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RESEARCH ARTICLE

Food Insecurity Moderates Association Between Perceived Fresh Fruit and Vegetable Access and Vegetable Intake in the Rural Southern US

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ABSTRACT

Objective. Assess associations between perceived fresh fruit and vegetable access and obtaining fresh fruit and vegetables from various food sources with meeting national recommendations for fruit and vegetable intakes and BMI, and whether associations differ by food insecurity.

Methods. Secondary data analysis of a cross-sectional survey evaluating a health equity initiative among 1,474 respondents in 6 rural Georgia counties. Logistic regressions assessed associations between perceived fresh fruit and vegetable access and fresh fruit and vegetable sources with meeting/not meeting fruit and vegetable recommendations and BMI, and interactions with food insecurity.

Results. Respondents who obtained fresh fruit and vegetables at small local grocery stores, farmer's markets, and community/home gardens had twice the odds of meeting national vegetable recommendations. Food secure adults with greater perceived fresh fruit and vegetable access had 1.5 times the odds of meeting national vegetable recommendations.

Conclusions and Implications. Results highlight perceived access inequities for food insecure adults and the importance of food sources for vegetable consumption in the rural South.

INTRODUCTION

The obesity epidemic is of modern public health importance due to high prevalence,[1,2] associations with poor health outcomes,[3–5] and economic toll on the healthcare system.[6,7] Healthy eating, particularly a diet high in fruits and vegetables (FV), is one modifiable lifestyle behavior to lower risk for obesity,[8–11] yet most US adults do not meet national FV recommendations.[12,13]

While national dietary recommendations describe an optimal diet, complying with recommendations may not be possible due to constraints within the food environment.[14–17] Food environments that promote poor diet and the development of obesity are known as obesogenic food environments and are characterized by low access to healthy foods.[14,15,18] Much recent research has focused on objective measures of access, which are limited to geographic dimensions (e.g., distance to nearest store);[14,15] yet US consumers often travel beyond their nearest food source for food,[19,20] highlighting the need to consider non-geographic dimensions of access. Perceived measures of access may offset the potential limits of objective measures.[14,16]

The food sources from which people obtain foods are influenced by dimensions of access[15,21,22] and associate with diet and weight.[23–29] Food source-healthy eating research typically focuses on different retail sources, often comparing supermarkets or grocery stores with convenience stores.[23,25,26] Obtaining foods at convenience stores as opposed to supermarkets and grocery stores is associated with poor diet quality, lower FV intakes, and higher BMI.[23,25,26] Many studies, however, do not include other community food sources, such as farmer's markets, community and home gardens, or food pantries,[23,25,26,30] all of which have been targets for increased access to address the obesity epidemic.[24,27,31] Studies that focus specifically on these sources have found that those who obtain foods at farmer's markets and community and home gardens have healthier diets and BMI and are more likely to meet FV recommendations.[24,27–29] Research on food pantries is more complicated as many food pantry clients experience food insecurity (FI),[32] (i.e., the limited and inconsistent access to enough food to live a healthy, active life[33]), and have lower diet quality compared to non-pantry users.[34] However, one study found that frequency of obtaining foods at food pantries was associated with better diet quality.[31]

Adults experiencing FI report lower food access,[30,35] obtain food more often at food pantries and convenience stores and less often at supermarkets, grocery stores, and community or home gardens,[26,30,32,35,36] and have worse diet quality, lower FV intakes, and higher BMI compared with food secure (FS) adults.[30,37–39] The associations between FI, environmental factors, and health outcomes point to the inequitable distribution of and access to healthy foods, yet there is a lack of research on how FI impacts associations between food environments and diet-related outcomes.[40,41] Food insecurity may differentially impact these associations; for instance, FI adults, who by very definition have limited access to food,[31] may have lower perceptions of access which could further negatively impact diet and weight outcomes, while this association may be weaker for FS adults.

This study sought to address three questions: (1) Is perceived fresh fruit and vegetable (FFV) access associated with meeting recommendations for FV intakes and BMI? (2) Is obtaining FFV from different sources associated with meeting national recommendations for FV intakes and BMI? (3) Do associations vary by FI? We adapted a conceptual model[21] to depict the obesogenic food environment and its influence on FV intakes and BMI (Figure 1), to guide this secondary data analysis with a sample of rural adults. Much of the current evidence on these associations is from urban areas.[17,20,25,27,30,35] Rural areas are characterized by low food access[42–44] and a different mix of food sources compared to urban areas,[45–47] and rural adults have higher rates of FI, lower FV intakes, and higher BMI compared to urban adults.[23-24] Results can inform policies and interventions to improve FV intakes and BMI by addressing obesogenic food environment factors and the inequitable access to FFV in rural settings.

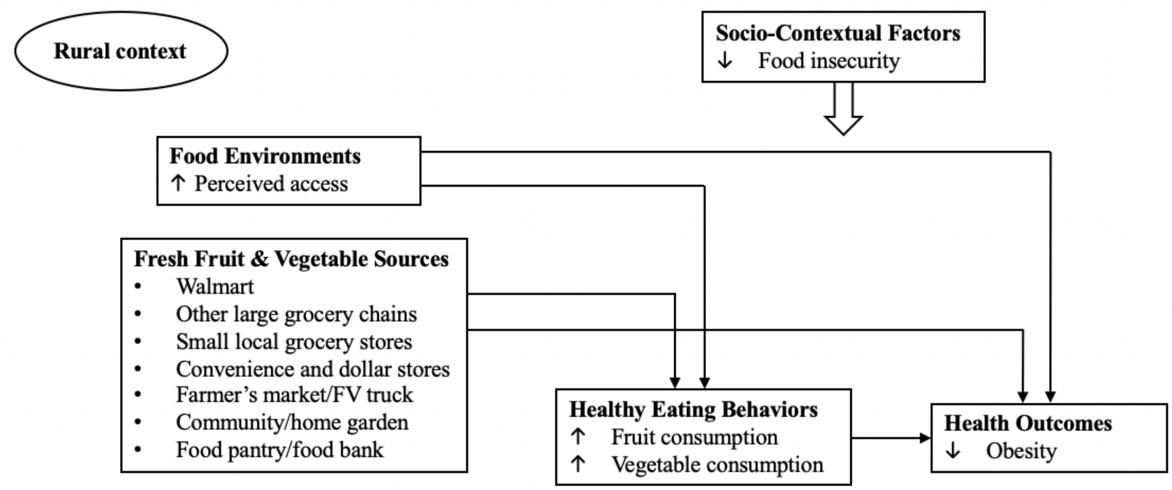

Figure. Conceptual Model of the Influence of the Food Environment on Diet and Weight

METHODS

Study Design and Sample

This cross-sectional secondary data analysis utilized a population-based survey that evaluated The Two Georgias Initiative (TGI). The TGI, developed by Healthcare Georgia Foundation, was a multi-year initiative to support community coalitions in 11 rural Georgia counties in their efforts to improve health and eliminate health disparities. Between December 2018 and June 2019, a random sample of 11,406 households within the 11 counties were mailed a survey exploring health behaviors and health-promoting resources related to common coalition priority areas. Coalitions chose which modules to include based on their priority areas. The response rate for the full sample was 26.2%. This study used data from the 6 counties that included the food access and healthy eating modules (response rate 27.7%). The university's IRB deemed this study a non-research program evaluation.

Measures

Fruit and vegetable intakes were measured with 2-items asking respondents to report the number of servings of all forms of FV usually eaten daily.[48,49] This measure has been validated against 24-h dietary recalls (r_{fruit}=.67 and $r_{vegetable}$=.65).[49] Daily FV intakes were retained as separate variables and dichotomized into "met" or "did not meet" the 2020 Dietary Guidelines for Americans (DGA) recommendations to consume ≥1.5 cups of fruit and ≥2 cups of vegetables.[13] Daily FV servings from the survey were converted into cups to align with the DGA recommendations (1 serving=½ cup).[50] Respondents met recommendations if they consumed ≥3 servings of fruits and ≥4 servings of vegetables per day.

Self-reported height and weight were used to construct the BMI variable (weight in pounds / height in inches^2 x 703), which was categorized into 3 groups: healthy/underweight (<25.0kg/m^2), overweight (25.0 to <30.0 kg/m^2), and obese (30.0 kg/m^2 or higher).[51]

Four statements adapted from the Perceived Nutrition Environment Measures Survey (NEMS-P) measured perceived FFV access.[21] The NEMS-P has been shown to have moderate criterion validity when compared with objective measures.[21,52] Statements included responses to "In my community…": "It is easy to get fresh fruits and vegetables," "The fresh fruits and vegetables are of high quality," "The fresh fruits and vegetables cost too much," (reverse coded) and "There is a large selection of fresh fruits and vegetables." Responses ranged from strongly disagree=0 to strongly agree=4 on a 5-point Likert scale. Cronbach alpha was .72.

To measure FFV sources, respondents were asked to choose all that apply to the question "In the past month, where did you get fresh fruits and vegetables?[53] Sources included Walmart, other large grocery store chain, small local grocery store, gas station/convenience store, Dollar General/Family Dollar, farmer's market/produce stand, FV truck/mobile market, community/home garden, food pantry/food bank, and I did not get any FFV. Farmer's market/produce stand and FV truck/mobile market were combined, as were gas station/convenience store and Dollar

General/Family Dollar due to small cell sizes for those sources. Each source was treated as a distinct binary variable (i.e., obtained/did not obtain FFV at source).

Food insecurity was measured using a 2-item screener,[54] previously shown to have high sensitivity (97%) and specificity (83%).[55] Respondents indicated whether two scenarios applied to them never, sometimes, or often in the last 12 months: "I worried whether my food would run out before I got money to buy more;" "The food I bought just didn't last and I didn't have money to get more." Respondents were classified as FI if they responded sometimes or often to at least one statement.

Demographic variables included self-reported age, race/ethnicity (White, African American/Black, Hispanic, more than one race, and other please specify), sex (male, female), annual household income (≤$20,000, $20,001-$50,000, >$50,000), education (some high school or less, high school or GED, some college or technical school, college graduate and above), household size, and receipt of SNAP benefits (yes, no). Measures were adapted from the Behavioral Risk Factor Surveillance System[56] or the American Communities Survey.[57]

Analysis

Variables were assessed for missingness and normality, and descriptive statistics were calculated for categorical (percentages and frequencies) and continuous variables (means and standard deviations). Bivariate analyses evaluated associations between outcomes (FV intakes, BMI), explanatory variables (perceived FFV access, FFV sources), and FI moderator using t-tests or ANOVA and chi-squared tests, with logistic regressions used to obtain OR and 95% CIs. The logistic regression model-building process resulted in two models per outcome: We first tested for interaction between perceived FFV access and FI and either retained the significant interaction term and stratified by FI or removed the non-significant interaction term. We then tested for interactions between the FFV sources and FI and either retained significant interaction terms and stratified by FI or removed non-significant interaction terms. Due to small cell sizes, no interactions were included between FI and the FFV source of food pantries/food banks or the statement "I did not get any FFV." All regressions included the covariates of race, sex, age, income, education, and the county variable (to account for data clustering by county). Analyses were conducted in SAS 9.4 (SAS Institute Inc., Cary, NC, 2013), and significance was assessed at alpha=.05.

RESULTS

Sample Characteristics

The analytic sample included 1,474 respondents from 6 counties. Respondents were nearly 60 years old on average, female, and White (Table 1). Only 11% and 9% of respondents met the DGA recommendations for FV intakes, respectively. One-third of respondents were overweight and 40% were obese. Nearly half of respondents were FI. Respondents mostly obtained FFV from Walmart (72%) and other large grocery stores (58%), while fewer obtained FFV from small local grocery stores (29%), farmer's markets/FV trucks (17%), community or home gardens (10%), convenience/dollar stores (6%), and food pantries/food banks (4%).

Table 1. Sample Characteristics (N=1,474)

		Mean (SD)	% (n)
Counties	County 1		18 (262)
	County 2		19 (286)
	County 3		13 (195)
	County 4		15 (219)
	County 5		15 (227)
	County 6		19 (285)
Demographics	Age	59.93 (15.24)	
	Sex (women)		67 (961)
	Household size	2.34 (1.40)	
	Race/Ethnicity		
	White, not of Hispanic origin		72 (1064)
	African American/Black, not of Hispanic origin		22 (320)
	More than one race		2 (25)
	Hispanic		1 (11)
	Other		1 (6)

	Education		
	Some high school or less		11 (164)
	High school or GED		30 (430)
	Some college or technical school		33 (476)
	College graduate and above		26 (379)
	Annual household income		
	≤$20,000		30 (356)
	$20,001-$50,000		39 (466)
	>$50,000		31 (375)
	Receipt of SNAP benefits (yes)		14 (202)
Moderating Variable	Food insecurity		47 (692)
Explanatory Variables	Perceived FFV access	2.12 (0.82)	
	FFV sources		
	Walmart		72 (1054)
	Other large grocery chain		58 (857)
	Small local grocery store		29 (423)
	Convenience and dollar stores		6 (90)
	Farmer's market/FV truck		17 (257)
	Community/home garden		10 (141)
	Food pantry/food bank		4 (52)
	Did not get any FFV		2 (22)
Outcomes	FV intakes		
	Fruit intake (≥3 servings/day)		11 (161)
	Vegetable intake (≥4 servings/day)		9 (135)
	BMI (kg/m^2)		
	Healthy/underweight (<25.0)		28 (406)
	Overweight (25.0-29.9)		33 (476)
	Obese (≥30)		40 (583)

Note: FFV=fresh fruits and vegetables. FV=fruit and vegetable

Bivariate Associations

Table 2 shows the associations between the explanatory variables and the outcomes of FV intakes. Those who met the DGA recommendation for fruit reported higher perceived FFV access than those who did not meet the recommendation (*M*=2.3, *SD*=0.80 versus *M*=2.1, *SD*=0.82, *p*=.004). Meeting the DGA recommendation for fruit was associated with obtaining FFV from farmer's markets/FV trucks (*p*=.009) and community/home gardens (*p*=.03). Those who met the DGA recommendation for vegetables reported higher perceived FFV access compared with those who did not meet the recommendation (*M*=2.3, *SD*=0.87 versus *M*=2.1, *SD*=0.81, *p*=.04). Meeting the DGA recommendation for vegetables was associated with obtaining FFV from small local grocery stores (*p*=.008), farmer's markets/FV trucks (*p*=.001), and community/home gardens (*p*<.001).

Table 2. Associations between FV intakes, perceived FFV access, and obtaining FFV from various sources (N=1474)

		Fruit Intake			Vegetable Intake		
		≥3 servings/day (11% n=161)	**<3 servings/day** (89% n=1313)		**≥4 servings/day** (9% n=135)	**<4 servings/day** (91% n=1339)	
		M (SD)	**M (SD)**	***p***	**M (SD)**	**M (SD)**	***p***
Perceived FFV Access†		2.30 (0.80)	2.10 (0.82)	0.004*	2.26 (0.87)	2.11 (0.81)	0.04*
		% (n)	**% (n)**	***p***	**% (n)**	**% (n)**	***P***
FFV Source‡							
Walmart	Obtained FFV	12 (121)	89 (933)	0.28	10 (100)	91 (954)	0.49
	Did not obtain FFV	10 (40)	91 (380)		8 (35)	92 (385)	
Other large grocery chain	Obtained FFV	12 (104)	88 (753)	0.08	10 (85)	90 (772)	0.23
	Did not obtain FFV	9 (57)	91 (560)		8 (50)	92 (567)	
	Obtained FFV	11 (46)	89 (377)	0.97	12 (52)	88 (371)	0.008*

Small local grocery store	Did not obtain FFV	11 (115)	89 (936)		8 (83)	92 (968)	
Convenience/ dollar store	Obtained FFV	9 (8)	91 (82)	0.52	7 (6)	93 (84)	0.40
	Did not obtain FFV	11 (153)	89 (1231)		9 (129)	91 (1255)	
Farmer's market/FV truck	Obtained FFV	16 (40)	84 (217)	0.009*	14 (37)	86 (220)	0.001*
	Did not obtain FFV	10 (121)	90 (1096)		8 (98)	92 (1119)	
Community/ home garden	Obtained FFV	16 (23)	84 (118)	0.03*	18 (26)	82 (115)	<0.001*
	Did not obtain FFV	10 (138)	90 (1195)		8 (109)	92 (1224)	
Food pantry^	Obtained FFV	8 (4)	92 (48)	0.65	10 (5)	90 (47)	0.81
	Did not obtain FFV	11 (157)	89 (1265)		9 (130)	91 (1292)	
Did not get any FFV^	Yes	9 (2)	91 (20)	1.00	5 (1)	96 (21)	0.71
	No	11 (159)	89 (1293)		9 (134)	91 (1318)	

Note: FFV=fresh fruits and vegetables. FV=fruit and vegetable. *Significance at $p<0.05$. †Associations conducted using t-tests. ‡Associations conducted using Pearson's chi-squared. ^Associations conducted using the two-sided *p*-value from Fisher's exact test

As shown in Table 3, BMI was associated only with obtaining FFV from small local grocery stores ($p=.04$) and food pantries ($p=.05$). Table 4 shows bivariate associations with FI. Compared to FI adults, FS adults had higher perceived FFV access ($M=2.3$, $SD=0.76$ versus $M=1.9$, $SD=0.81$, $p<.001$). Additionally, FI was associated with obtaining FFV from other large grocery store chains ($p<.001$), convenience/dollar stores ($p=.04$), food pantries ($p<.001$), and responding "yes" to "I did not get any FFV" ($p<.001$), as well as all three of the outcomes.

Table 3. Associations between BMI, perceived FFV access, and obtaining FFV from various sources (N=1465)

		Healthy/underweight <25.0 kg/m^2 (26% n=380)	**Overweight** 25.0-29.9 kg/m^2 (33% n=476)	**Obese** ≥30 kg/m^2 (41% n=583)	
		M (SD)	**M (SD)**	**M (SD)**	***p***
Perceived FFV Access†		2.17 (0.82)	2.14 (0.80)	2.06 (0.83)	0.10
		% (n)	**% (n)**	**% (n)**	***p***
FFV Sources‡					
Walmart	Obtained FFV	27 (278)	33 (343)	41 (425)	0.29
	Did not obtain FFV	31 (128)	32 (133)	38 (158)	
Other large grocery chain	Obtained FFV	28 (240)	34 (287)	38 (323)	0.24
	Did not obtain FFV	27 (166)	31 (189)	42 (260)	
Small local grocery store	Obtained FFV	32 (136)	29 (123)	39 (163)	0.04*
	Did not obtain FFV	26 (270)	34 (353)	40 (420)	
Convenience/ dollar store	Obtained FFV	26 (23)	28 (25)	46 (40)	0.52
	Did not obtain FFV	28 (383)	33 (451)	39 (543)	
Farmer's market/FV truck	Obtained FFV	31 (78)	33 (84)	37 (94)	0.45
	Did not obtain FFV	27 (328)	32 (392)	41 (489)	
Community/ home garden	Obtained FFV	30 (42)	37 (51)	33 (46)	0.23
	Did not obtain FFV	28 (364)	32 (425)	41 (537)	
Food pantry	Obtained FFV	29 (15)	18 (9)	53 (27)	0.05*
	Did not obtain FFV	28 (391)	33 (467)	39 (556)	
Did not get any FFV	Yes	18 (4)	23 (5)	59 (13)	0.18
	No	28 (402)	33 (471)	40 (570)	

Note: FFV=fresh fruits and vegetables. FV=fruit and vegetable. *Significance at $p<0.05$. †Associations conducted using PROC ANOVA. ‡Associations conducted using Pearson's chi-squared.

Table 4. Associations between perceived FFV access and obtaining FFV from various sources with food insecurity (N=1463)

		Food Secure (53% n=771)	**Food Insecure** (47% n=692)	
		M (SD)	**M (SD)**	***p***
Perceived FFV Access†		2.34 (0.76)	1.88 (0.81)	<0.001*
		% (n)	**% (n)**	***p***
FFV Source‡				
Walmart	Obtained FFV	52 (547)	48 (499)	0.62
	Did not obtain FFV	54 (224)	46 (193)	
Other large grocery chain	Obtained FFV	60 (509)	40 (339)	<0.001*
	Did not obtain FFV	43 (262)	57 (353)	
Small local grocery store	Obtained FFV	51 (216)	49 (205)	0.50
	Did not obtain FFV	53 (555)	47 (487)	
Convenience/ dollar store	Obtained FFV	42 (38)	58 (52)	0.04*
	Did not obtain FFV	53 (733)	47 (640)	
Farmer's market/FV truck	Obtained FFV	57 (147)	43 (109)	0.10
	Did not obtain FFV	52 (624)	48 (583)	
Community/ home garden	Obtained FFV	59 (83)	41 (57)	0.10
	Did not obtain FFV	52 (688)	48 (635)	
Food pantry^	Obtained FFV	17 (9)	83 (43)	<0.001*
	Did not obtain FFV	54 (762)	46 (649)	
Did not get any FFV^	Yes	9 (2)	91 (20)	<0.001*
	No	53 (769)	47 (672)	
Outcomes				
Fruit intake‡	≥3 servings	68 (109)	32 (52)	<0.001*
	<3 servings	51 (662)	49 (640)	
Vegetable intake‡	≥4 servings	70 (91)	32 (43)	<0.001*
	<4 servings	51 (680)	49 (649)	
BMI§	Healthy/ underweight	57 (230)	43 (171)	<0.001*
	Overweight	58 (272)	43 (201)	
	Obese	46 (264)	55 (316)	

Note: FFV=fresh fruits and vegetables. FV=fruit and vegetable. *Significance at $p<0.05$. †Associations conducted using t-tests. ‡Associations conducted using Pearson's chi-squared. ^Associations conducted using the two-sided *p*-value from Fisher's exact test. §Associations conducted using ANOVA; healthy/underweight <25.0kg/m^2, overweight 25.0-29.9kg/m^2, obese ≥30.0kg/m^2.

Multivariable Logistic Regressions

Food insecurity did not moderate any associations with meeting the DGA recommendation for fruit, and no main effects with fruit intake were significant (Table 5). Also, FI did not moderate any associations between meeting the DGA recommendation for vegetables and FFV sources, but several significant main effects were found (Table 5). Obtaining FFV at small local grocery stores was associated with meeting the DGA recommendation for vegetables [OR=1.92, 95% CI 1.24, 3.07, *p*=.004]. Additionally, those who obtained FFV from farmer's markets/FV trucks and community/home gardens had 1.92 [95% CI 1.16, 3.21, *p*=.01] and 1.93 [95% CI 1.03, 3.65, *p*=.04] times the odds, respectively, of meeting the DGA recommendation for vegetables. FI did, however, moderate the relationship between meeting the DGA recommendation for vegetables and perceived FFV access among only those who were FS; for every 1-unit increase in perceived FFV access, FS respondents had 1.46 times the odds of meeting the DGA recommendation for vegetable intake [95% CI 1.00, 2.13, *p*=.049] (Table 6).

Lastly, FI did not moderate any associations with BMI, and no main effects with BMI were significant.

Table 5. Adjusted odds ratios for main effects of associations between perceived FFV access and obtaining FFV from various sources with FV intakes and BMI

	Fruit Intake (≥3 Servings/Day)		Vegetable Intake (≥4 Servings/Day)		BMI (Healthy/underweight)	
	OR (95% CI)	***p***	**OR (95% CI)**	***p***	**OR (95% CI)**	***p***
Perceived FFV Access	1.29 (0.97, 1.73)	0.08	---	---	1.08 (0.92, 1.26)	0.36
FFV Sources						
Walmart	1.50 (0.93, 2.41)	0.10	1.09 (0.50, 2.01)	0.82	1.08 (0.83, 1.39)	0.58
Other large grocery chain	1.01 (0.66, 1.55)	0.96	1.86 (0.99, 3.46)	0.33	0.99 (0.78, 1.25)	0.93
Small local grocery store	1.02 (0.66, 1.58)	0.94	1.92 (1.22, 3.02)	0.003*	0.92 (0.72, 1.19)	0.54
Convenience/dollar store	1.14 (0.49, 2.65)	0.77	1.15 (0.36, 3.65)	0.60	1.35 (0.83, 2.19)	0.22
Farmer's market/FV truck	1.50 (0.93, 2.42)	0.10	1.92 (1.15, 3.19)	0.002*	0.93 (0.69, 1.25)	0.61
Community/home garden	1.45 (0.78, 2.72)	0.24	1.93 (1.02, 3.64)	0.04*	0.69 (0.46 1.02)	0.07
Food pantry	0.88 (0.25, 3.07	0.85	0.61 (0.14, 2.71)	0.52	1.19 (0.64, 2.24)	0.58

Note: FFV=fresh fruits and vegetables. FV=fruit and vegetable. FI=food insecurity. *Significance at $p<0.05$. Logistic regressions were conducted using PROC GENMOD and modeled the probability of meeting DGA recommendations for FV intakes and being in the healthy/underweight category (<25.0 kg/m^2). Models included county, age, sex, race, income, education as covariates. Main effects not reported for variables involved with significant interactions.

Table 6. Stratified results of food insecurity as a moderator of perceived FFV access and meeting national vegetable recommendations

	Vegetable Intake (≥4 Servings/Day)			
	Food secure		Food insecure	
	Adjusted OR (95% CI)	***p***	**Adjusted OR (95% CI)**	***p***
Perceived FFV Access	1.46 (1.00, 2.13)	0.049*	0.76 (0.49, 1.17)	0.21

Note: FFV=fresh fruits and vegetables. *Significance at $p<0.05$. Regressions were conducted in PROC LOGISTIC. Models included county, age, sex, race, income, education as covariates. No significant main effects or interaction effects were found for the outcomes of fruit intake or BMI.

DISCUSSION

This paper explored rural adults' perceptions of FFV access and sources where they obtained FFV with meeting national guidelines for FV intakes and BMI, as well as whether and how FI impacted these associations. Few respondents met the DGA recommendations for FV intakes (11% and 9%, respectively), though our data are similar to state estimates (12% and 9%, respectively).[12] A greater percentage of our sample was obese (40%) compared to state estimates (30%), and FI was high in our sample (47.3%) compared to state estimates (26.2%), though studies show that rural residents have higher BMI and FI compared to urban residents.[19,36,58–60]

To our knowledge, this is one of only a few studies to explore FI as a moderator of perceived access and healthy eating behaviors. Gupta and Freedman found a positive association between perceived healthy food access and diet quality among urban adults with very low food security, whereas the opposite was true among FS adults who had lower perceived healthy food access yet better diet quality.[40] The authors hypothesized that these unexpected findings may be due to food secure adults' access to a personal vehicle and their ability to travel outside their local food environment to access healthier foods, as only 14% of participants with very low food security had access to a personal vehicle, and a significantly greater number of food secure participants reported using a personal vehicle to grocery shop. Oladele and colleagues parceled out different dimensions of FV access and found that more positive perceptions of FV affordability were associated with greater FV intake among FI participants, though no relationship was found for FS participants nor the other dimensions of FV access among their sample of adults living in the Eastern Caribbean.[41] The authors suggest that this finding may be due to the globalization of food in this region where the availability and consumption of imported, energy-dense, highly processed foods has risen steeply, driving up prices of locally-sourced FV.[41] The high prices of FV may be particularly salient for FI individuals. In contrast to these studies, our results demonstrate that the positive relationship between perceived FFV access and vegetable consumption is only significant for FS adults. Perhaps, since FS adults typically report higher perceived healthy food access and have higher FV intakes,[30,35,37] associations also present in our sample, this association was strong enough to be detected among the FS adults, but not among the FI adults in our sample. However, as this is still an emerging literature, it is hard to make comparisons among these studies due to measurement differences in the explanatory (e.g., perceived FFV access, perceived affordability), moderator (e.g., FI vs. FS, FS vs. low FS vs. very low FS), and outcome variables (e.g., combined FV intake, separate FV intakes).

Our results confirm findings that obtaining FFV from community/home gardens and farmer's markets is associated with meeting national FV recommendations specifically among rural adults.[24,28,61] Kegler *et al.*, for instance, found that home gardening was associated with consuming at least 4.5 cups of FV among rural respondents.[28] Barnidge and colleagues found that rural Missouri adults who obtained FV from a community garden had more than twice the odds of meeting FV recommendations compared to those who did not obtain FV from a community garden.[61] Additionally, Jilcott Pitts *et al.* found that rural women who shopped at farmer's markets were more likely to consume 5 FV per day compared with those who did not shop at farmer's markets.[24] These studies, and others with similarly positive findings in urban settings,[30,62] have assessed associations with combined FV intake. By exploring FV intakes separately, our results are more nuanced and highlight that these sources are associated specifically with meeting national vegetable recommendations. The few studies that have explored FV intakes separately lend support to our findings, revealing either only significant associations between use of farmer's markets, community, or home gardens and vegetable intake, or a greater increase in vegetable relative to fruit intake in intervention studies.[63–66]

Our findings add to the literature on perceived access-diet associations, though our findings are specific to perceived FFV access and separate FV intakes, whereas many previous studies focus on one's perceived access to all forms of FV or healthy foods in general with combined FV intake.[14,52,67–71] Surprisingly, no significant relationship was found between perceived FFV access and BMI; previous research has demonstrated a significant inverse relationship between perceived access and BMI, though these studies were either longitudinal or had a higher percentage of participants with obesity compared with our sample, potentially making it easier to detect associations with BMI.[52,72–75] Lastly, the many significant bivariate associations with FI paint a picture of inequitable access to FFV and disparate health behaviors and outcomes experienced by FI adults in our rural sample, including lower perceived FFV access, greater reliance on convenience stores and food pantries, lower FV intakes, and higher BMI, all of which is reflected in the wider literature.[30,35,36,76-65]

This study has several limitations. The cross-sectional study limits our ability to draw causal conclusions, and our findings may not generalize to other communities. Also, as some data were collected during cold months, the percentage of respondents who obtained FFV from community/home gardens, for example, may be lower than if all data were collected in warm months. Similarly, as respondents were asked where they obtained FFV in the past month, these data may not reflect typical shopping patterns, rather a snapshot into the types of sources visited specifically for FFV and within a one-month span. These data were self-reported and are subject to social desirability bias (e.g., FV intakes may be inflated), and we were limited by the survey measures and unable to draw direct comparisons between explanatory variables which specified *fresh* FV and outcome variables which asked about *all forms* of FV. We also did not find any main or interaction effects for fruit intake or BMI, potentially due to lost statistical information from the categorization of outcomes, the different social contexts for FV intakes, or because BMI is a more distal outcome than FV intakes. Finally, there may be a risk of Type I error as we probed for many different interactions in this exploratory analysis, though even if statistical significance was lowered to p=.01, all but one main effect would have remained significant.

CONCLUSIONS

The current study revealed a positive relationship between perceived FFV access and odds of meeting daily vegetable recommendations among FS but not FI adults, though research on FI as a moderator of this association is still emerging and more is needed to truly understand current disparities in perceived access and its impact on healthy eating behaviors. Findings also identified small local grocery stores, farmer's markets/FV trucks, and community/home gardens as sources for FFV that increase the odds of meeting daily vegetable recommendations. Interventions could examine a range of strategies to promote FFV purchasing from these sources to increase FV intakes and longitudinally monitor BMI, while also being mindful as to not widen disparities in perceived or actual access to these sources.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

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