

# Factors related to poor diet quality in food insecure populations

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## Abstract

It is well-known that consumption of nutrient-rich foods, especially fruits and vegetables, are low among food insecure populations. While cost is an important reason for these inadequate diets, underlying factors such as poor food purchase and management behaviors, and low levels of psychosocial factors that motivate dietary improvements, may exacerbate food insufficiency among the food-insecure. In this analysis, we examine these underlying factors across food-secure and food-insecure populations in Texas. Data on self-reported food insecurity, dietary practices, behaviors related to food purchase and management, and psychosocial factors related to food were obtained from a survey administered to a convenience sample of SNAP-eligible adults ( $n = 1,171$ ) ages 18 and older, drawn from multiple low-income areas across the state of Texas in 2018 over two survey rounds. Mixed linear regression models adjusting for zip code as a random effect were used to compare mediators of diet across food-insecure and food-secure participants. Using the binary categories defined by the U.S. Household Food Security Survey Module scale 753 participants (64.3% of the sample collected) were classified as food insecure. Food insecure participants had notably unhealthier diet profiles, with significantly lower ( $p < .001$ ) frequency and average serving size of fruit and vegetable consumption. They were also less likely to use food labels to make food choices ( $p < .001$ ), and to cook a meal at home ( $p = .008$ ). In contrast, differences across food secure and food insecure households in planning meals before going shopping, and making lists were much smaller. Finally, levels of various psychosocial precursors of healthy eating were also lower among food insecure participants, including self-efficacy for healthy eating ( $p = .014$ ), self-efficacy to plan meals with vegetables ( $p = .048$ ), and stage of change of fruit and vegetable consumption ( $p < .001$ ). Overall, eating habits, specific food procurement and preparation practices, and levels of psychosocial precursors of healthy eating are significantly poorer among food insecure populations compared with food-secure low-income participants. Our results point to specific behaviors that can be targeted in educational and skill building interventions seeking to address poor dietary practices among the food insecure.

## Keywords

Diet, Food Insecurity, Low-income, SNAP-Ed, psychosocial factors, food purchase

## INTRODUCTION

The defining characteristic of food insecurity, a social and economic measure of poverty, is limited or uncertain access to adequate food [1]. However, the

## Implications

**Practice:** This study identifies diet behaviors and factors affecting these behaviors in a low-income, high-risk population, as well as important targets for behavioral interventions.

**Policy:** Policymakers looking to decrease the prevalence of food insecurity need to look at psychosocial measures that mediate food procurement and consumption choices.

**Research:** Future research should look for evidence of a temporal relationship between psychosocial measures that mediate food procurement and consumption choices and food insecurity.

most common manifestation of food insecurity in the USA is not food inadequacy; rather, it describes reduced intake of nutritionally adequate and safe food [2]. A 2014 review of the literature showed consistent inverse associations of food insecurity with intake of nutrient-rich foods such as fruit, vegetables, and dairy [3]; at the same time, consumption of energy dense foods such as high-fat dairy products, salty snacks, and sugar-sweetened beverages is higher among food insecure participants [4,5]. The most likely explanation for these imbalanced diets lies in the differentials in the cost per serving of nutrient-dense versus energy dense foods [6,7], and the fact that food insecurity closely tracks poverty levels. Indeed, the consumption of low-cost diets that are energy-dense, rather than nutrient-dense, is widely hypothesized to explain the higher rates of obesity and chronic disease observed in food-insecure populations [8,9]. Not surprisingly, food insecurity is associated with specific food shopping practices that are driven by efforts to reduce costs of food procurement. Very low food-secure adults are most likely to use convenience stores, which tend to be more accessible, but typically stock foods with the poorest diet quality profile [10]. Some research suggests that participants with very low food security make fewer shopping trips (with implications for purchase of fresh produce) and travel fewer miles food shopping

than food secure populations [11]; however, in other studies, frequency of food shopping is higher among food-insecure women [12]; moreover, food insecure women may be more likely to engage in some degree of food price comparison across stores [13].

Apart from food shopping behaviors motivated by cost considerations, literature on other modifiable food-related behaviors and attitudes that affect food procurement and purchase among the food-insecure (e.g., utilization of food pantries or SNAP benefits, planned shopping) is scant, and typically limited to small, socio-demographically focused samples [5, 11, 13, 14], with limited generalizability. Other mechanisms that could present amenable targets for policy and/or behavioral interventions include psychosocial variables that mediate food procurement and consumption choices, such as knowledge about healthy eating, cooking skills and self-efficacy related to fruit and vegetable intake. Studies that have examined one or more of such psychosocial measures [15–18] consistently show lower levels of cooking or consumption self-efficacy among the food-insecure; nevertheless, the majority of these studies do not examine if variation in these psychosocial measures explains diet quality within food-insecure populations.

This article is motivated by an attempt to address some of these important gaps in our knowledge. Despite the existence of over a dozen federal programs and hundreds of state-specific programs in the USA to alleviate food insecurity, over one in nine households (11.8%) is classified as food-insecure [19]. A more nuanced understanding of the behavioral and demographic characteristics associated with food insecurity may offer insights that help policymakers refine and alter the ways in which we address the issue. We hypothesized that food-insecure respondents would show poorer diet quality and lower levels of positive food procurement-related behaviors and psychosocial attitudes than low-income respondents that were food-secure, and that further, that these associations would mediate the diet quality gap across food-secure and food-insecure participants. To examine these hypotheses, we utilized self-reported survey data obtained from a large sample of low-income participants from across the state of Texas, a state in which one in six residents is food-insecure.

## METHODS

### Recruitment of survey participants

Data for this study were obtained during two waves of data collection, in Spring 2018 and Fall 2018, respectively, as part of a larger study evaluating SNAP-Ed (Supplemental Nutrition Assistance Program-Education) in Texas. SNAP-Ed is a federally funded grant program that supports a variety of direct nutrition education programs as well as public health approaches to improve nutrition. It targets

low-income persons and households who meet the income and resource limits to qualify for federal food assistance and benefits through the SNAP program. SNAP-Ed funding in Texas is administered to seven implementing agencies serving socioeconomically disadvantaged populations throughout the state through a variety of nutrition and physical activity educational programs.

The protocol for data collection was approved by the Institutional Review Board at UTHealth School of Public Health (Approval Number: HSC-SPH-17-0205). Survey participants were a convenience sample of adults recruited from SNAP-Ed classes administered in multiple low-income communities across the state of Texas. Metropolitan areas represented in the sample include Austin, Houston, Dallas, San Antonio, El Paso, and Brownsville; peri-urban areas outside these cities where SNAP-Ed classes were offered were also included. Approval for data collectors to recruit participants from the SNAP-Ed funded classes was sought first at the implementing agency, and subsequently at the administering site, as a single SNAP-Ed implementing agency typically administers classes at multiple sites and times, in response to request from those sites. These sites included recreation centers, senior centers, senior housing centers, low-income housing apartments, elementary and middle schools, food pantries, community centers, libraries, food banks, clinics, and grocery stores. Whenever possible, the site manager or coordinator was informed of the data collectors' impending visit at least 2 weeks in advance. Prior to being out in the field, all data collectors went through a comprehensive training of the survey tool and administration protocol, to ensure consistency across data collectors in the field. This process included self-administration of the survey, shadowing a senior research assistant in the field, and utilizing various checklists to deal with exception-handling.

A verbal description of study details was provided by data collectors to prospective participants, either in a group or singly, depending on the educational setting. Depending on number of staff available, one to four data collectors were present at each class site, and always included a senior research assistant. Adults who expressed an interest in participating were provided the survey questionnaires and assent forms. Although the surveys underwent two rounds of cognitive testing prior to administration, a small subgroup of older adult participants experienced difficulties in understanding some of the questions. In such cases, data collectors provided clarification on specific questions. Furthermore, some of these adults required data collectors to read the entire survey out loud to them due to lack of eyesight, inability to read and understand, or inability to write. When data collectors had to read the survey aloud, the participant

was led to the back of the class or space to ensure the maximum amount of privacy. The survey took an average of 15 min to complete, and was available in either English or Spanish to participants. Participants who completed the survey were given (or mailed) a small educational gift as compensation for their time.

In all, the surveys were administered to 1,526 adults aged 18 and older, drawn from urban or semi-urban areas across Texas. Although all participants were recruited from SNAP-Ed classes serving low-income areas, about a quarter of the participants ( $n = 355$ ) exceeded the income cutoffs defining eligibility for SNAP benefits. These were dropped from the analytic sample in order to limit the sample to low-income residents of the surveyed area ( $n = 1,171$ ) and rule out possible confounding from behaviors and attributes specific to higher-income sample members.

#### Measures of key exposures, outcomes, and covariate measures

##### *Exposure*

*Food security status*, the primary independent variable in this analysis, was determined using the U.S. Department of Agriculture Household Food Security Six-Item Food Security Scale. This scale was developed by researchers at the National Center for Health Statistics in collaboration with Abt Associates Inc. as a condensed version of a longer 18-item U.S. Household Food Security Survey Module, and is considered to be an acceptable substitute, as it can identify food-insecure households and households with very low food security with reasonably high specificity and sensitivity and minimal bias compared with the 18-item measure [20]. For this study, food security status was dichotomized into two categories following USDA guidelines: *food secure* (high or marginal food security) and *food insecure* (low food security and very low food security).

##### *Primary outcome*

*Diet quality* was examined as the primary outcome in these analyses. Diet quality was assessed with questions adapted from a Food and Physical Activity Questionnaire that is widely used across the USA by the federally funded Expanded Food and Nutrition Education Program (EFNEP), with similar resource-limited populations [21,22]. Participants were asked how many days in the past week they had consumed each of a selected set of nutrient-dense and energy-dense index foods, including: fruit, vegetables, whole wheat bread, low fat milk, fries/chips, sugary beverages, and sweetened cereal. These frequency measures were supplemented with questions relating to amount of fruits and vegetables eaten per day, drawn from a validated questionnaire [23].

##### *Secondary outcomes*

Two sets of secondary outcomes related to healthy eating, that is, potential mediators, were identified, as follows:

- (i) *Behaviors related to food procurement and preparation*: Specific behaviors related to purchase of foods were ascertained with questions drawn from published resources [21,22]. Respondents were asked, on a six-point Likert scale ranging from never to always, how often they (a) compared food prices, (b) planned meals in advance, (c) made a list before shopping, and (d) read food labels. Measures related to food preparation ascertained by asking participants how many days per week (ranging from 0 to 6 or 7) they (a) ate a home-cooked meal and (b) cooked a meal at home. All behaviors related to food procurement and preparation were specified as continuous measures in models, except for the measures relating to utilization of low-cost food sources, which were scored as binary variables.
- (ii) *Psychosocial attitudes related to healthy eating*: Respondents indicated their degree of agreement with each of the following measures of *self-efficacy related to healthy eating* (a) I can plan meals or snacks with more fruit, (b) I can plan meals with more vegetables, and (c) I can eat two or more servings of vegetables at dinner. Two questions measured respondents' perceived stage of change of consumption of fruits and of vegetables, respectively. One stage of change question pertained to overall healthy eating, that is, "I eat and drink healthy foods and don't need to change." Response options for each of these questions were presented along an ordinal scale, and the resulting variables were specified as continuous for modeling purposes.

##### *Demographic covariates*

*Race/ethnicity* was assessed by allowing respondents to check one of nine race/ethnicity categories, including a category to indicate multiple races. Responses were combined into three categories: Hispanic, Non-Hispanic Black, and Non-Hispanic White/Other racial-ethnic groups. *Language spoken at home* was classified as *English* or *Other language*, with the other language assigned only if the respondent indicated that no English was spoken at home. Three categories of *Educational Level*, that is, high school or less, beyond high school but no college degree, and college degree were obtained by collapsing responses to a six-category nominal variable. Categories for the *Household monthly income* variable were defined by cutoffs corresponding to eligibility criteria for SNAP benefits, and included income from child support, alimony, disability, social security, etc. Household monthly income was classified into three levels: <\$1,005, \$1,006–\$1,354, and >\$1,355, to ensure sufficient sample size at each level. Four *age* categories were defined: 18–34, 35–44, 45–60, and 61 or more; again, these cutoffs

were utilized to ensure sufficiency of sample size at each level. *Presence of children aged 0–18 years* was ascertained by asking participants to enumerate the number of children in their household in each of several age categories spanning 0–18. Answers to these were used to generate a binary variable indicating whether or not there was at least one child age 0–18 years in the participant's household. *Household size* was assessed by the question: "How many people live in your household? Include yourself when counting." The variable was assessed for consistency by comparing with the variable on presence of children, and values set to missing where responses were inconsistent. The cleaned variable was classified into four categories, corresponding to household sizes of one, two to three, four to five, and six or more. Respondents were also asked (a) if they had used food pantries or food banks in the preceding 12 months and (b) if they had utilized SNAP benefits/food stamps in the preceding 12 months. Finally, zip codes where participants resided were coded as being food deserts or not, according to USDA's Food Access Research Atlas [24].

#### Statistical analysis methods

Descriptive statistics were obtained as frequency distributions of key demographic variables for the full sample and by food-security status, with Chi-square tests used to indicate distributional differences in demographic composition by food-security status. Estimated means for each of the primary outcomes (diet quality measures), as well as each of the secondary measures (food procurement/preparation and psychosocial attitudes) were obtained for food-secure and food-insecure participants via mixed effects regressions. *Primary outcomes* examined included: days per week that each of fruit, vegetables, whole wheat bread, low fat milk, fries/chips, sugary beverages, and sweetened cereal were consumed; and average daily servings of fruit and vegetables, all measured on a continuous scale. *Secondary outcomes pertaining to food procurement and preparation* included: frequency of comparing food prices, planning meals in advance, making a list before shopping, reading food labels, cooking, and eating a full meal at home, as well as use of food banks/pantries and utilization of SNAP benefits in the past year. *Secondary psychosocial measures* included: self-efficacy for healthy eating, stage of change of fruit and vegetable consumption, self-efficacy for planning healthy meals, and self-efficacy for consumption of vegetables.

Mixed effect regression models controlled for all demographic confounders (age, gender, race/ethnicity, language spoken at home, educational level, income, number of children and household size, and food desert status), and adjusted for zip code of residence as a random effect, to account for unmeasured spatial disparities in access to food resources, as well as possible segregation by poverty levels. To

examine the extent to which secondary outcomes served as mechanisms explaining diet quality gap across food-secure and food-insecure participants, marginal effects from additional adjusted mixed-effects regressions were examined to determine the extent to which the magnitude of such gaps were reduced by inclusion of one or more of the secondary outcomes in the models. The threshold for statistical significance was set at a value of  $p < .05$ , across all models. All analyses were carried out using Stata 15.1 (StataCorp, College Station, TX, USA).

#### RESULTS

The demographic and socioeconomic composition of the total sample and by food-security status described in Table 1, shows that this low-income population is largely Hispanic (75%). Up to a quarter of the sample spoke a language other than English at home, suggesting a substantial proportion of first-generation immigrants. Respondents were mostly female (90%), and over three-quarters were age 35 or older. A little over half the respondents had a child <18 years of age in the household, and about half had a household size of 4 or more. Less than 40% of participants had a high school education or better, and nearly half the sample had a monthly household income of less than \$1,000. For the most part, these tabulations point to a very comparable demographic composition across food-secure and insecure-populations, but with notable exceptions. The food insecure population has a larger proportion of non-Hispanic Whites and respondents that speak English at home, and two indirect socio-economic indicators, use of SNAP benefits and use of food banks/pantries, show greater levels of socioeconomic disadvantage in the food-insecure population. Half of all participants reside in a zip code characterized as a food desert, with little difference by food security status.

Food insecurity, as defined in these analyses, is clearly associated with less healthy dietary behaviors, as evidenced by Fig. 1. While these differences are especially striking with regard to frequency of fruit and vegetable consumption, which are both significantly lower in food-insecure populations (nearly a day less in the case of fruit and half-a-day less in the case of vegetables), it is clear that this group has lower frequency of consumption of a variety of healthy foods. The average daily number of servings of both fruit and vegetables are also significantly lower (.44 fewer servings of fruit per day and .43 fewer servings of vegetables per day) in food-insecure participants. With regard to energy-dense foods, such as sugary beverages and cereal, consumption frequency is relatively high across both groups, and very comparable in magnitude. Estimates presented in Fig. 1 are controlled for demographic and socioeconomic covariates,

**Table 1** | Demographics of sample by SNAP eligibility and food insecurity

	All	SNAP eligible, food secure	Food insecure	p Value
Sample size	1,171	418 (27.4)	753 (49.3)	
<b>Ethnicity</b>				
Hispanic	874 (75.1)	82.0	71.2	
Non-Hispanic Black	113 (9.7)	7.0	11.2	
Non-Hispanic White	177 (15.2)	11.0	17.5	<0.001
<b>Language spoken at home</b>				
English	867 (74.6)	70.7	76.7	
Other language	296 (25.5)	29.3	23.3	0.024
<b>Education level</b>				
High School or less	721 (63.52)	63.2	63.7	
Beyond high School	285 (25.11)	25.4	24.9	
Has college degree	129 (11.37)	11.4	11.4	0.982
<b>Monthly income</b>				
Less than \$1,005	531 (46.6)	47.1	46.3	
\$1,006–\$1,354	266 (23.4)	25.1	22.3	
\$1,355 or more	342 (30)	27.8	31.4	0.358
<b>Age group</b>				
18–34	278 (24.4)	23.5	24.9	
35–44	290 (25.5)	27.7	24.3	
45–60	247 (21.7)	18.9	23.3	
61 or older	323 (28.4)	29.9	27.5	0.231
<b>Gender</b>				
Male	110 (9.4)	9.8	9.2	
Female	1,060 (90.6)	90.2	90.8	0.722
<b>Has child under years</b>				
No	519 (44.3)	45.5	43.7	
Yes	652 (55.7)	54.6	56.3	0.561
<b>Household size</b>				
1 member	183 (16.1)	15.2	16.6	
2–3 members	345 (30.3)	33.8	28.3	
4–5 members	419 (36.8)	36.8	36.8	
6 or more members	192 (16.9)	14.2	18.3	0.136
<b>Received SNAP benefits in past year</b>				
No	515 (48.1)	51.7	46.1	
Yes	555 (51.9)	48.3	53.9	0.081
<b>Used food bank in past year</b>				
No	651 (63.6)	73.9	57.9	
Yes	373 (36.4)	26.1	42.1	<.001
<b>Lives in a food desert</b>				
No	588 (51.0)	50.6	51.1	
Yes	566 (49.0)	49.4	48.9	<.087

suggesting that the observed dietary behaviors are not completely explained by these factors.

Tables 2 and 3 examine differences in secondary outcomes that are related to, but upstream of, food consumption. Differences in food procurement and preparation behaviors by food-security status, presented in Table 2, are not as consistent as differences in diet. Consistent with the literature, food insecure populations are significantly more likely to utilize cost-saving practices such as comparing food prices. Surprisingly, they are less likely than

food-secure participants to cook or eat a home-cooked meal. There is little difference between food secure and food insecure participants in anticipatory behaviors, such as meal planning or making a list before shopping. Food insecure participants are significantly less likely to read food labels, suggesting that nutrient information is perceived by them as less relevant. Table 3 shows that a number of well-recognized psychosocial mediators of healthy diet, including healthy food self-efficacy, stage of fruit and vegetable consumption, and self-efficacy with



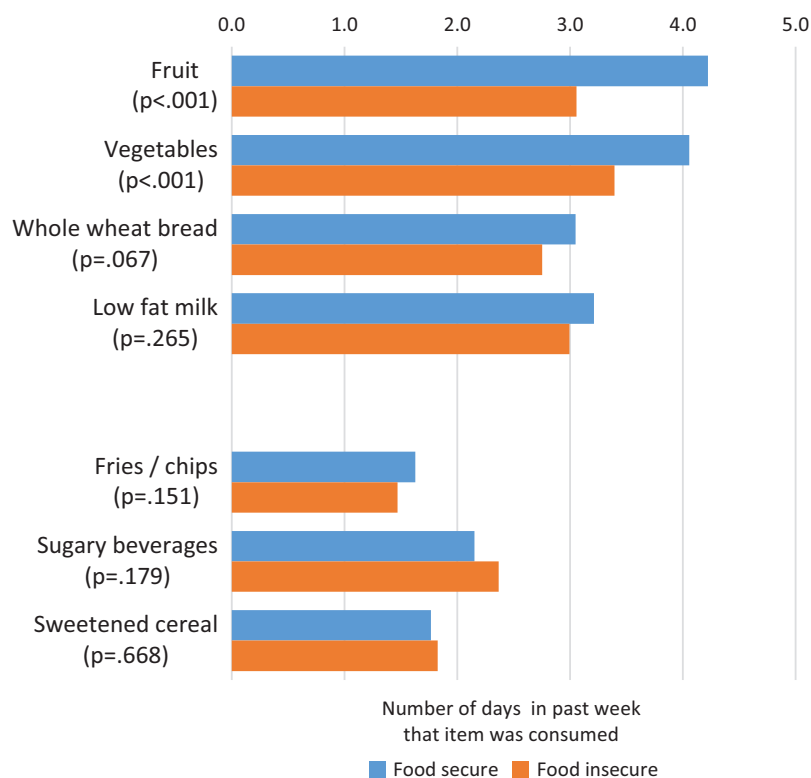


Fig 1 | Weekly frequency of consumption of index food groups in a low-income population, by food security status

Table 2 | Behaviors related to food procurement and preparation by food insecurity

	Food secure	Food insecure	Gap	p Value
How often do you compare food prices	2.06	2.24	0.18	0.01
How often do you plan meals in advance	1.79	1.76	-0.03	0.727
How often do you make a list before shopping	1.81	1.76	-0.05	0.535
How often do you read food labels	1.42	1.24	-0.18	0.024
How many days do you eat a home cooked meal	6.07	5.82	-0.26	0.025
How many days do you cook	5.97	5.67	-0.30	0.009

regard to consuming and serving fruit and vegetables, are significantly higher in food secure populations than in food-insecure populations.

Although the behaviors and attitudes described in Tables 2 and 3 are conceptually considered to be upstream of dietary behaviors, little is known of their relative importance as mechanisms. Table 4 examines the effect of each of these potential mechanisms on reducing the diet quality gap between food-secure and food-insecure on salient measures of diet quality, after adjusting for confounders. As described in Fig. 1 and the accompanying text, the largest gaps were in the weekly frequency and daily servings of fruit and vegetable consumption. Accordingly, Table 4 is limited to these four measures of diet.

The results are striking. Of the procurement/purchase behaviors, preparation and consumption of home cooked meals have the largest impact on reducing the food security gap in frequency of vegetable

consumption and frequency of fruit consumption. These behaviors, however, do not noticeably impact the gap in amounts of fruit and vegetables consumed. Comparing prices, paradoxically, increases the food security gap, supporting previous literature that this is a common behavior associated with food insecurity. For all outcomes, the largest reductions are seen when all purchase and procurement behaviors are included in the models. Overall, adjusting for psychosocial measures was more effective than adjusting for procurement/purchase behaviors in reducing the food security gap, from 1.16 to 0.91 for vegetable frequency; 0.66 to 0.38 for fruit frequency when adjusting for psychosocial measures, and 1.16 to 1.08 for vegetable frequency; 0.66 to 0.50 for fruit frequency when adjusting for psychosocial measures. Stage of readiness with regard to consuming and serving fruit and vegetables were particularly important measures in reducing the food security gap in each of the four outcomes examined.

**Table 3** | Psychosocial measures related to healthy eating

	Food secure	Food insecure	Gap	p Value
I eat and drink healthy foods and don't need to change	1.74	1.59	-0.15	0.021
Stage of fruit consumption	2.96	2.65	-0.31	<0.001
Stage of vegetable consumption	2.95	2.66	-0.28	<0.001
I can plan meals or snacks with more fruit	3.14	2.95	-0.19	0.01
I can eat two or more servings of vegetables at dinner	3.13	2.99	-0.14	0.068
I can plan meals with more vegetables	3.20	3.05	-0.14	0.05

**Table 4** | Food security gap in diet measures before and after adjusting for food-related behaviors and attitudes

	Frequency of fruit consumption	Frequency of vegetable consumption	Average daily servings of fruit	Average daily servings of vegetable
Adjusted for all demographic and socioeconomic confounders	-1.16	-0.66	-0.44	-0.45
How often do you compare food prices	-1.21	-0.70	-0.45	-0.46
How often do you plan meals in advance	-1.15	-0.62	-0.44	-0.44
How often do you make a list before shopping	-1.15	-0.62	-0.44	-0.44
How often do you read food labels	-1.15	-0.57	-0.42	-0.41
How many days do you eat a home cooked meal	-1.09	-0.59	-0.42	-0.43
How many days do you cook	-1.10	-0.59	-0.42	-0.41
Adjusted for all procurement/preparation behaviors	-1.08	-0.50	-0.40	-0.39
I eat and drink healthy foods and don't need to change	-1.13	-0.62	-0.41	-0.42
Stage of fruit consumption	-0.92	-0.45	-0.37	-0.37
Stage of vegetable consumption	-1.01	-0.46	-0.40	-0.36
I can plan meals or snacks with more fruit	-1.14	-0.64	-0.42	-0.42
I can eat two or more servings of vegetables at dinner	-1.16	-0.62	-0.44	-0.42
I can plan meals with more vegetables	-1.16	-0.65	-0.43	-0.42
Adjusted for all psychosocial variables	-0.91	-0.39	-0.36	-0.34
Adjusted for all psychosocial and behavioral variables	-0.89	-0.31	-0.34	-0.30

## DISCUSSION

While several studies describe diet quality among low-income and/or food insecure populations, there is little discussion in the literature of behavioral and psychosocial measures that explain the persistence of these outcomes. The findings presented in this study go a considerable way in addressing this gap.

First, we found that even within a low-income sample, people that are food insecure have significantly poorer diets than those that are food secure, with lower frequency and amount of fruit and vegetable consumption. Food insecurity as defined in this study is a temporary state, and it is documented that people move in and out of food insecurity [25,26]. Our findings strongly suggest that during periods of food insecurity, low-income populations are particularly vulnerable to poor diets. People that are food insecure become less likely to consume fruits and vegetables, not surprisingly, given the cost

of these items. Indeed, consumption of sugary beverages and fried snacks is comparable across both low-income groups, likely reflecting the fact that these foods are cheap and ubiquitous.

Second, we identified important modifiable behavioral and psychosocial factors, outside of cost, that are identified with being low income or food insecure. Across low-income people, regardless of food security status, the prevalence of planning behaviors related to buying and preparing food is low. In addition, food insecure participants are less likely to study food labels. While food insecure participants are more likely to be price-sensitive and engage in comparison shopping, this behavior may in fact lead to purchase of low-nutrient foods that are less costly. Frequency of cooking at home or eating a home-cooked meal is relatively high across both groups, but lower in food insecure participants. Lower frequency of cooking/eating at home may

reflect differentials in knowledge, facilities and time, as well as greater reliance on outside sources of food, such as food banks and pantries. Gaps in psychosocial predictors of healthy eating, including measures of self-efficacy and perceived stage of readiness to eat fruit and vegetables, are especially large across food-secure and food insecure participants.

Our results show that these factors do indeed help explain a substantial part of the dietary gap observed between food secure and food insecure populations. Among the behavioral factors, we found that home cooking clearly reduces the gap, but beyond cooking, adjusting for all behaviors related to procurement and preparation substantially reduced the gap. Likewise, large reductions in the gap were seen after adjustment for various psychosocial measures, particularly stage of readiness to consume fruit and vegetables. Overall, psychosocial factors were more effective in reducing the gap than behavioral factors.

This study has many unique strengths. Most important of all, the comparisons of interest (i.e., across food secure and food insecure participants) are conducted within a low-income sample; thus, explanations of behaviors and attitudes that are primarily attributable to higher income are ruled out by design. An additional strength of this study is the inclusion of a large number of relevant demographic characteristics as confounders. While a number of studies have identified personal-level socio-demographic factors that are strongly associated with food insecurity, such as race and ethnicity [27,28]; household structure, with single-headed households at highest risk [19]; and children in the household [3,29], few studies include as many demographic variables as our study. Adjustment for a wide variety of demographic and socioeconomic covariates reduces the possibility of residual confounding. Finally, this study is unique in examining both dietary outcomes as well as behaviors and attitudes that may mediate such outcomes. These strengths outweigh the primary limitation of the study, that is, that it is cross-sectional, and especially in the case of psychosocial attitudes, cannot affirm that attitudes are upstream of dietary behaviors. However, the use of multiple indicators of attitudes and consistent findings across these lends a measure of plausibility to the results.

In conclusion, this is an important study in that it identifies diet behaviors and factors affecting these behaviors in a low-income, high-risk population. In doing so, it identifies important targets for behavioral interventions, as well as points to a need to support these behavioral and psychosocial targets by larger societal changes that directly affect factors of cost, access, and availability.

#### TRANSLATIONAL IMPLICATIONS

While these data show gaps in healthy food consumption in low income populations, it is important

to note that levels of healthy eating were low across the entire population. Systemic factors such as cost, access and availability need to be comprehensively addressed to increase the consumption of healthy foods in low-income populations. While such programs do exist, in the form of subsidized food banks and pantries and a variety of small farms markets, our data suggest that substantial segments of the population do not necessarily use these programs. While geographically targeted programming to increase availability of healthy food is necessary, our results point to the need for research to examine barriers to utilizing such programs when they are available. Our results showing that procurement behaviors and psychosocial attitudes explain at least some of the gaps in fruit and vegetable consumption across the food secure and the food insecure are important because these mechanisms are modifiable. A large number of health literacy and capacity building interventions directed towards SNAP-eligible and low-income populations, such as SNAP-Ed programs, target fruit and vegetable consumption in part by addressing these behaviors, attitudes, and skills. Our results suggest that these efforts may indeed improve consumption of fruits and vegetables among the very poor and food insecure populations, further intervention research examining these mechanisms in greater detail may present a more nuanced picture with specific implications for practice.

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#### Compliance with Ethical Standards

**Conflicts of Interest:** Nalini Ranjit, Sarah Macias, Deanna Hoelscher declare that they have no conflicts of interest.

**Ethical Approval:** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards (Approval number: HSC-SPH-17-0205).

**Informed Consent:** Informed consent was obtained from all individual participants included in the study. This article does not contain any studies with animals performed by any of the authors.

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