fruit and vegetable quality			Model 8: Observed fruit and vegetable affordability		
	Estimate	**SE**	**p-value**	**Estimate**	**SE**	**p-value**	**Estimate**	**SE**	**p-value**	**Estimate**	**SE**	**p-value**
Intercept	3.333	0.104	<0.001	3.136	0.125	<0.001	3.222	0.125	<0.001	3.583	0.143	<0.001
Age, years	<0.001	0.007	0.960	<0.001	0.007	0.898	0.001	0.007	0.920	<0.001	0.007	0.993
Household size, # members	0.021	0.087	0.812	0.022	0.087	0.800	0.022	0.087	0.801	0.025	0.087	0.773
Years of residence in neighborhood	−0.012	0.008	0.136	−0.012	0.008	0.126	−0.012	0.008	0.142	−0.011	0.008	0.186
Female (Ref: Male)	−0.237	0.251	0.345	−0.229	0.250	0.360	−0.241	0.250	0.335	−0.236	0.299	0.347
Currently married (Ref: Not married)	0.683	0.296	0.021	0.674	0.296	0.023	0.666	0.299	0.026	0.677	0.250	0.023
Race/ethnicity (Ref: African-American)												
Latino	1.708	0.400	<0.001	1.563	0.367	<0.001	1.629	0.364	<0.001	1.754	0.349	<0.001
White	−0.361	0.225	0.109	−0.433	0.215	0.044	−0.410	0.213	0.054	−0.329	0.212	0.122
Education (Ref: At least some college)												
Less than high school	0.102	0.315	0.747	0.109	0.314	0.728	0.103	0.317	0.744	0.128	0.317	0.685
High school diploma or GED	−0.434	0.309	0.161	−0.444	0.304	0.145	−0.435	0.306	0.155	−0.403	0.303	0.184
Annual income (Ref: ≥$35,000)												
<$10,000	0.126	0.322	0.696	0.154	0.321	0.630	0.114	0.320	0.722	0.098	0.322	0.761
$10,000–$19,999	0.385	0.456	0.398	0.390	0.453	0.390	0.362	0.448	0.419	0.375	0.451	0.405
$20,000–$34,999	−0.168	0.286	0.556	−0.154	0.288	0.591	−0.184	0.289	0.525	−0.156	0.290	0.590
Currently employed (Ref: Not employed)	0.297	0.310	0.340	0.309	0.311	0.321	0.303	0.310	0.330	0.263	0.309	0.395
Owns car (Ref: Does not own car)	−0.143	0.262	0.586	−0.140	0.264	0.587	−0.143	0.264	0.587	−0.139	0.263	0.596
Fresh produce availability, # stores	<−0.001	0.070	0.998									
Fresh produce variety (Ref: No store in upper quartile)												
No store with produce				0.137	0.339	0.686						
Store present in upper quartile				0.383	0.212	0.072						
Fresh produce quality (Ref: No store in upper quartile)												
No store with produce							−0.053	0.345	0.878			
Store present in upper quartile							0.237	0.218	0.280			

	Model 5: Observed fruit and vegetable availability			Model 6: Observed fruit and vegetable variety			Model 7: Observed fruit and vegetable quality			Model 8: Observed fruit and vegetable affordability		
	Estimate	**SE**	**p-value**	**Estimate**	**SE**	**p-value**	**Estimate**	**SE**	**p-value**	**Estimate**	**SE**	**p-value**
Fresh produce affordability (Ref: No store in upper quartile)												
No store with produce										−0.287	0.344	0.406
Store present in upper quartile										−0.416	0.213	0.052
Neighborhood variance	0.271		0.011	0.248		0.014	0.265		0.011	0.180		0.026
Individual variance	6.791			6.788			6.787			6.837		

*All individual-level independent variables and fresh produce availability were grand-mean centered.

Table 4

Cross-level interactions between individual race/ethnicity and neighborhood retail food environment on daily servings of fruit and vegetables*

	Model 1: Food store availability			Model 2: Observed fruit and vegetable availability		
	Estimate	**SE**	**p-value**	**Estimate**	**SE**	**p-value**
Intercept	3.151	0.204	<0.001	3.171	0.114	<0.001
Race/ethnicity (Ref: African-American)						
Latino	0.817	0.839	0.331	1.418	0.500	0.005
White	−0.324	0.353	0.359	−0.247	0.226	0.274
Large grocery store	0.740	0.230	0.002			
Specialty store	0.061	0.295	0.838			
Convenience store	−0.268	0.234	0.253			
Liquor stores, #	−0.080	0.051	0.121			
Small grocery store	−0.471	0.207	0.025			
Distance to nearest supermarket, miles	0.054	0.170	0.753			
Fresh produce availability, # stores				−0.055	0.064	0.392
Latino * large grocery store	2.196	0.852	0.010			
Latino * specialty store	1.218	0.957	0.204			
Latino * convenience store	−1.836	0.757	0.016			
Latino * liquor stores	−0.063	0.156	0.686			
Latino * small grocery store	−0.409	0.712	0.565			
Latino * distance to nearest supermarket	0.633	0.739	0.392			
White * large grocery store	0.380	0.527	0.472			
White * specialty store	−0.500	0.655	0.445			
White * convenience store	−0.083	0.420	0.844			
White * liquor stores	−0.008	0.122	0.947			
White * small grocery store	0.585	0.484	0.228			
White * distance to nearest supermarket	0.546	0.309	0.078			

	Model 1: Food store availability			Model 2: Observed fruit and vegetable availability		
	Estimate	**SE**	**p-value**	**Estimate**	**SE**	**p-value**
Latino * fresh produce availability				0.351	0.181	0.053
White * fresh produce availability				0.159	0.119	0.182
Neighborhood variance	0.021		0.217	0.289		0.010
Individual variance	6.704			6.720		

* Covariates include age, household size, years of neighborhood residence, gender, marital status, education, annual household income, employment status, and car ownership.