Preventive Medicine Reports 26 (2022) 101694

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

Perceptions of the local food environment and fruit and vegetable intake in the Eastern Caribbean Health Outcomes research Network (ECHORN) Cohort study

Carol R. Oladele [a,*], Uriyoán Colón-Ramos [b], Deron Galusha [a], Emma Tran [a], Oswald P. Adams [c], Rohan G. Maharaj [d], Cruz M. Nazario [e], Maxine Nunez [f], Rafael Pérez-Escamilla [g], Marcella Nunez-Smith [a]

[a] Equity Research and Innovation Center, Yale School of Medicine, 100 Church Street South, Suite A200, New Haven, CT 06510, USA
[b] Milken Institute School of Public Health, George Washington University, 950 New Hampshire Ave NW #2, Washington, DC 20052, USA
[c] Faculty of Medical Sciences, The University of the West Indies, Cave Hill Campus, Bridgetown, Barbados
[d] Faculty of Medical Sciences, The University of the West Indies, St. Augustine Campus, Trinidad and Tobago
[e] Department of Biostatistics and Epidemiology, Graduate School of Public Health, University of Puerto Rico, Medical Sciences Campus, San Juan, Puerto Rico
[f] University of the Virgin Islands, School of Nursing, St. Thomas, US VI, USA
[g] Department of Social and Behavioral Sciences, Yale School of Public Health, 135 College Street, Suite 216, New Haven, CT 06520, USA

ARTICLE INFO

Keywords:
Food environment perceptions
Caribbean
Fruit and vegetable consumption
ECHORN Cohort

ABSTRACT

Introduction: Studies conducted in the US and other high-income countries show that the local food environment influences dietary intakes that are protective for cardiovascular health.
However, few studies have examined this relationship in the Caribbean. This study aimed to determine whether perceptions of the local food environment were associated with fruit and vegetable (FV) intake in the Eastern Caribbean, where daily FV intake remains below recommended levels.
Methods: Cross-sectional analysis of Eastern Caribbean Health Outcomes Research Network Cohort Study (ECS) baseline data (2013–2016) from Barbados, Puerto Rico, Trinidad and Tobago, and US Virgin Islands was conducted in 2020. The National Cancer Institute Dietary Screener Questionnaire was adapted to measure daily servings of FV. Existing scales were used to assess participant perceptions of the food environment (availability, affordability, and quality). Chi-square tests and Poisson regression were used for analyses.
Results: Participants reported eating one mean daily serving of FV. Mean daily intake was higher among those who perceived FV as usually/always affordable, available, and high quality. Multivariate results showed statistically significant associations between FV and affordability. Persons who perceived FV as affordable had 0.10 more daily servings of FV compared to those who reported FV as not always affordable ($p = 0.02$). Food insecurity modified the association between affordability and FV intake.
Conclusions: This study highlights the importance of affordability in consumption of FV in the Eastern Caribbean, and how this relationship may be modified by food insecurity.

1. Introduction

Diets rich in fruits and vegetables (FV) are associated with lower prevalence of cardiovascular disease (CVD) and its risk factors (i.e. obesity, diabetes, and hypertension), as well as with better management of these diet-sensitive risk factors (Boeing et al., 2012). The World Health Organization recommendation for FV is 5 servings per day. Daily FV intake remains persistently below WHO recommendations in the Caribbean as well as in other places around the world {World Health Organization, 2018 #1205; Frank et al., 2019 #1499; Micha et al., 2015 #1500; Global Burden of Disease Collaborative Network, 2021 #1696}. Yet, few studies have sought to examine the role the food environment plays in FV consumption in the region.

Studies conducted in the US and other high income countries show that the local food environment influences FV consumption as well as diet-related chronic conditions (e.g. obesity, diabetes, hypertension)

* Corresponding author at: Equity Research and Innovation Center, Yale School of Medicine, PO Box 208093m New Haven, CT 06520, USA.
E-mail address: carol.oladele@yale.edu (C.R. Oladele).

https://doi.org/10.1016/j.pmedr.2022.101694
Received 8 January 2021; Received in revised form 26 December 2021; Accepted 15 January 2022
Available online 2 February 2022

(Lovasi et al., 2009; Hilmers et al., 2012; Larson et al., 2009). The local food environment is a concept that aims to characterize the neighborhood where people typically shop or otherwise obtain food, capturing aspects that may be important determinants of people's food purchasing and consumption. Existing evidence on the local food environment has primarily focused on structural aspects of the community food environment (e.g. distance to stores, density of fast food stores or supermarkets, types of stores) and its influence on dietary intakes and health outcomes (Ding et al., 2012; Holsten, 2009; Pitt et al., 2017). Fewer studies have examined local food environment characteristics like affordability, availability, and quality, which are more proximal to food consumption. These are important aspects of the food environment to consider in understanding dietary behaviors.

Though mixed, some evidence suggests that affordability, availability, and quality are determinants of food choice and eating behaviors. A study conducted in a low-income area showed that perceptions of quality and availability influenced FV intake (Williams et al., 2012; Blitstein et al., 2012). Other studies have also shown affordability to be an important factor in FV intake (Alber et al., 2018). Studies that focused on access in neighborhood food environments also demonstrate consistent findings. A 2016 study conducted in Brazil showed that average FV consumption was higher in neighborhoods with increased access to healthy foods. Similarly, Duran et al. (2016) demonstrated that regular consumption of fruits and vegetables was associated with availability of supermarkets and fresh food markets. Understanding the local food environment and its impact on FV consumption is critically important in the Caribbean, where a nutritional transition is underway (Forrester, 2013), and rates of noncommunicable disease risk factors (e.g. obesity, diabetes, hypertension) are rapidly rising (Razzaghi et al., 2019).

The nutrition transition in the Caribbean is characterized by a dietary shift from locally sourced high fiber staples, fruits, and vegetables to energy-dense and highly processed foods, most of which are imported. The globalization of food and the Caribbean's increasing reliance on imported foods are major determining factors in changing dietary patterns (Walters and Jones, 2016; Nations FaAOotU, 2015). The heavy reliance on imported food and drink is also linked to higher food costs and decreased food security, defined as access to safe, sufficient, and nutritious foods that meet food preferences and dietary needs (FAO et al., 2019). These trends have implications for FV consumption in the region as some evidence has shown food insecurity to negatively affect FV consumption and health (Derose et al., 2018; Gulliford et al., 2003; McWade et al., 2019). A narrative review of food environment studies from Latin American countries found that fresh FV were more expensive compared to processed and other foods. The review also revealed that few studies have examined the relationship between FV price and consumption despite high prevalence of food insecurity in many Latin American countries and its relevance to dietary consumption. (ref) Relevant evidence from the Caribbean is lacking, though changes related to the nutrition transition and increasing food importation warrant studies.

The increase in rates of obesity and other NCD risk factors attributed to this transition has prompted policy and research initiatives to increase healthy dietary intakes. However, efforts to date have been primarily regulatory and focused on sugary beverage intake (Alvarado et al., 2017; Foster et al., 2018; Alvarado et al., 2019). There has been minimal research on the role that the local food environment plays in influencing FV consumption and dietary quality in the Caribbean. Recent studies have sought to understand structural aspects of the food environment (Cunningham-Myrie et al., 2020) and social factors that influence diet, including how food is sourced, to inform policies and targeted interventions (Haynes et al., 2020; Guariguata et al., 2020; Guell et al., 2021). However, knowledge gaps remain concerning the role that dimensions of the perceived food environment (affordability, availability, and quality) play in determining dietary consumption in the Caribbean (Turner et al., 2021). Few studies have examined this relationship, findings vary, and most evidence in the region come from Latin American countries (Turner et al., 2020).

Given this knowledge gap, our study aimed to characterize perceptions of the local food environment and examine influences on FV consumption in the Caribbean. A secondary aim was to examine the potential modifying effect of food insecurity in the relationship between food environment perceptions and FV consumption. We used baseline data from the Eastern Caribbean Health Outcomes Research Network to conduct this investigation. We hypothesized that food environment perceptions were positively associated with FV intake, and that food insecurity would modify the relationship.

2. Methods

2.1. Study population

We used baseline data (2013–2018) from the Eastern Caribbean Health Outcomes Research Network (ECHORN) Cohort Study (ECS), a population-based cohort of 2,961 community-dwelling individuals 40 years or older residing in Barbados, Puerto Rico, Trinidad and Tobago, and U.S. Virgin Islands. The primary aim of the study is to identify novel risk and protective factors for non-communicable diseases. Stratified multi-stage probability sampling was used on the islands of Puerto Rico, Barbados, and Trinidad. Participants were recruited from households island-wide in Barbados and from households in select enumeration districts in Puerto Rico and Trinidad. Simple random sampling via random digit dialing was used to identify individuals for recruitment in the US Virgin Islands. Individuals were eligible for participation if they were 1) English or Spanish speaking, 2) 40 years or older, 3) permanent residents for 10 or more years, and 4) had no plans to relocate within the next 5 years. Exclusion criteria included cognitive impairment and residential instability. Following informed consent procedures, participants completed a comprehensive survey that included self-reported measures of diet, other lifestyle factors (e.g., physical activity, smoking), chronic disease outcomes (hypertension, heart disease, cancer), medical history, and demographic characteristics. Survey items were pilot tested at each research site to ensure that items were comprehensible and examples or references were culturally relevant. Participants also underwent a clinical examination by trained research nurses that included height and weight measurements. Additional details regarding the methodology for the ECS have been previously published.

2.2. Measures

Dependent variable. FV intake was assessed using the National Cancer Institute Dietary Screener Questionnaire (DSQ) (Thompson et al., 2017). The DSQ was used in the absence of an available validated diet screener for the Caribbean. It is a well-established screener that allowed investigators to capture intakes relevant to noncommunicable diseases without conducting a total dietary assessment. The screener was adapted by a group of experts in nutrition research in Latin America and the Caribbean (UCR, RPE). Local dietitians and nutritionists were contacted in each island-nation and asked to review the original screener. Meetings were then conducted with local dieticians and nutritionists to review the screener and identify idiosyncrasies in the food groups by country and the variety of foods available at the local level for use as examples. For example, recommendations were made to include the more popular item of *Vienna Sausages* instead of the example hot dogs for the dietary risk factor of 'processed meats'. For Puerto Rico, the screener was translated into Spanish by a native Spanish-speaker and nutrition investigator familiar with Puerto Rican diet (UCR), in consultation with a nutritionist and the PI (CMN) for Puerto Rico, and cognitively tested in Spanish. Once adapted, the instrument was back-translated into English for English speakers inPuerto Rico. The adapted instrument is available from the corresponding author upon request. To assess FV consumption, participants were asked: 1) "During the past month, how often did you

eat a green leafy or lettuce salad, with or without other vegetables?" 2) "During the past month, how often did you eat fruit? Including fresh, frozen, and canned fruit." Participants selected one of eight response options that ranged from "never" to "2 or more times per day." The research team converted participant responses to mean daily servings of FV using established DSQ scoring algorithms (NIH).

Independent variable. We used two previously validated scales to assess perceptions of *availability*, *affordability*, and *quality* of fruits and vegetables in the local food environment (Moore et al., 2008); these were adapted in order to prompt participants to exclude starchy tubers (provisions) from the FV categories. The scale prompts participants to think about food resources in their neighborhood and rate how much they agreed with the following statements according to a 5-point Likert scale: 1) "Thinking about where you buy most of your foods, how often are the fruits and vegetables, *excluding provisions*, affordable for you?" 2) "Thinking about food resources in your neighborhood, how often are the fresh fruits and vegetables in your neighborhood of high quality?"3) "Thinking about food resources in your neighborhood, how often are a large selection of fresh fruits and vegetables available in your neighborhood?"

Covariates. Sociodemographic, lifestyle, clinical, dietary, and food environment factors shown to be associated with the food environment and FV intake were included in models (Alber et al., 2018; Colon-Lopez et al., 2013; Menezes et al., 2018; Jiang et al., 2021; Zhao et al., 2020). Sociodemographic variables included age, sex, marital status, and educational attainment. Variables were self-reported by participants.

Lifestyle characteristics included physical activity and vegetarian diet. Physical activity was measured using the WHO Global Physical Activity Questionnaire and categorized as low versus medium/high activity (Saelens et al., 2003). Categories were determined based on established scoring criteria outlined in the Global Physical Health Questionnaire Analysis Guide and validation study (Herrmann et al., 2013; Organization WH). Vegetarian diet was measured using the de novo question, "Are you vegetarian?"

Clinical variables included body mass index, which was calculated from weight and height measurements taken during the ECS clinical assessment. Weight was measured using a standardized calibrated scale at all sites and the average of two measures was used to determine participant weight. Height measurements were obtained using the same stadiometer at each ECS site. Food insecurity in the past 90 days and mode of transportation to obtain groceries were also included. Household food insecurity within the past 90 days was measured using the 9-item sub-scale for adults from the validated Latin American and Caribbean Food Security Scale (ELCSA) (Perez-Escamilla et al., 2009). Response options were binary (yes/no), and one point was given for each question with a "yes" response. Responses to the first eight questions on the scale (ninth question is not typically included in scoring) were summed for each participant and ranged from 0 to 8. Following standard guidelines for categorizing food insecurity (Pérez-Escamilla et al., 2007), those who scored 0 were classified as having no food insecurity, 1–6 as having mild/moderate food insecurity, and 7–8 as having severe food insecurity.

Mode of transportation to obtain food was adapted from Rose et al. (2004) and included the following question, "What is the most typical way you travel to the store for your groceries?" as done elsewhere (Gustafson et al., 2011; Rose and Richards, 2004). Participants selected one of five response options (drive own car, ride with friend or family member, take the bus, take a taxi, walk or ride a bicycle) to indicate their most frequent mode of transportation. Participants were also asked to indicate the time (in minutes) it takes to get the nearest grocer (Rose and Richards, 2004).

2.3. Statistical analysis

We first examined means and frequency distributions of variables. Analysis of variance was conducted to assess differences in mean daily FV intake across sociodemographic characteristics. Poisson regression was used to determine associations between FV intake and each food environment perception (affordability, availability, and quality) separately. Likert responses were collapsed into two categories for analyses to increase interpretability: rarely/never/sometimes, and usually/always. We used Poisson regression to assess the relationship between the three food environment perceptions and FV intake, adjusting for covariates that were statistically significant in the bivariate analyses and unadjusted regression models. Finally, we conducted food insecurity stratified models to examine the potential for effect modification between food environment perceptions and FV consumption. Food security was hypothesized to hinder access to FV based on prior studies (Mook et al., 2016; Nunnery et al., 2018). We measured food security with three levels (secure, mild/moderate, severe) in primary analyses (Lucan et al., 2014). In stratified models, food insecurity was measured as a binary (yes/no) to account for small cell size. SAS Statistical Software Package 9.4 was used to perform all analyses, which were conducted in 2020.

The ECS study was approved by the Yale University Human Subjects Investigation Committee, the Institutional Review Boards of the University of Puerto Rico Medical Sciences Campus, the University of the Virgin Islands, the University of the West Indies Cave Hill Campus, and the Ministry of Health of Trinidad and Tobago. The current analysis was approved by the ECS Data Access and Scientific Review Committee.

3. Results

We included data for participants that was collected after the inclusion of the food insecurity scale in the ECHORN baseline survey (n = 2350). The final analytic sample included 1962 participants after

Table 1
Demographic characteristics of ECS participants.

	Total (n = 1,962)		Daily servings of fruit and vegetables		p-value
	n	%	Mean	SD	
Age group					0.0001
40–49	498	25.4	1.28	1.01	
50–59	716	36.5	1.30	0.86	
60–69	490	25.0	1.44	0.95	
70+	258	13.2	1.54	0.84	
Sex					<0.0001
Male	686	35.0	1.19	0.86	
Female	1276	65.0	1.45	0.95	
Education					<0.0001
Less than high school	653	33.3	1.24	0.90	
High school	466	23.8	1.35	0.91	
Some college	436	22.2	1.36	0.88	
College+	407	20.7	1.57	0.98	
Marital Status					0.0601
Married	818	41.7	1.40	0.92	
Single	789	40.2	1.29	0.91	
Separated/Divorced	210	10.7	1.42	1.01	
Widowed	145	7.4	1.45	0.89	
BMI					0.5719
Underweight/Normal	513	26.2	1.35	0.98	
Overweight	709	36.1	1.39	0.92	
Obese	740	37.7	1.34	0.89	
Physical Activity					<0.0001
Low physical activity	895	45.6	1.25	0.87	
Moderate physical activity	364	18.6	1.42	0.90	
High physical activity	703	35.8	1.47	0.99	
Vegetarian	146	7.4	1.58	1.09	0.0028
Non-Vegetarian	1816	92.6	1.34	0.91	
Food Insecurity					<0.0001
No insecurity (0)	1434	73.1	1.42	0.90	
Mild/Moderate Insecurity (1–6)	449	22.9	1.26	1.00	
Severe Insecurity (7–8)	79	4.0	0.91	0.79	

Note: t-tests and ANOVA were used to determine statistical significance

excluding observations with missing values on study variables (n = 388). Participant characteristics are presented in Table 1. Sixty-two percent of participants were between 50 and 69 years, 65 percent were women, 64 percent had a high school education or higher, and most participants were married (42%). Seventy-four percent of participants had BMI values that fell within the overweight or obese range and most (46%) reported low levels of physical activity. Mean daily FV servings varied by participant demographic characteristics. FV consumption was higher among older persons, women, those with higher education, higher physical activity, and persons with food security.

Table 2 shows the results of t-tests and analysis of variance to determine differences in mean FV intake by food environment characteristics. Participants reported eating 1.4 daily servings of FV on average. Mean daily intake of FV varied by food affordability, and quality. Persons who perceived FV as usually/always affordable had greater mean daily servings of FV (1.43, SD = 0.93) compared to those who thought FV were never/rarely/sometimes affordable (1.22, SD = 0.90). A similar pattern was observed for perceptions of quality. FV consumption did not vary by perceptions of availability (p = 0.28). Mean daily FV intake also varied according to mode of transportation. Those who obtained groceries via taxi had lower mean FV intake (1.02, SD = 0.78) compared to persons with other modes of transportation including driving (1.41, SD = 0.93) their own car or riding with friends or family (1.42, SD = 0.91) (p < 0.0001).

Multivariate model results (Table 3) showed that perceptions of FV as always/usually *affordable* was associated with a 0.11 greater mean daily servings of FV compared to those who perceived FV as sometimes/rarely/never affordable (p = 0.022). Availability and quality were not significantly associated with FV consumption. Age, educational attainment, physical activity, and vegetarian diet were positively associated with daily FV consumption. In contrast, food insecurity was inversely associated with FV consumption. Findings showed that mild/moderate and severe food insecurity was associated with 0.03 and 0.30, respectively, fewer daily FV servings. Site stratified models (not present here) showed affordability was the only food environment perception significantly associated with FV intake across sites, which was consistent with overall results. Food insecurity stratified model results showed (Table 4) that the relationship between perceptions of affordability and daily FV intake was only statistically significant among those with food insecurity. Among participants who experienced food insecurity, those who perceived FV as affordable had 0.29 greater daily servings (p = 0.002) of FV compared with those who perceived FV as sometimes/rarely/never affordable.

We conducted sensitivity analyses to evaluate the potential impact of excluded observations on our study findings. Results showed no differences in responses to main study variables like FV consumption, perceptions of affordability and quality between participants who were included and excluded from analyses. Responses for perceptions of availability differed between groups.

Table 2
Mean daily FV servings by food environment characteristics.

	Daily servings of fruits and vegetables				
	n	%	Mean	SD	p-value
Total mean servings of FV	1962	100.0	1.36	0.92	
Fruits and Vegetables Affordable					<0.0001
Never/Rarely/ Sometimes	663	33.8	1.22	0.90	
Usually/Always	1299	66.2	1.43	0.93	
Fruits and Vegetables Available					0.2752
Never/Rarely/Sometimes	732	37.3	1.33	0.93	
Usually/Always	1230	62.7	1.38	0.92	
Fruits and Vegetables High Quality					0.0385
Never/Rarely/Sometimes	775	39.5	1.31	0.93	
Usually/Always	1187	60.5	1.40	0.92	
Mode of transportation to get groceries					<0.0001
Drive own car	1099	56.0	1.41	0.93	
Ride with friend or family	338	17.2	1.42	0.91	
Take the bus	171	8.7	1.36	0.96	
Take a taxi	147	7.5	1.02	0.78	
Walk or ride bicycle	207	10.6	1.22	0.95	
Number of minutes to get to grocery store					0.0459
<=5	392	20.0	1.31	0.94	
6–10	443	22.6	1.40	0.95	
11–20	693	35.3	1.42	0.95	
>20	434	22.1	1.28	0.83	

Note: t-tests and ANOVA were used to determine statistical significance

Table 3
Unadjusted regression model results for FV intake.

	Beta estimate	SE	p-value
Fruits and Vegetables Affordable			
Never/Rarely/Sometimes	*reference*		
Usually/Always	0.16	0.04	<0.0001
Fruits and Vegetables Available			
Never/Rarely/Sometimes	*reference*		
Usually/Always	0.05	0.04	0.2442
Fruits and Vegetables High Quality			
Never/Rarely/Sometimes	*reference*		
Usually/Always	0.07	0.04	0.0768
Age group			
40–49	*reference*		
50–59	0.03	0.05	0.5884
60–69	0.14	0.05	0.0101
70+	0.23	0.06	0.0003
Sex			
Male	−0.19	0.04	<0.0001
Female	*reference*		
Education			
Less than high school	*reference*		
High school	0.11	0.05	0.0446
Some college	0.12	0.05	0.0271
College+	0.26	0.05	<0.0001
Marital Status			
Married	*reference*		
Single	−0.08	0.04	0.066
Separated/Divorced	0.03	0.06	0.6741
Widowed	0.06	0.07	0.4561
BMI			
Underweight/Normal	*reference*		
Overweight	0.04	0.05	0.4299
Obese	0.00	0.05	0.9988
Physical Activity			
Low physical activity	*reference*		
Moderate physical activity	0.13	0.05	0.0155
High physical activity	0.16	0.04	0.0001
Number of minutes it takes to get to grocery store			
< = 5 min	*reference*		
6–10 min	0.05	0.06	0.3693
11–20 min	0.07	0.05	0.1703
>20 min	−0.03	0.06	0.678
Mode of transportation to get groceries			
Drive own car	*reference*		
Ride with a friend or family member	0.02	0.05	0.7617
Take the bus	−0.04	0.07	0.5712
Take a taxi	−0.36	0.09	<0.0001
Walk or ride bicycle	−0.17	0.07	0.0106
Food insecurity			
Food secure	*reference*		
Mild/moderate insecurity	−0.13	0.05	0.0072
Severe insecurity	−0.47	0.12	0.0001
Vegetarian diet	0.15	0.07	0.0235

4. Discussion

This study aimed to determine whether food environment perceptions are associated with FV intake in an Eastern Caribbean Cohort (ECS) representative of four small island developing states. Our study findings support our hypothesis that perceived *affordability* and socioeconomic

Table 4
Adjusted and Stratified Model results for Affordability and FV Intake.

	Full model			No food insecurity			Food insecurity		
	Beta estimate	SE	p-value	Beta estimate	SE	p-value	Beta estimate	SE	p-value
Fruits and Vegetables Affordable									
Never/Rarely/Sometimes	*reference*			*reference*			*reference*		
Usually/Always	0.11	0.05	0.0224	0.05	0.06	0.3737	0.27	0.09	0.0026
Fruit and Vegetables Available									
Never/Rarely/Sometimes	*reference*			*reference*			*reference*		
Usually/Always	−0.04	0.06	0.5292	−0.08	0.07	0.2571	0.06	0.11	0.554
Fruits and Vegetables High Quality									
Never/Rarely/Sometimes	*reference*			*reference*			*reference*		
Usually/Always	0.02	0.06	0.6913	0.07	0.07	0.3328	−0.09	0.10	0.4066
Age group									
40–49	*reference*			*reference*			*reference*		
50–59	0.03	0.05	0.5223	0.04	0.06	0.5118	−0.02	0.09	0.8399
60–69	0.14	0.06	0.0141	0.13	0.07	0.049	0.17	0.11	0.1381
70+	0.28	0.07	<0.0001	0.26	0.08	0.0005	0.27	0.21	0.1988
Sex									
Male	−0.26	0.05	<0.0001	−0.25	0.05	<0.0001	−0.28	0.10	0.004
Female	*reference*			*reference*			*reference*		
Education									
Less than high school	*reference*			*reference*			*reference*		
High school	0.08	0.05	0.1411	0.08	0.06	0.2122	0.03	0.11	0.7839
Some college	0.11	0.06	0.047	0.05	0.07	0.4208	0.25	0.11	0.0186
College +	0.22	0.06	0.0002	0.20	0.07	0.0021	0.21	0.13	0.1055
Marital Status									
Married	*reference*			*reference*			*reference*		
Single	−0.04	0.04	0.3879	−0.06	0.05	0.2408	0.04	0.10	0.6804
Separated/Divorced	−0.01	0.07	0.8454	−0.04	0.08	0.5715	0.08	0.14	0.5635
Widowed	−0.02	0.08	0.7618	−0.03	0.09	0.756	0.10	0.18	0.5792
BMI									
Underweight/Normal	*reference*			*reference*			*reference*		
Overweight	0.04	0.05	0.4146	0.05	0.06	0.4043	0.06	0.11	0.6025
Obese	0.03	0.05	0.584	0.02	0.06	0.6837	0.07	0.11	0.4798
Physical Activity									
Low physical activity	*reference*			*reference*			*reference*		
Moderate physical activity	0.15	0.05	0.0052	0.14	0.06	0.022	0.20	0.12	0.0961
High physical activity	0.26	0.05	<0.0001	0.21	0.05	<0.0001	0.44	0.09	<0.0001
Number of minutes to get to grocery store									
< = 5 min	*reference*			*reference*			*reference*		
6–10 min	0.02	0.06	0.7267	0.04	0.07	0.5616	0.00	0.12	0.9946
11–20 min	0.02	0.05	0.6914	0.05	0.06	0.4547	−0.02	0.11	0.8708
>20 min	−0.06	0.06	0.317	−0.07	0.07	0.3713	0.00	0.12	0.9915
Mode of transportation to get groceries									
Drive own car	*reference*			*reference*			*reference*		
Ride with a friend or family member	0.01	0.06	0.8999	−0.01	0.06	0.9309	0.03	0.11	0.7803
Take the bus	0.00	0.08	0.9648	0.05	0.09	0.5833	−0.16	0.15	0.2966
Take a taxi	−0.26	0.09	0.0049	−0.37	0.13	0.0062	−0.19	0.13	0.1614
Walk or ride bicycle	−0.12	0.07	0.0844	−0.17	0.09	0.0534	−0.11	0.13	0.4195
Food insecurity									
Food secure	*reference*			*reference*			*reference*		
Mild/moderate insecurity	−0.03	0.05	0.5495						
Severe insecurity	−0.30	0.12	0.0155						
Vegetarian diet	0.20	0.07	0.0045	0.19	0.08	0.0284	0.21	0.13	0.1125

status are associated with mean daily FV intake in the ECS. However, results of our multivariate analyses did not support hypotheses regarding the relationship between the other two food environment dimensions explored: perceived *quality*, *availability*, and FV intake. Prior evidence is mixed in demonstrating relationships between food environment perceptions and FV intake, especially when considering variations in the characteristics of study populations and food environments, as well as in measurement of food environment, sample size, study design, etc. (Alber et al., 2018; Turner et al., 2021; Menezes et al., 2018; Flint et al., 2013; Coalition, 2016). Nonetheless, the current findings suggest food environment perceptions play an important role in FV intakes in the Eastern Caribbean, which warrants additional investigation. Efforts to support healthier dietary intakes in the region primarily involve fiscal policies to reduce unhealthy intakes for prevention of noncommunicable diseases (Alvarado et al., 2019; Coalition and Policies, 2019). Limited evidence suggest benefit (Alvarado et al., 2019), however, most efforts to date have not addressed structural factors like local food environment or characteristics influential for consumption of healthy foods. Few existing initiatives and interventions are specifically focused on policies to support healthy food environments to address childhood obesity (Francis et al., 2010; Franken et al., 2018; Sobers et al., 2021). Few efforts currently target broader food environments beyond schools, though emerging evidence demonstrates need (US Department of Agriculture, 2019).

To our knowledge, this study is the first of its kind in the Caribbean to examine characteristics of the local food environment and their association with dietary intakes (e.g., FV intake) across multiple islands. An important finding is the influence of food insecurity as a potential moderator in the association between FV intake and perceived affordability: the relationship between affordability and FV consumption was only significant among those who experienced food insecurity. We observed this relationship despite the existence of programs and policies in place to address food security in the region (FAO, 2011; Perez-Escamilla et al., 2018). Food assistance policies and programs should

be reexamined to ensure that they are designed to align with population needs and wants, are effective in reaching target communities, and help address nutritional gaps. These considerations are particularly important in the context of the ongoing nutrition transition (Murphy et al., 2018) in the Eastern Caribbean region. In parallel to strengthening safely net programs, initiatives to increase economic stability among those who experience food insecurity should also be explored.

The perceived lack of affordability of FV, moderated by food security, may be attributed to increased reliance on imported FV in the region (FAO, 2016; Beckford and Campbell, 2013). Evidence show increased reliance on imported foods (FAO, 2016; Beckford and Campbell, 2013) overall and lower market viability for local foods, including FV (Caribbean Public Health Association, 2015). As a consequence of high net importing, foods like FV are costly and may thereby affect food security (Beckford and Campbell, 2013; FAO, 2011; Ma et al., 2016). Perceived lack of affordability has implications for decreased food access (particularly among low-income individuals), poor dietary quality, and threats to food security (Hallen and Leung, 2018). Existing trade policies and pricing regulations may also contribute to food insecurity and unaffordability of FV in the region.

Finally, the results of our sensitivity analyses did not suggest any potential impact of excluded observations (n = 388) on study findings. This supports the robustness of our findings and provides confidence in the observed associations.

4.1. Limitations

This study was cross-sectional and therefore precludes the ability to establish causal or temporal relationships between perceptions of the food environment and FV intake. Our findings may only be generalizable to individuals 40 years and older in the Caribbean. The use of single-item questions to assess perceived affordability, availability, and quality of FV may have resulted in measurement error as these aspects of the food environment are influenced by multiple factors that may not be sufficiently captured through single-item questions. However, similarities in associations (data not shown) across the four Eastern Caribbean countries included in the ECS, as well as with prior studies that used different measures, (Blitstein et al., 2012; Alber et al., 2018) provide confidence in the validity of our measurement. This limitation highlights gaps in measurement and opportunities for future development of other measures. Our study also did not assess participants' geographic definition or conceptualization of their neighborhood. It is possible that there may be considerable variation in how neighborhoods are defined among participants. Further, although the dietary screener was systematically adapted for each island-nation, this instrument has not been validated for this population, and the algorithms used to calculate typical consumption have been derived from US populations. Therefore, the values for FV consumption indicated in this manuscript must not be interpreted alone as values of consumption but rather as a picture of exposure to food groups of interest in their association with food environment perceptions.

Despite these limitations, our study findings that perceived affordability is associated with FV consumption, and that this association is modified by food insecurity, are important contributions to the evidence base for the Eastern Caribbean region. These findings have implications for cardiovascular disease prevention and policies relevant to food security to support the creation of food environments where health-promoting foods are affordable (FAO, 2016).

5. Conclusions

This study examined the role of perceptions of the local food environment on FV intake in a population-based cohort of adults 40 years or older residing in the Eastern Caribbean. The results showed that perceived affordability is associated with consumption of FV in the Eastern Caribbean. Food insecurity emerged as a moderator of this association. Availability and quality, however, were not found to be associated with FV intake.

CRediT authorship contribution statement

Carol R. Oladele: Conceptualization, Methodology, Writing – review & editing. **Uriyoán Colón-Ramos:** Conceptualization, Methodology, Writing – review & editing. **Deron Galusha:** Methodology, Software, Formal analysis, Writing – review & editing. **Emma Tran:** Visualization, Writing – review & editing. **Oswald P Adams:** Investigation, Resources, Writing – review & editing. **Rohan G Maharaj:** Investigation, Resources, Writing – review & editing. **Cruz M Nazario:** Investigation, Resources, Writing – review & editing. **Maxine Nunez:** Investigation, Resources, Writing – review & editing. **Rafael Pérez-Escamilla:** Methodology, Writing – review & editing, Supervision. **Marcella Nunez-Smith:** Resources, Supervision, Writing – review & editing, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Disclaimer: The research presented in this paper is that of the authors and does not reflect the official policy of the NIH.

This research was supported by the National Institute on Minority Health and Health Disparities through the Yale Transdisciplinary Collaborative Center for Health Disparities Research focused on Precision Medicine (Yale-TCC)–U54MD010711 and the National Heart, Lung, and Blood Institute through career development award K01HL145347.

The content presented in this manuscript has not been previously presented.

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