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

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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 (ECHORN) 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...
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., 2015). 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 (Deroze 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., 2016; 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 ECHS 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 in Puerto 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..."
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; Nummery 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 |                  |        |       |
| 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      |                  |        |       |
| Male     | 686              | 35.0   | 1.19  | 0.86  |
| Female   | 1276             | 65.0   | 1.45  | 0.95  |
| Education|                  |        |       |
| 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 |      |        |       |
| 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      |                  |        |       |
| Underweight/Normal | 513 | 26.2   | 1.35  | 0.98  |
| Overweight| 799              | 36.1   | 1.39  | 0.92  |
| Obese    | 740              | 37.7   | 1.34  | 0.89  |
| Physical Activity |                |        |       |
| Low physical activity | 895 | 45.6   | 1.25  | 0.87  |
| Moderate physical activity | 364 | 18.6   | 1.42  | 0.90  |
| High physical activity | 763 | 35.8   | 1.47  | 0.99  |
| Vegetarian | 146             | 7.4    | 1.58  | 1.09  |
| Non-Vegetarian | 1816           | 92.6   | 1.34  | 0.91  |
| Food Insecurity |            |        |       |
| 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 were between 50 and 69 years, 65 percent had a high school education or higher, and most (42%) 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 = 0.91) 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| <0.0001 |
| Never/Rarely/Sometimes                 | 663 | 33.8 | 1.22  | 0.90|         |
| Usually/Always                         | 1299| 66.2 | 1.43  | 0.93| 0.2752  |
| Fruits and Vegetables Available        | 732 | 37.3 | 1.33  | 0.93|         |
| Usual/Always                           | 1230| 62.7 | 1.38  | 0.92|         |
| Fruits and Vegetables High Quality     | 775 | 39.5 | 1.31  | 0.93| 0.0385  |
| 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                       | reference     |     |         |
| 6–10                     | 0.05          | 0.06| 0.3693  |
| 11–20                    | 0.07          | 0.05| 0.1703  |
| >20                      | −0.03         | 0.06| 0.678   |
| Mode of transportation to get grocisko | reference |     |         |
| 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  |

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
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 intake 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 intake.

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...

### Table 4

| Beta estimate | SE  | p-value | Beta estimate | SE  | p-value | Beta estimate | SE  | p-value |
|---------------|-----|---------|---------------|-----|---------|---------------|-----|---------|
| Fruits and Vegetables Affordable | Never/Rarely/Sometimes | reference | No food insecurity | reference | 0.11 | 0.05 | 0.0224 | 0.05 | 0.06 | 0.3737 | 0.27 | 0.09 | 0.0026 |
| Usually/Always | reference | 0.06 | 0.5292 | 0.07 | 0.07 | 0.2571 | 0.06 | 0.11 | 0.554 |
| Fruit and Vegetables Available | Never/Rarely/Sometimes | reference | No food insecurity | reference | 0.02 | 0.06 | 0.6913 | 0.07 | 0.07 | 0.3328 | -0.09 | 0.10 | 0.4066 |
| Usually/Always | reference | 0.06 | 0.5223 | 0.04 | 0.06 | 0.5118 | -0.02 | 0.09 | 0.8399 |
| Fruits and Vegetables High Quality | 70+ | 0.28 | 0.07 | <0.0001 | 0.26 | 0.08 | 0.0005 | 0.27 | 0.21 | 0.1988 |
| Age group | Sex | Male | reference | 0.03 | 0.05 | 0.5223 | 0.04 | 0.06 | 0.5118 | -0.02 | 0.09 | 0.8399 |
| Married | reference | Single | reference | 0.14 | 0.06 | 0.0141 | 0.13 | 0.07 | 0.049 | 0.17 | 0.11 | 0.1381 |
| Separated/Divorced | Widowed | 0.02 | 0.08 | 0.7618 | <0.0001 | 0.26 | 0.08 | 0.0005 | 0.27 | 0.21 | 0.1988 |
| BMI | Less than high school | reference | High school | reference | 0.08 | 0.05 | 0.1411 | 0.08 | 0.06 | 0.2122 | 0.03 | 0.11 | 0.7839 |
| Some college | College + | 0.11 | 0.06 | 0.047 | 0.05 | 0.07 | 0.4208 | 0.25 | 0.11 | 0.0186 |
| Marital Status | Married | reference | Single | reference | -0.04 | 0.04 | 0.3879 | -0.06 | 0.05 | 0.2408 | 0.04 | 0.10 | 0.6804 |
| Separated/Divorced | Widowed | 0.01 | 0.07 | 0.8454 | -0.04 | 0.08 | 0.5715 | 0.08 | 0.14 | 0.5635 |
| Physical Activity | Physical Activity | reference | Moderate physical activity | reference | 0.15 | 0.05 | 0.0052 | 0.14 | 0.06 | 0.022 | 0.20 | 0.12 | 0.0961 |
| High physical activity | reference | 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 | 0.02 | 0.06 | 0.7267 | 0.04 | 0.07 | 0.5616 | 0.00 | 0.12 | 0.9946 |
| 6–10 min | 0.02 | 0.05 | 0.6914 | 0.05 | 0.06 | 0.4547 | <0.02 | 0.11 | 0.8708 |
| 11–20 min | -0.06 | 0.06 | 0.317 | -0.07 | 0.07 | 0.3713 | 0.00 | 0.12 | 0.9915 |
| Drive own car | reference | 0.01 | 0.06 | 0.8999 | -0.01 | 0.06 | 0.9309 | 0.03 | 0.11 | 0.7803 |
| Mode of transportation to get groceries | Ride with a friend or family member | reference | Take the bus | reference | 0.00 | 0.08 | 0.9648 | 0.05 | 0.09 | 0.5833 | -0.16 | 0.15 | 0.2966 |
| Take a taxi | Walk or ride bicycle | -0.26 | 0.09 | 0.0049 | -0.37 | 0.13 | 0.0062 | -0.19 | 0.13 | 0.1614 |
| Food insecurity | reference | 0.12 | 0.07 | 0.844 | -0.17 | 0.09 | 0.0034 | -0.11 | 0.13 | 0.4195 |
| Food secure | reference | Mild/moderate insecurity | reference | -0.03 | 0.05 | 0.5495 | -0.03 | 0.05 | 0.5495 |
| Severe insecurity | Vegetarian diet | -0.30 | 0.12 | 0.0155 | 0.20 | 0.07 | 0.0045 | 0.19 | 0.08 | 0.0284 | 0.21 | 0.13 | 0.1125 |
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, (Bliststein 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. Uriyóan 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.

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References

Alber, J.M., Green, S.H., Glanz, K., 2018. Perceived and Observed Food Environments, Eating Behaviors, and BMI. Am. J. Prev. Med. 54 (3), 423-429.
Alvarado, Miriam, Kostova, Deliana, Subrcke, Marc, Hambleton, Ian, Hassell, Trevor, Samuels, T. Afiafa, Adams, Jean, Unwin, Nigel, 2017. Trends in beverage prices following the introduction of a tax on sugar-sweetened beverages in Barbados. Prev. Med. 105, 523–525.
Alvarado, Miriam, Unwin, Nigel, Sharp, Stephen J., Hambleton, Ian, Murphy, Madhuvani M., Samuels, T. Afiafa, Subrcke, Marc, Adams, Jean, 2019. Assessing the impact of the Barbados sugar-sweetened beverage tax on beverage sales: an observational study. Int. J. Behav. Nutr. Phys. Activity 16 (1), https://doi.org/10.1186/s12966-019-0776-7.
Beckford, Clinton L., Campbell, Donovan R. (Eds.), 2013. Domestic Food Production and Food Security in the Caribbean. Palgrave Macmillan US, New York.
Bliststein, J.L., Snyder, J., Evans, W.D., 2012. Perceptions of the food shopping environment are associated with greater consumption of fruits and vegetables. Public Health Nutr. 15 (6), 1124-1129.
Boehn, H., Bchthold, A., Bub, A., Ellinger, S., Haller, D., Kroke, A., Leschik-Bonnet, E., Müller, M.J., Obrętter, H., Schulz, M., Stehle, P., Warl, B., 2012. Critical review: vegetables and fruit in the prevention of chronic diseases. Eur. J. Nutr. 51 (6), 637-663.
Healthy Caribbean Coalition. Accelerating Nutrition Policies in the Caribbean-Creating Supportive Environments for Healthy Children https://www.healthycaribbean.org/accelerating-nutrition-policies-in-the-caribbean/. Published 2019. Accessed July 1, 2020.
Coalition HC. The Implementation of Taxation on Sugar-Sweetened Beverages by the Government of Barbados. 2016.
Caribbean Public Health Association, 2015. Promoting Healthy Diets, Food Security and Sustainable Development in the Caribbean through Joint Policy Action. CARPHA, Trinidad.
Colón-Lopez, V., Banerjee, G., Gertz, A.M., et al., 2013. Behavioral correlates of fruit and vegetable intake in Puerto Rico: results from the Health Information National Trends Survey. P R Health Sci J. 32 (4), 194-199.
Cunningham-Myrie, Colette Andrea, Younger, Novie O, Theall, Katherine P, Greene, Lisa-Gaye, Lyew-Ayee, Parris, Wilks, Rainford, 2020. Understanding neighbourhood retail food environmental mechanisms influencing BMI in the Caribbean: a
