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Perceived and Geographic Food Access and Food Security Status among Households with Children

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Abstract

Objective—To examine the association of both perceived and geographic neighborhood food access with food security status among households with children.

Design—This was a cross-sectional study in which participants' perceptions of neighborhood food access were assessed by a standard survey instrument, and geographic food access was evaluated by distance to the nearest supermarket. Multinomial logistic regression models were used to examine the associations.

Subjects—The Midlands Family Study included 544 households with children in eight counties in South Carolina. Food security status among participants was classified into three categories: food secure (FS), food insecure (FI) and very low food security among children (VLFS-C).

Results—Compared to FS households, VLFS-C households had lower odds of reporting easy access to adequate food shopping. VLFS-C households also had lower odds of reporting neighborhood access to affordable fruits and vegetables compared to FS households and reported worse selection of fruits and vegetables, quality of fruits and vegetables and selection of low-fat products. FI households had lower odds of reporting fewer opportunities to purchase fast food. None of the geographic access measures was significantly associated with food security status.

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ETHICAL STANDARDS DISCLOSURE

The study was reviewed and approved by the University of South Carolina Institutional Review Board.

Conclusions—Caregivers with children that experienced hunger perceived that they had less access to healthy affordably food in their community, even though grocery stores were present. Approaches to improve perceived access to healthy affordable food should be considered as part of the overall approach to improving food security and eliminating child hunger.

Keywords

food security; food access; hunger; child; secure; SNAP

INTRODUCTION

In 2013, approximately 9.9% (3.8 million) of households with children experienced food insecurity in both adults and children in the United States (US) [(1)]. Food insecurity is defined as limited access to adequate food due to lack of money and other resources[(1)]. The most severe form of food insecurity in children, very low food security in children (VLFS-C, which entails caregivers reporting that “children were hungry, skipped a meal, or did not eat for a whole day because there was not enough money for food.” was experienced by children in 0.9% of US households with children in 2013[(1)].

Previous research has shown that few children in food-insecure (FI) (especially VLFS-C) households meet the recommendations for dietary intake, including nutrients such as calcium, dietary fiber, sodium, etc.[(2–5)]. Given that the food environment has been shown to be associated with dietary intake[(6–13)], it is possible that the neighborhood food environment may exacerbate poor dietary intake associated with FI among households with children by 1) providing insufficient availability and accessibility of low-energy nutritious foods and excess availability and accessibility of energy-dense foods[(6, 7, 14)]; 2) pricing nutritious foods higher[(15–17)]; and 3) demanding an extra transportation burden for low-income populations[(18, 19)].

A neighborhood food environment can be characterized by different measures and instruments, including geographic information system (GIS)-based measurements and self-reported individual perceptions of the food environment. GIS has been used to characterize the food environment by relying on geographic data about the presence of retail food outlets and residents, and GIS measures include population number and density in an area and the distance to the nearest food outlet, among other factors[(20)]. Few studies have examined the association between GIS-based food environment measures and food security status, and the findings that do exist have been inconsistent[(21–25)]. Kirkpatrick and her colleagues found that food security status was not associated with proximity to food retail or community food programs in Canadian families [(21)]. Another Canadian study found that FI respondents lived significantly closer to nutritious food sources and grocery stores than FS respondents[(22)]. Carter and her colleagues reported a null relationship between food security status and residence location of children in the study[(23)]. Two studies have claimed that easy access to less healthful foods (i.e., fast foods) in the household is associated with FI among children[(24, 25)].

When policies attempting to improve access to healthy foods have focused on improving proximity to the geographic locations of healthy food stores, the importance of considering

self-reported perceptions of food access has been emphasized[26], because individual perceptions capture different dimensions of access than GIS-based features of the food environment[7, 27, 28]. However, few studies have focused on caregivers' perceptions of the food environment and household food security status, especially in households with children. Sharkey and his colleagues investigated parents' perceived neighborhood food environments in Mexican-origin households in Texas border *colonias* with VLFS-C compared to households without child hunger and found that VLFS-C households reported little variety of foods, few grocery stores and high food prices in their neighborhood[29]. Based on three waves of the Southeastern Pennsylvania Household Health Survey, Mayer et al. found that self-reported easy access to fruits and vegetables and availability of good-quality foods in neighborhoods were associated with lower odds of being food insecure[30]. However, none of the previous research utilized comprehensive standard questionnaires on perceived food access and adequately adjusted for confounders.

In this study, we examined the association between perceived and GIS-based food access and food security status in a sample of rural and urban predominantly African-American households with children in South Carolina in the United States with extensive information on attributes that may confound relationships between access and food security.

METHODS

Study population

The study sample was derived from the Midlands Family Study of the household and community conditions associated with very low food security in children. The families in this study were recruited from a contiguous eight-county region in South Carolina, including one metropolitan county and seven surrounding rural counties. To recruit participants, a sampling framework of traditional food sources (e.g., grocery stores, farmers markets and daycare providers) and emergency food sources (e.g., food pantries) was constructed, resulting in a list of 1,646 potential recruitment sites generated through online searches or by contacting the appropriate agency (e.g., obtaining lists of summer feeding sites from the administering agency). The sites were stratified by urban (n=776) and non-urban (n=870) location. Then 40 urban and 40 non-urban sites were randomly sampled from the list. The sites were replaced as necessary if the site refused to participate, was unreachable or yielded no participants. In total, 249 urban sites and 178 non-urban sites were included.

At each sampled site, the clients or customers were invited to participate in a screening survey. The screened participants were invited to complete the household caregiver survey if they 1) had a child under 18 living in the household at least 50% of the time, 2) resided in one of the eight study counties, 3) had a total annual household income below $100,000 and 4) fell into one of the three food security status categories, food secure (FS), FI or VLFS-C. The income threshold was chosen because it is close to the value corresponding to 300% of the poverty line for a family with four children ($97,710). This value (300% of the poverty line) is currently being advocated as a new cutoff for participation in food assistance programs, as studies have shown that families may be food insecure at this level and may struggle because they do not qualify for food assistance programs under current guidelines[31]. From among 1,039 eligible participants, 236 were not invited to participate in

the caregiver survey because we had filled their food security group, and 259 declined to participate in the survey, leaving 544 caregivers who completed the survey (52.4%). The details of recruitment procedure can be found elsewhere[32]. Among these caregivers, 158 were from FS households, 207 were from FI households, and 179 were from VLFS-C households. The analysis in the present study included 423 households (128 FS, 158 FI and 137 VLFS-C) with complete data on all variables of interest.

The data were collected from April 2011 through May 2013. Written informed consent was obtained before survey administration. Additional details about the Midlands Family Study and recruitment procedures can be found elsewhere[33, 34]. The study protocol was approved by the University of South Carolina Institutional Review Board for the Protection of Human Subjects.

Measures

The classification of food security status was based on the Household Food Security Survey Module (HFSSM) [35–37]. The HFSSM portion of the screener inquired about 18 household food insecurity experiences (including 8 child-specific items) related to anxiety about food shortages, reduced quality of foods available and reduced quantity of foods available. Households were classified as FS if they affirmed two or fewer items on the HFSSM, FI if they affirmed three or more items but not five or more child-specific items, or VLFS-C if they affirmed five or more of the eight child-specific items. The coding of food security categories was consistent with the main paper of the study (manuscript under review).

We included both perceived and GIS-based food environment measures in this study. Five questions on perceptions of the food environment previously developed for the Multi-Ethnic Study of Atherosclerosis (MESA) Neighborhood Study[38], in addition to one perception question of food affordability, “are the fresh fruits and vegetables in your community or neighborhood affordable?,” were used to evaluate perceived food environment. Thus, six questions and assessment statements on perceptions of the food environment were used in this study, including (a) how much of a problem would you say that lack of access to adequate food shopping is in your neighborhood?; (b) a large selection of fresh fruits and vegetables is available in my neighborhood; (c) the fresh fruits and vegetables in my neighborhood are of high quality; (d) are the fresh fruits and vegetables in your community or neighborhood affordable?; (e) a large selection of low-fat products is available in my neighborhood; and (f) there are many opportunities to purchase fast foods in my neighborhood such as McDonald’s, Taco Bell, KFC and takeout pizza places, etc. As in other food environment research, the neighborhood was defined as an area within a 20-minute walk or 1 mile (1.6 km) from home[27, 38]. The responses to above questions in the questionnaire were on a Likert scale ranging from 1 (strongly agree) to 6 (strongly disagree) except for question (a), for which the responses ranged from 1 (very serious problem) to 4 (not really a problem). To align the interpretation of responses so that a higher score indicated better food access, the responses were reverse coded for questions (b), (c), (d) and (e) (i.e., responses to opportunities to purchase fast food (f) and to the overall access question (a) were left as is). The validity and reliability of the MESA questions has been assessed in previous studies showing that the questions are valid and have good internal and

test-retest reliability[27, 39]; however, we used a 6-point response for questions (b), (c), (e) and (f) rather than the 5-point scale from the original MESA questionnaire. The validity and reliability of the revised questionnaire has not been evaluated.

For geographic measures, distance from a participant's home to the nearest supermarket (including grocery stores) was calculated based on the list of supermarkets in the South Carolina Department of Health and Environmental Control food retail licensing database from 2012–2013. According to our previous validation, this dataset is one of the best secondary food outlet datasets in this eight-county area, with a sensitivity (the fraction of open food outlets that were listed and found to be open during the field census) of 68% and a positive predictive value (the fraction of all listed food outlets that were "located and open" during the field census) of 89%[40].

The covariates included race (White, African-American or other), urbanicity (urban or non-urban), number of children in the household (1, 2, 3 or more), number of adults in the household (1, 2, 3 or more), homeless in past year (yes or no), monthly mortgage/rent expense ($), monthly transportation expense ($), monthly utilities expense ($), healthcare expense over $2,000 in the past year (yes or no), monthly household wages ($), monthly Supplemental Nutrition Assistance Program (SNAP) allotment ($), other monthly assistance ($), Confusion, Hubbub, and Order Scale (CHAOS, a scale designed to assess the level of confusion and disorganization in the home environment) (ranging from 0 to 14), perceived social support (ranging from 3 to 21), negative life events (ranging from 0 to 57), perceived stress (ranging from 0 to 30) and intrinsic religiosity (ranging from 2 to 15). The monetary variables were transformed to be in increments of $100. The variables with outliers and skewed distributions were Winsorized at the 95th percentile to reduce the influence of outliers (e.g., monthly household wages and other monthly assistance) and centered for the analysis.

Statistical analysis

The network distance (along the road) to the nearest supermarket was calculated in ArcGIS (ESRI, Version 10.0). Street centerlines from Streetmap Premium (ESRI, 2011) based on commercial street centerline data from NAVTEQ and TomTom were used within the Network Analyst extension of ArcGIS. US Census 2010 boundaries were used in this study. The distance was log transformed because of the skewness of the distribution. Multinomial logistic regression models were used to examine the associations between perception measures and GIS distance variables, with food security status as the outcome variable, while controlling for the covariates described above. The food-secure group was considered as the reference group in the models. Considering the potential clustering errors of households in tracts, i.e., households in the same census tract might be correlated in some unknown way (423 households in 115 tracts), and to prevent the standard errors from being too small, clustering in census tracts was adjusted in the models using robust standard errors. The statistical analyses were performed in Stata (College Station, TX, Version 11) using an alpha level of 0.05 for statistical significance.

RESULTS

Characteristics of the study households are summarized by food security status in Table 1. Monthly wages, monthly mortgage/rent expenses, percent of households with healthcare expenses over $2,000 in past year, quality of home environment and social support were lower as food insecurity worsened across the three food security categories, and negative life events and perceived stress levels were higher as food insecurity levels became more severe. Compared with FS households, FI households were less likely to live in an urban area and tended to have higher response scores on the intrinsic religiosity scale, and VLFS-C households were more likely to be African American, live in an urban area, have less monthly transportation expense and have been homeless in the past year.

Table 2 summarizes the perceived and GIS-based food environment measures by food security status. Compared to FS households, FI households reported poorer quality of fruits and vegetables in the neighborhood and reported that food access is a more severe problem in the neighborhood. Similarly, compared to FS households, VLFS-C households reported lower scores on all other food environment perception items except for opportunities to purchase fast food, indicating that VLFS-C households perceived a much worse neighborhood food environment than food-secure households. On average, the GIS-based distance to the nearest supermarket was shorter for VLFS-C households than for FS households.

The results from multinomial logistic regression models adjusting for the key covariates are shown in Table 3. Compared to FS households, VLFS-C households had lower odds of reporting easy access to healthful and adequate food shopping (OR=0.56, 95% CI: 0.41, 0.75). VLFS-C households had a 39% reduction in the odds of perceiving access to affordable food compared to FS households (OR=0.61, 95% CI: 0.50, 0.74). Likewise, compared to FS households, VLFS-C households had lower odds of reporting fruit and vegetable availability (OR=0.75, 95% CI: 0.61, 0.92), fruit and vegetable quality (OR=0.72, 95% CI: 0.59, 0.87) and availability of low-fat products in their neighborhoods (OR=0.72, 95% CI: 0.58, 0.90). FI households had lower odds of reporting fewer opportunities to purchase fast food (OR=0.81, 95% CI: 0.68, 0.97). No significant differences were found between FI and FS households for other perception items. The network distance to the nearest supermarket was not associated with food security status among children.

DISCUSSION

In the present study, we evaluated the associations between varying food security status and perceptions about the nutritional quality of the neighborhood food environment among households with children. We found that FI households reported more opportunities to purchase fast food than FS households, and VLFS-C households reported substantially poorer perceptions of neighborhood availability, quality and affordability of fruits and vegetables and availability of low-fat products but not opportunities to purchase fast food. We did not find statistically significant differences in GIS-based measures of access to grocery stores and supermarkets by household food security status.

This is one of the first attempts to employ a standard instrument to evaluate perceptions of food environment, especially on the availability, quality and affordability of nutritious foods among households in different food security groups, and examine associations with food security status. Perception is a key element of access[26], and this study confirmed that perceptions about food access are an important factor associated with food security status among households with children. Sharkey and his colleagues[29] evaluated several perception questions on food environment, including the variety of foods available, the availability of grocery stores and the prices of the foods, in their study among Mexican-origin families in Texas border *colonias*. They found that VLFS-C families reported little variety, few grocery stores and high food prices compared to families without child hunger. However, these differences were not tested with adjustment for covariates in the models[29]. Mayer et al. evaluated perceived food access and quality through two simple questions and found that respondents reporting easy access to fruits and vegetables and good quality of neighborhood grocery stores were less likely to report food insecurity[30]. These results are consistent with those in our study. However, Mayer et al. only focused on two simple questions and did not adjust for neighborhood-level factors during the multivariate analysis. In the present study, we additionally adjusted our multivariate analyses of perceived food environment attributes for GIS-based geographic access to supermarkets and grocery stores (distance to the nearest supermarket/grocery store), and the significant results remained. In the present study, VLFS-C households (equivalent to the child hunger group in the study by Sharkey et al.[29]) were less likely than food-secure households to report that fruits and vegetables were affordable. Previous evidence has indicated that higher overall food prices are associated with increased risk of food insecurity and very low food security among American low-income households with children[17]. According to our study, VLFS-C and FI households earn significantly less monthly wages than FS households. FI families identify price as the most salient factor influencing their food-purchasing decisions[41]. However, after adjusting for monthly wages, monthly expenses and monthly assistance, the differences in perceptions of food access between VLFS-C and food-secure households remained significant in our study. In the study by Zenk and her colleagues[42], the authors posited that income may be associated with fruit and vegetable intake in an indirect way through perceptions of available selection and affordability of fruits and vegetables[42]. VLFS-C and FI households have lower income on average than FS households, and they thus might have poorer ratings on perceptions of neighborhood food access, which in turn results in decreased intake of healthful foods.

In this study, our initial, GIS-based mapped data suggested that retail outlets for fruits and vegetables may be relatively closer to VLFS-C households, but the difference disappeared after adjustment for covariates. In the study based on Canadian, UK and Australian households, researchers also reported that FI families lived closer to nutritious food sources and grocery stores[22, 43, 44]. In addition, in our study, the geographic measure of distance to the nearest supermarket was not associated with food security status, nor were other distance-based access measures such as the USDA food desert definition or CDC healthier retail tracts. Thus, our results are consistent with previous findings by Kirkpatrick et al. who reported that food security was not associated with proximity to food retail[21].

The inconsistency of significance between perception and GIS-based measures of the food environment in this study could be explained by different dimensions of the environment being characterized by the instruments[7, 27, 28, 45]. Previous studies have indicated that individual perceptions are quite distinct from GIS-based features of the food environment[7, 27, 28]. Subjective reports may provide information about the foods that are actually available and are of interest to residents, characteristics that are not captured by GIS data on the locations of facilities[46], and perception measures cannot be substituted for GIS-based measures or vice versa[45]. Subjective concepts of food access perceptions—evaluated by subjective and behavioral questions—might be more important than GIS measures in determining food security[47]. According to previous findings from our group, residents quite accurately reported the presence (or absence) of certain food outlets and the types of these food outlets in their neighborhood, suggesting that residents are well aware of their built neighborhood landscape (i.e., perceptions seemed to be congruent with reality). In addition, subjective reports (i.e., perceived lack of food shopping access, availability, quality and affordability of fruits and vegetables and availability of low-fat products in the neighborhood) may provide more information on the foods actually available and of interest to residents, characteristics that are not captured by geographic data[45]. Thus, perception measures are more likely to reflect a person's reality, and that subjective reality is likely to affect behaviors such as food shopping. It is also possible that the responses to the perception questions in our studies were a reflection not only of the environment but also of the respondent's social position. Researchers have shown that an individual's perception can vary by sociodemographic factors such as age, race, gender, class and others [45, 48, 49]. Another explanation might be social exclusion, which makes respondents feel that they have poor access because of their low purchasing power but in reality do live near supermarkets [43, 50]. For instance, studies from UK and Australia found relatively more large supermarkets in deprived than affluent areas and living in a disadvantaged area did not mean fewer opportunities to purchase fresh fruit and vegetables, and social exclusion might be a debate for this phenomenon [43, 44].

The findings should be interpreted with caution in light of several limitations. First, the cross-sectional design precludes inference of a temporal causal relationship between food access measures and food security status, especially for perception measures and food security status. Second, we did not have information on food shopping behaviors of the households (e.g., whether they shopped at the nearest grocery store, the kinds of foods they prefer to buy, etc.) or the food prices or food available in the stores. Third, we included distance to the nearest supermarket as the only geographic access measure. Although this was one of the best access measures on accessibility in the neighborhood food environment, it might not cover all access characteristics and did not allow for evaluation of access to other types of food outlets. Fourth, the responses on both perceived food access and food security status were from parents rather than children in the households in this study. Previous studies showed that parents and children may not report food security status equivalently and children self-report food security status may be more common than their parents' reports [51]. In addition, among FI households, children may be successfully shielded by adults from food shortage [52]. All these may bias the associations between food access and food security status among households with children in this study. However, we

used child-specific items from the HFSSM questionnaire to define the VLFS-C category (five or more items were affirmed of eight child-specific questions) in this study. All these questions were designed for households with children, so we believe they caught somewhat the status of the children. Last, although we included several important covariates in the models, we cannot exclude the possibility of residual confounding. Despite these limitations, this study is one of the first to examine the association between several dimensions of perceived food access (i.e., availability, quality and affordability of nutritious foods) in the neighborhood and food security status among households with children. Moreover, we had residential addresses and used a high-quality food environment database as the basis for our GIS measures.

VLFS-C households reported lower ratings on perceptions of access to healthful and affordable foods than FS households. Perceived food access was clearly a problem among VLFS-C households in our study population, but there were no differences in spatial access to supermarkets and grocery stores across food security levels. Further research is needed to understand what determines a person's perception of his/her neighborhood food environment and how this perception is related to food shopping behaviors and local food prices, as well as food security status. Future policies on improving geographic neighborhood food access and targeting food security should incorporate local residents' perceptions of their neighborhood food access, especially households with food insecurity.

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Table 1

Characteristics of study households by food security status (N=423)

Characteristics	Percentage (%) or mean (SD)		
	Food security N=128	Food insecurity N=158	VLFS-C N=137
African American, %	68.8	77.2	**89.1**
Living in an urban area, %	58.6	**46.8**	**70.1**
Number of children in the household, %			
1	34.4	40.5	30.7
2	35.9	38.0	33.6
3 or more	29.7	21.5	35.8
Number of adults in the household, %			
1	38.3	46.2	49.6
2	48.4	36.1	39.4
3 or more	13.3	17.7	11.0
Monthly wages, $	2,226.0 (2,556.8)	**1,201 (1,390.4)**	**786.2 (903.2)**
Monthly SNAP, $	263.1 (278.2)	265.3 (226.1)	281.2 (249.8)
Monthly other assistance, $	426.7 (742.8)	500.3 (1052.3)	437.2 (574.2)
Monthly mortgage/rent expense, $	472.2 (370.8)	**367.6 (292.5)**	**368.4 (277.9)**
Monthly transportation expense, $	121.0 (203.6)	112.9 (179.0)	**50.7 (119.4)**
Monthly utilities expense, $	362.4 (213.8)	351.3 (232.6)	322.7 (254.9)
Healthcare expense over $2,000 in past year, %	33.6	**21.5**	**19.7**
Confusion, Hubbub, and Order Scale (CHAOS)[a]	3.1 (2.8)	**4.2 (2.9)**	**5.5 (3.7)**
Perceived social support[b]	17.4 (3.3)	**15.9 (3.5)**	**14.1 (4.2)**
Negative life events[c]	8.9 (7.8)	**13.9 (9.6)**	**18.7 (11.0)**
Perceived stress[d]	10.8 (5.6)	**14.3 (5.9)**	**16.1 (5.8)**
Intrinsic religiosity[e]	12.5 (3.1)	**13.5 (1.9)**	12.9 (2.8)
Homeless in the past year, %	21.1	27.9	**44.5**

Bold The difference by food security group is significant based on t-test for continuous variables and chi square test for categorical variables ($p<.05$).

[a]: Ranges from 0 to 14, the larger the score, the more chaotic the home environment.

[b]: Ranges from 3 to 21, the larger the score, the better the social support.

[c]: Ranges from 0 to 57, the higher the score, the more negative life events.

[d]: Ranges from 0 to 30, the larger the score, the more severe the perceived stress.

[e]: Ranges from 3 to 15, the larger the score, the more frequent religious activity.

SD, standard deviation; VLFS-C, very low food security among children; SNAP, Supplemental Nutrition Assistance Program.

Table 2

Descriptive statistics on neighborhood food access measures by food security status (N=423)

Neighborhood food access measures	Mean (SD) or percentage (%)		
	Food security N=128	**Food insecurity N=158**	**VLFS-C N=137**
Perceptions of neighborhood food access[#]			
Food access is a problem[†]	3.3 (1.0)	**3.0 (1.0)**	**2.5 (1.1)**
Availability of fruits and vegetables[*]	4.3 (1.8)	3.9 (1.8)	**3.4 (1.9)**
Quality of fruits and vegetables[*]	4.2 (1.7)	**3.8 (1.6)**	**3.3 (1.7)**
Fruits and vegetables are affordable[*]	4.3 (1.5)	3.9 (1.6)	**3.2 (1.6)**
Availability of low-fat products[*]	4.2 (1.7)	3.8 (1.7)	**3.3 (1.8)**
Opportunities to purchase fast food[‡]	2.7 (1.9)	2.4 (1.6)	2.5 (1.7)
Geographic access to supermarkets			
Distance to nearest supermarket, miles	1.9 (1.9)	2.1 (2.1)	**1.6 (1.6)**

Bold The difference by food security group is significant based on t-test for continuous variables and chi square test for categorical variables ($p<.05$).

[#]: We coded the responses to all the perception questions in this way: larger value indicates better food access/neighborhood food environment.

[†]: Larger value indicates less of a food access problem (Scale: 1-very serious problem, 2-somewhat serious problem, 3-minor problem, 4-not really a problem).

[*]: Larger value indicates better availability/quality/affordability (Scale: 1-strongly disagree, 2-disagree, 3-somewhat disagree, 4-somewhat agree, 5-agree, 6-strongly agree).

[‡]: Larger value indicates less opportunities to purchase fast food (Scale: 1-strongly agree, 2-agree, 3-somewhat agree, 4-somewhat disagree, 5-disagree, 6-strongly disagree).

SD, standard deviation; VLFS, very low food security.

Table 3

The associations between neighborhood food access measures and food security status (N=423)

Neighborhood food access measures	FI vs FS		VLFS-C vs FS	
	Adjusted OR (95% CI)$^{\Delta}$	p-value	Adjusted OR (95% CI)$^{\Delta}$	p-value
Perceptions of neighborhood food access$^{\#}$				
Food access is a problem†	0.82 (0.63, 1.07)	0.145	0.56 (0.41, 0.75)	0.000
Availability of fruits and vegetables*	0.91 (0.77, 1.09)	0.317	0.75 (0.61, 0.92)	0.006
Quality of fruits and vegetables*	0.88 (0.74, 1.04)	0.157	0.72 (0.59, 0.87)	0.001
Fruits and vegetables are affordable*	0.86 (0.71, 1.02)	0.094	0.61 (0.50, 0.74)	0.000
Availability of low fat products*	0.92 (0.77, 1.11)	0.404	0.72 (0.58, 0.90)	0.004
Opportunities to purchase fast food‡	0.81 (0.68, 0.97)	0.023	0.94 (0.77, 1.14)	0.508
Geographic access to supermarkets				
Distance to nearest supermarket, log$^{\Phi}$	0.98 (0.72, 1.32)	0.869	0.96 (0.65, 1.41)	0.837

$^{\#}$: We coded the responses to all the perception questions in this way: larger value indicates better food access/neighborhood food environment.

†: Larger value indicates less of a food access problem (Scale: 1-very serious problem, 2-somewhat serious problem, 3-minor problem, 4-not really a problem).

*: Larger value indicates better availability/quality/affordability (Scale: 1-strongly disagree, 2-disagree, 3-somewhat disagree, 4-somewhat agree, 5-agree, 6-strongly agree).

‡: Larger value indicates less opportunities to purchase fast food (Scale: 1-strongly agree, 2-agree, 3-somewhat agree, 4-somewhat disagree, 5-disagree, 6-strongly disagree).

$^{\Phi}$: The variable was log transformed.

$^{\Delta}$The multinomial logistic regression models were used to examine the association between each access variable and food security status. These models were adjusted for race, urbanicity, number of children in the household, number of adults in the household, homeless in the past year, monthly mortgage/rent expense, monthly transportation expense, monthly utilities expense, healthcare expense over $2,000 in the past year, monthly household wages, monthly SNAP, other monthly assistance, CHAOS, perceived social support, negative life events, perceived stress and intrinsic religiosity. For all variables of perceptions of neighborhood food access, the distance to nearest supermarket (log transformed) was adjusted in the models.

OR, odds ratio; CI, confidence interval; FS, food security; FI, food insecurity; VLFS-C, very low food security among children.