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Food insecurity and risk of nutrition insecurity among Supplemental Nutrition Assistance Program participants in Rhode Island and Connecticut, USA

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ABSTRACT

Objective: To 1) describe food insecurity and risk of nutrition insecurity (henceforth nutrition insecurity); 2) test the associations between perceived food access and neighborhood environment and food and nutrition insecurity, and differences in these associations; and 3) test the associations between food and nutrition insecurity and diet quality, among a sample of adults with low income.
Methods: Between May–September 2023, Supplemental Nutrition Assistance Program (SNAP) participants in Rhode Island and Connecticut, USA (n = 1234) completed a food frequency questionnaire, from which we calculated healthy eating index (HEI)-2015 scores. An online survey included questions on perceived food access barriers and the food environment, and food and nutrition security. We used separate adjusted regression models to estimate correlates associated with food and/or nutrition insecurity and their associations with diet quality.
Results: Individuals were 35 years old, on average, 92 % were women, 43 % identified as Hispanic, and 58 % and 30 % were food and nutrition insecure, respectively. The average HEI-2015 score was 64. Lack of money was associated with an 8-fold higher odds of experiencing food insecurity (95 % Confidence Interval [CI] = 5.76, 10.67). The largest magnitude of association with nutrition insecurity was having few or no full-service grocery stores nearby (Odds Ratio[OR] = 2.27; 95 % CI = 1.27, 4.06), followed by lack of money and limited transportation. Associations between food and nutrition insecurity and HEI-2015 were negative but not statistically significant.
Conclusions: The prevalence of food insecurity among SNAP participants was higher than Americans, on average. Perceived food access barriers were associated with food and nutrition insecurity.

1. Introduction

In the United States (U.S.), diet-related chronic diseases are highly prevalent (National Center for Health Statistics, 2022; Ostchega et al., 2020; Centers for Disease Control and Prevention, 2025) and are now among the leading causes of death (National Center for Health Statistics, 2022). The economic burden of these diseases is also significant, with the U.S. spending $50 billion annually on diet-related chronic disease treatment (Jardim et al., 2019). Improving diet using multipronged strategies is critical to reduce disease burden and healthcare spending. Concomitantly, addressing food insecurity, a driver of poor diet quality among adults (Cowan et al., 2019; Bhattacharya et al., 2004; Basiotis and Lino, 2003; Hanson and Connor, 2014; Leung and Tester, 2019; Leung et al., 2014; Leung and Wolfson, 2021; Choi et al., 2022), and the related risk factor of nutrition insecurity, particularly among historically marginalized populations, is a national priority (Executive Office of the President of the United States, 2022).

Food security emphasizes the importance of having enough food (Rabbitt et al., 2023) and has been the focus of most U.S.-based research and national policy. Both structural and individual-level factors, such as

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neighborhood conditions, racial/ethnic discrimination, unemployment, and low educational attainment are associated with food insecurity (Doar, 2016; Odoms-Young and Bruce, 2018; Drewnowski, 2022). Research finds that households with children, households with low-income, older adults, people with disabilities, and racially minoritized households, particularly those at the intersection of these groups, are at the highest risk of experiencing food insecurity (Doar, 2016; Seligman and Schillinger, 2010; Coleman-Jensen, 2020; Schwartz et al., 2019; Berkowitz et al., 2024). For example, adults with disabilities and older adults may be at a higher risk for food insecurity due to limited or fixed incomes and/or healthcare expenses that reduce their ability to buy food (Coleman-Jensen and Nord, 2013; Huang et al., 2010; Hartline-Grafton, 2019). Racial and ethnic disparities in food insecurity can also stem from lower incomes and neighborhood conditions (U.S. Department of Health and Human Services, 2025; Ploeg et al., 2009; Powell et al., 2007). Moreover, evidence from a systematic review (Hanson and Connor, 2014) and several nationally representative samples (Cowan et al., 2019; Bhattacharya et al., 2004; Basiotis and Lino, 2003; Hanson and Connor, 2014; Leung and Tester, 2019; Leung and Wolfson, 2021; Choi et al., 2022) find that food insecurity is associated with poorer diet quality among adults.

Nutrition security emphasizes consistent access, availability, and affordability of foods and beverages that promote well-being and prevent disease (Thorndike et al., 2022; Tucker et al., 2024; Seligman et al., 2023). Despite the increasing focus on nutrition security from the White House (Executive Office of the President of the United States, 2022) and in U.S. Department of Agriculture (USDA) programs (USDA, Food and Nutrition Service, 2024), there is not a unified definition and competing frameworks have been proposed (Thorndike et al., 2022; Tucker et al., 2024; Seligman et al., 2023). Moreover, a nutrition security measure is not available in any large-scale surveys, therefore, few studies have described the prevalence of nutrition insecurity in the U.S. (Tucker et al., 2024; Calloway et al., 2024; Byker Shanks and Gordon, 2024), and none have explored modifiable non-sociodemographic correlates (e.g., food access, food environment) of nutrition security nor its relation with overall diet quality.

We aimed to fill this gap in the literature by describing food insecurity and risk of nutrition insecurity (henceforth referred to as nutrition insecurity); testing the associations between perceived food access and neighborhood environment and food and nutrition insecurity, and differences in these associations; and testing the associations between food and nutrition insecurity and diet quality, drawing on a large sample of adults with low income participating in the Supplemental Nutrition Assistance Program (SNAP) in Rhode Island (RI) or Connecticut (CT), U.S. Study results will contribute to our understanding of food and nutrition insecurity among individuals with low-income, which may help inform the future direction of food assistance programs in the U.S.

2. Methods

2.1. Study overview

In 2022, RI passed an amendment funding administration and implementation of the nation's first state-level SNAP nutrition incentive program, *Eat Well, Be Well*, which launched on January 23, 2024 and aims to improve fruit and vegetable consumption among RI SNAP recipients by providing a credit of $0.50 for every $1.00 participants spend on fresh fruits and vegetables sold by qualified retailers. These cross-sectional analyses utilized 2023 baseline data from a larger evaluation (*What's On Your Plate*) of the nutrition incentive program in RI, with the comparison state of CT. As part of the *What's On Your Plate* evaluation, we recruited 1366 SNAP participants who completed an online survey and food frequency questionnaire (FFQ).

2.2. Study procedures

Study procedures are more fully detailed elsewhere (Vadiveloo et al., 2024). Briefly, we recruited participants between May and September 2023 via in-person events, community partnerships, and text messages sent to Women, Infants, and Children (WIC) program participants, a U.S. federal nutrition assistance program. Inclusion criteria were as follows: speak and read English or Spanish; be ≥18 years; currently participate in SNAP; live in RI or CT; have access to email; have access to a phone that receives text messages; and provide consent to participate.

Following the eligibility determination and consent provision, we implemented a rigorous quality assurance process designed to prevent duplicate responses and bots, given that the survey was administered online (e.g., Amazon Web Service programming interface that detected duplicate phone numbers and/or emails, verifying geotags, Qualtrics reCAPTCHA scores) (Vadiveloo et al., 2024). Research assistants also followed up with any participant whose FFQ responses took <10 min to complete, those who reported <600 kcal or > 10,000 kcal (Kristal et al., 2014), and those whose date of births were not within 1 year of their reported age on the screener. A total of 1367 individuals completed the survey and passed all quality checks. These participants received a $50 electronic gift card for their participation.

2.3. Key study variables

2.3.1. Correlates of food and nutrition security

Dependent variables. For our first set of models, food and nutrition insecurity (binary variables) served as our dependent variables. Food insecurity was measured using the 6-item USDA Module (USDA, Food and Nutrition Service, 2024). Responses in the affirmative (i.e., often, sometimes, yes, almost or some months) were assigned a 1 (versus 0). A score of 0–1 = high or marginal food security; 2–4 = low food security; 5–6 = very low food security. A binary food insecure measure was then created based on a score of 0–1 (food secure) versus 2–6 (food insecure).

A binary nutrition insecurity measure was defined using the 1-item screener developed and validated by the Center for Nutrition and Health Impact (Calloway et al., 2022) based on responses in the affirmative (i.e., sometimes, often, or always) to the question, "In the last 30 days, we worried that the food we were able to eat would hurt our health and well-being". The validation study involved a formative phase, whereby survey item pools were developed via literature scans, formative interviews, cognitive interviews, and Expert Advisory Group and a testing phase, which involved piloting and testing the new measures using exploratory factor analysis and classical test theory approaches (Calloway et al., 2022). The 1-item nutrition insecurity item was selected as the screener with a sensitivity of 93 %, specificity of 78 %, and Cohen's kappa of 0.66, meeting the desired thresholds for assessing *risk of* nutrition insecurity.

Independent variables. For analyses investigating the modifiable correlates of food and nutrition security, independent variables included 1) perceived barriers to accessing food; 2) perceived food environment; and 3) food shopping behavior.

Perceived food access barriers were modeled as binary variables (yes/no) assessed by the following response options to the query (adapted from prior studies and surveys (Gearing et al., 2021; Wolfson et al., 2019; Gretchen Swanson Center for Nutrition, 2022)), "In the past month, have you experienced any of the following barriers for accessing groceries": not enough money to buy groceries; very few or no transportation options to a grocery store; very few or no full-service grocery stores in my area/nearby; not enough time; very few or no affordable food stores.

Perceived quality and access to fruits and vegetables in one's neighborhood (Gretchen Swanson Center for Nutrition, 2022) were modeled as binary variables assessed by the following questions: "It is easy to get fruits and vegetables in my neighborhood"; "the fruits and vegetables in my neighborhood are appealing and look good"; and

"there is a large variety of fresh fruits and vegetables in my neighborhood." Response options of strongly disagree, somewhat disagree, neutral, somewhat agree, strongly agree were dichotomized as agree versus disagree or neutral.

Participants were also asked how often their household got food from the supermarket/grocery store in the past month (Gretchen Swanson Center for Nutrition, 2022). Response options of always, most of the time, about half the time, sometimes, never were dichotomized as always shop at supermarket/grocery store versus most of the time, half the time, sometimes, or never.

2.3.2. Food and nutrition security and diet quality

Dependent Variables. For our second set of models, the Healthy Eating Index (HEI-2015) score (range = 0–100) was our primary dependent variable. The HEI score included 13 dietary components; the nine adequacy components (those recommended for inclusion in a healthy diet) included total fruits, whole fruits, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, and fatty acids, and the four moderation components (those that should be consumed sparingly) included refined grains, sodium, added sugars, and saturated fats (Krebs-Smith et al., 2018). We also investigated intake of total fruit and vegetable (excluding legumes) cup equivalents per 1000 kcal as our dependent variable.

Dietary information was collected via VioScreen FFQ, a validated dietary assessment tool (Kristal et al., 2014). Respondents were queried about their intake over the past 3-months within 20 food groupings and up to 6 graphical portion size options that are displayed on a plate.

Independent Variables. For analyses investigating associations between food and nutrition insecurity and diet quality, food and nutrition insecurity (binary variables described above) served as our independent variables.

2.3.3. Covariates

Based on prior literature (Doar, 2016; Seligman and Schillinger, 2010; Coleman-Jensen, 2020; Schwartz et al., 2019; Berkowitz et al., 2024; Tucker et al., 2024; Byker Shanks and Gordon, 2024), covariates included the following for both research questions: age (continuous), gender (woman versus man or non-binary/third gender), educational attainment (< grade 12, grade 12 or General Educational Development test, some college or trade school, ≥ college graduate), race/ethnicity (non-Hispanic [NH] White, NH-Black, NH-Other, Hispanic), marital status (married or living with partner, never married/divorced/widowed/separated, prefer not to answer), household size (continuous), and state (RI, CT).

2.4. Analytic sample

A total of 1367 individuals completed the survey and quality assurance checks. Of those, four individuals were determined not to be current SNAP participants based on their open-ended responses, leaving 1363 study participants. An additional 119 participants were excluded from the current analyses because they reported extreme dietary intakes (defined in this study as ≤500 kcal, ≥5500 kcal, or ≤ 25 different foods from the FFQ), and 10 were excluded with missing data on covariates. The final analytical sample included 1234 SNAP participants in RI or CT.

2.5. Statistical analyses

We estimated means and standard deviations (SD) for continuous variables and frequencies for categorical variables for the overall sample. We also described non-sociodemographic correlates (food access barriers, food environment, food shopping behavior) and diet quality in this sample by food and nutrition security status.

We used separate adjusted logistic regression models to estimate the extent to which non-sociodemographic correlates were associated with food and/or nutrition insecurity, and seemingly unrelated estimation (Clogg et al., 1995), a statistical method used to compare the parameters of separate regression models, to test whether associations differed with food and nutrition insecurity, respectively. We then tested the associations between food and nutrition insecurity and measures of diet quality using adjusted linear regression models. As a sensitivity analysis, we controlled for WIC participation, given that a large proportion of our sample also received WIC benefits. All regression models employed robust standard errors.

Data were analyzed using Stata/MP version 18.0 (College Station, Texas). This study was approved by the institutional review board at Brown University and met the institution's guidelines for protection of human subjects concerning safety and privacy.

3. Results

3.1. Descriptive results

Table 1 presents characteristics of the study sample. Participants' mean age was 35.4 years old (SD = 11.7), 92 % were women, and 43 % identified as Hispanic. Half of the sample had ≤ a high school diploma (49 %) and 23 % each were employed full and part-time. Most participants were not married (67 %). Three fourths of participants received SNAP benefits for >1 year and 71 % also received WIC benefits. Thirty-six percent of participants were neither food nor nutrition insecure, 6 % were not food insecure but were nutrition insecure, 34 % were food insecure but not nutrition insecure, and 24 % were both food insecure and nutrition insecure (data not shown).

The primary barrier to accessing food was lack of money, with a higher prevalence observed among those experiencing food (59 %) and/or nutrition (54 %) insecurity versus the pooled sample (40 %) (Table 2). Following lack of money, 19 % of the sample reported limited access to affordable food stores, with a higher prevalence observed among those who were food (27 %) and/or nutrition insecure (27 %).

Most of the pooled sample perceived that it was easy to get fruits and vegetables in their neighborhood (59 %), but this was somewhat lower among those who were food (52 %) and/or nutrition (46 %) insecure. Similarly, lower percentages of individuals who were food and/or nutrition insecure (versus the pooled sample) perceived that fruits and vegetables were appealing and that there were a variety of fresh fruits and vegetables in their neighborhood. Approximately one-third of the pooled sample reported always shopping at a supermarket or grocery store.

Dietary quality was similar among those experiencing food or nutrition insecurity. The mean HEI-2015 score was 63.9 (SD = 11.6). On average, individuals consumed 2.3 cup equivalents per 1000 kcal (SD = 1.4) of fruits and vegetables daily.

3.2. Adjusted regression models

3.2.1. Correlates of food insecurity

Lack of money was associated with a 8-fold higher odds of experiencing food insecurity (Odds Ratio [OR] = 7.84; 95 % Confidence Interval [CI] = 5.76, 10.67) (Table 3). Consistent with the descriptive trends above, participants reporting few or no affordable food stores (OR = 2.62; 95 % CI = 1.68, 4.09), few or no full-service grocery stores nearby (OR = 2.40; 95 % CI = 1.26, 4.58) and/or few transportation options (OR = 2.08; 95 % CI = 1.37, 3.16) had significantly higher odds of experiencing food insecurity. Perceiving that fruits and vegetables were appealing and looked good (OR = 0.65; 95 % CI = 0.45, 0.95) and always shopping at a supermarket or grocery store (OR = 0.74; 95 % CI = 0.56, 0.98) were associated with lower odds of experiencing food insecurity.

3.2.2. Correlates of risk of nutrition insecurity

Having few or no full-service grocery stores nearby (OR = 2.27; 95 % CI = 1.27, 4.06), lack of money (OR = 1.83; 95 % CI = 1.39, 2.40) and

Table 1
Selected characteristics of sample of Rhode Island and Connecticut Supplemental Nutrition Assistance Program (SNAP) participants, 2023.

	N (%) or Mean (Standard Deviation)	
	Pooled Sample (N = 1234)	
Age[1]	35.4	11.7
Woman	1139	92.3
Race/Ethnicity		
Non-Hispanic White	389	31.5
Non-Hispanic Black	197	16.0
Hispanic	529	42.9
Non-Hispanic Other	119	9.6
Mostly speak English at home	964	78.1
U.S. born	933	75.6
Educational Attainment		
Less than grade 12	171	13.9
Grade 12 or General Educational Development Test	439	35.6
Some college or trade school	429	34.8
College graduate or higher	195	15.8
Employment		
Employed full-time (30+ h/week)	284	23.0
Employed part-time (1–29 h/week)	280	22.7
Not employed, seeking employment	296	24.0
Not employed, retired, disabled, stay-at-home, student	374	30.3
Marital Status		
Married or living with a partner	340	27.6
Never married, divorced, widowed, separated	830	67.3
Prefer not to answer	64	5.2
Total Household Size[1]	3.7	1.6
SNAP Participation Duration[2]		
< 1 year	289	25.2
> 1 year	860	74.8
Participation in Programs Other than SNAP[2]		
Women, Infants, and Children	872	71.3
Medicaid/Medicare	789	64.5
Free/Reduced-Price School Lunch	454	37.1
Food Banks	293	24.0
Other (Disability, CACFP, UI, TANF)	370	30.3
Food Insecure[3]	712	57.7
Nutrition Insecure[4]	370	30.0

CACFP = Child and Adult Care Food Program; TANF = Temporary Assistance for Needy Families; UI = unemployment insurance.
[1] Value represents the mean (standard deviation).
[2] Missing data: SNAP participation duration (N = 1149), Participation in other programs (N = 1223).
[3] Food security is defined using the 6-item U.S. Department of Agriculture Food Security Survey Module. Responses in the affirmative (i.e., often, sometimes, yes, almost or some months) were assigned a 1 (versus 0). A score of 0–1 = high or marginal food security; 2–4 = low food security; 5–6 = very low food security. Food insecure is dichotomized as score of 0–1 (food secure) versus 2–6 (food insecure).
[4] Nutrition security was queried using the 1-item measure developed by the Center for Nutrition and Health Impact. At risk of nutrition insecurity was defined as responding sometimes, often, or always to the question, "In the last 30 days, we worried that the food we were able to eat would hurt our health and well-being."

Table 2
Non-sociodemographic correlates and dietary quality among a sample of Rhode Island and Connecticut Supplemental Nutrition Assistance Program participants, 2023.

	N (%) or Mean (Standard Deviation)		
	Pooled Sample (N = 1234)	Food Insecurity (N = 712)[1]	At risk of Nutrition Insecurity (N = 370)[2]
Non-sociodemographic Correlates			
Barriers to Accessing Food			
Lack of money	496 (40.2)	418 (58.7)	199 (53.8)
Few or no transportation options	184 (14.9)	134 (18.8)	76 (20.5)
Few or no full-service grocery stores in my area/nearby	69 (5.6)	53 (7.4)	34 (9.2)
Not enough time	162 (13.1)	115 (16.2)	70 (18.9)
Very few or no affordable food stores	229 (18.6)	191 (26.8)	100 (27.0)
Quality and Access to Fruits and Vegetables in Neighborhood			
Agree easy to get fruits and vegetables	733 (59.4)	368 (51.7)	170 (45.9)
Agree fruits and vegetables are appealing and look good	645 (52.3)	309 (43.4)	147 (39.7)
Agree large variety of fresh fruits and vegetables	647 (52.4)	307 (43.1)	145 (39.2)
Always Shop at Supermarket/ Grocery Store	446 (36.1)	233 (32.7)	124 (33.5)
Diet Quality[3]			
Mean Healthy Eating Index-2015 Score[4]	63.9 (11.6)	63.2 (11.4)	63.5 (11.2)
Total fruit and vegetable cup equivalents per 1000 kcal[4]	2.3 (1.4)	2.2 (1.3)	2.3 (1.4)

[1] Food security status is defined using the 6-item U.S. Department of Agriculture Food Security Survey Module. Responses in the affirmative (i.e., often, sometimes, yes, almost or some months) were assigned a 1 (versus 0). A score of 0–1 = high or marginal food security; 2–4 = low food security; 5–6 = very low food security. Food insecure is dichotomized as score of 0–1 (food secure) versus 2–6 (food insecure).
[2] Nutrition security status was queried using the 1-item measure developed by the Center for Nutrition and Health Impact. At risk of nutrition insecurity was defined as responding sometimes, often, or always to the question, "In the last 30 days, we worried that the food we were able to eat would hurt our health and well-being."
[3] Estimated using a food frequency questionnaire, administered via ViaScreen. Values include fresh, frozen, or canned fruits and vegetables. Total fruit and vegetables exclude legumes.
[4] Value represents the mean (standard deviation).

limited transportation (OR = 1.60; 95 % CI = 1.11, 2.30) were associated with higher odds of experiencing nutrition insecurity (Table 4). Perceiving that it was easy to get fruits and vegetables in one's neighborhood was inversely associated with experiencing nutrition insecurity (OR = 0.66; 95 % CI = 0.47, 0.93). Using seemingly unrelated estimation (Clogg et al., 1995), associations with food and nutrition insecurity shown in Tables 3 and 4 were not statistically significantly different from each other at the $p < 0.05$ level with the exception of those for lack of money ($p < 0.01$) and few or no affordable food stores ($p = 0.01$) as barriers to accessing food (results not shown). Results for correlates of food and nutrition insecurity were unchanged when controlling for WIC

Table 3
Associations between non-sociodemographic correlates and food insecurity among Rhode Island and Connecticut Supplemental Nutrition Assistance Program participants, 2023[1].

		N = 1234
	Odds Ratio[2]	95 % Confidence Interval
Barriers to Accessing Food		
Lack of money	7.84	5.76, 10.67
Few or no transportation options	2.08	1.37, 3.16
Few or no full-service grocery stores in my area/nearby	2.40	1.26, 4.58
Not enough time	1.06	0.67, 1.69
Very few or no affordable food stores	2.62	1.68, 4.09
Perceived Quality and Access to Fruits and Vegetables in Neighborhood		
Agree easy to get fruits and vegetables	0.93	0.65, 1.34
Agree fruits and vegetables are appealing and look good	0.65	0.45, 0.95
Agree large variety of fresh fruits and vegetables	0.72	0.49, 1.05
Where Households Got Food		
Always shop at supermarket/grocery store	0.74	0.56, 0.98

[1] Responses in the affirmative (i.e., often, sometimes, yes, almost or some months) were assigned a 1 (versus 0). A score of 0–1 = high or marginal food security; 2–4 = low food security; 5–6 = very low food security. Food insecure is dichotomized as score of 0–1 (food secure) versus 2–6 (food insecure).
[2] Odds ratios are estimated using separate logistic regression models with robust standard errors, adjusted for respondent age, gender, educational attainment, race/ethnicity, marital status, household size, and state.

Table 4
Associations between non-sociodemographic correlates and risk of nutrition insecurity among Rhode Island and Connecticut Supplemental Nutrition Assistance Program participants, 2023[1].

	N = 1234	
	Odds Ratio[2]	95 % Confidence Interval
Barriers to Accessing Food		
Lack of money	1.83	1.39, 2.40
Few or no transportation options	1.60	1.11, 2.30
Few or no full-service grocery stores in my area/nearby	2.27	1.27, 4.06
Not enough time	1.25	0.85, 1.85
Very few or no affordable food stores	1.36	0.97, 1.91
Perceived Quality and Access to Fruits and Vegetables in Neighborhood		
Agree easy to get fruits and vegetables	0.66	0.47, 0.93
Agree fruits and vegetables are appealing and look good	0.78	0.54, 1.14
Agree large variety of fresh fruits and vegetables	0.76	0.52, 1.10
Where Households Got Food		
Always shop at supermarket/grocery store	0.94	0.72, 1.23

[1] Nutrition security status was queried using the 1-item measure developed by the Center for Nutrition and Health Impact. Risk of nutrition insecurity was defined as responding sometimes, often, or always to the question, "In the last 30 days, we worried that the food we were able to eat would hurt our health and well-being."
[2] Odds ratios are estimated using separate logistic regression models with robust standard errors, adjusted for respondent age, gender, educational attainment, race/ethnicity, marital status, household size, and state.

participation (results not shown).

3.2.3. Diet quality

The association between food insecurity and HEI-2015 was negative but not statistically significant (coefficient = −1.28; 95 % CI = -2.58, 0.02) (Table 5). However, food insecurity was associated with significantly lower total fruit and vegetable intake (coefficient = −0.18; 95 % CI = -0.34, −0.03). Nutrition insecurity was not associated with HEI-2015 (coefficient = −0.17; 95 % CI = -1.57, 1.22) nor total fruit and vegetable intake (coefficient = −0.01; 95 % CI = -0.18, 0.16) (Supplemental Table 1). Results were unchanged when controlling for WIC participation (results not shown).

4. Discussion

Addressing food and nutrition insecurity is a national priority (Executive Office of the President of the United States, 2022), as both measures plausibly influence diet quality, and in turn, chronic disease risk. Perceived food access and environment and diet quality were generally similar among individuals categorized as either experiencing food or nutrition insecurity. In adjusted regression models, the association between lack of money and experiencing food insecurity was the largest in magnitude. Having few or no full-service grocery stores nearby was the largest magnitude correlate of nutrition insecurity, followed by lack of money and limited transportation. Although associations were in the expected direction between food and nutrition security and HEI-2015, they were not statistically significant; however, experiencing food insecurity was associated with lower total fruit and vegetable intake.

Our finding that lack of money was associated with experiencing food insecurity is consistent with the definition of food insecurity, as food insecurity is inextricably linked to poverty; in 2022, 37 % of households with incomes below the federal poverty line were food insecure (USDA, 2024) and unstable employment, inflation, and the rising cost of living exacerbate financial strain, making it even harder for households to access enough food. Associations between having few or no affordable food stores, few or no full-service grocery stores nearby and/or few transportation options and experiencing food insecurity are also consistent with prior studies reporting associations between neighborhood food access (National Institute on Minority Health and Health Disparities, 2025; Mayer et al., 2014; Bonanno and Li, 2015) and transportation (Antrum et al., 2023) and food insecurity risk.

In our study, 30 % of individuals were nutrition insecure, which is lower than the prevalence of nutrition insecurity (~50 %) reported by both Tucker et al. (Tucker et al., 2024) and Calloway et al. (Calloway et al., 2024). One possible explanation for the lower prevalence observed in our sample is that a large proportion also received WIC

Table 5
Associations between food insecurity and diet quality among Rhode Island and Connecticut Supplemental Nutrition Assistance Program participants, 2023[1,2].

	N = 1234	
	Coefficient[3]	95 % Confidence Interval
Healthy Eating Index-2015 score	−1.28	−2.58, 0.02
Total fruit and vegetable (excluding legumes) cup equivalents per 1000 kcal	−0.18	−0.34, −0.03

[1] Estimated using a food frequency questionnaire, administered via VioScreen.
[2] Responses in the affirmative (i.e., often, sometimes, yes, almost or some months) were assigned a 1 (versus 0). A score of 0–1 = high or marginal food security; 2–4 = low food security; 5–6 = very low food security. Food insecure is dichotomized as score of 0–1 (food secure) versus 2–6 (food insecure).
[3] Coefficients are estimated using separate linear regression models with robust standard errors, adjusted for respondent age, gender, educational attainment, race/ethnicity, marital status, household size, and state.

benefits, which likely provides an additional buffer against food and nutrition insecurity. Additionally, Tucker et al. used a 4-item measure of nutrition insecurity (versus our 1-item screener) and both prior studies (Tucker et al., 2024; Calloway et al., 2024) used 12-month versus 30-day measures. To our knowledge, only Tucker et al. has explored correlates of nutrition security in the U.S. (Tucker et al., 2024) and that study only investigated sociodemographic correlates (e.g., gender, race/ethnicity). Nevertheless, given that nutrition security emphasizes access, availability, and affordability of foods, our finding that few or no full-service grocery stores nearby was positively associated with nutrition insecurity is generally aligned with studies suggesting that the neighborhood food environment is related to nutrition (Cantor et al., 2020; Dubowitz et al., 2015).

The average HEI-2015 score in this sample was 64; while the difference was modest, it was higher than the average American (HEI-2015 = 58) (USDA, Food and Nutrition Service, 2023). It is possible that diet quality in this sample is somewhat higher than the average American because many individuals also received WIC benefits. WIC is more explicitly designed to improve diet quality, as the program provides monthly benefits for specific food items. Additionally, data were collected between May and September, when we would expect fruit and vegetable consumption to be higher. Nonetheless, the average consumption of fruits and vegetables (2.3 cup equivalents per 1000 kcal) was still lower that the recommended intake of 1.5–2 cup-equivalents of fruits and 2–3 cup-equivalents of vegetables daily, based on a 2000 kcal diet.

We did not observe a significant association between food security and HEI-2015, but did find that food insecurity was associated with lower total fruit and vegetable intake. While results for total fruit and vegetable intake in relation to food insecurity are aligned with prior literature (Hanson and Connor, 2014), our findings regarding HEI are contrary to those from a 2014 review that reported inverse associations between food insecurity (versus security) and overall dietary quality among adults, in nationally representative samples (Cowan et al., 2019; Bhattacharya et al., 2004; Basiotis and Lino, 2003; Hanson and Connor, 2014; Leung and Tester, 2019; Leung et al., 2014; Leung and Wolfson, 2021; Choi et al., 2022).

We also did not observe a significant association between nutrition security and diet. While there are no prior U.S.-based studies investigating nutrition security in relation to overall diet quality, Calloway et al. recently reported an association between experiencing food and nutrition insecurity in combination (versus food secure and nutrition secure) and "low" fruit and vegetable intake, using a dietary screener (Calloway et al., 2024). Plausible explanations for our null findings include the dual enrollment in WIC among many in this sample, as noted above, and the measurement of nutrition security. At the time the nutrition security measure was developed, there was no operationalized definition of nutrition security and Calloway et al. (Calloway et al., 2022) based their conceptualization of nutrition security and their survey questions on formative interviews largely with adults experiencing food insecurity (71 %). Tucker et al. outline several reasons this measure may not accurately capture nutrition security (Tucker et al., 2024), including threats to content validity. While we used the 1-item screener, similar to Calloway (Calloway et al., 2024), versus the 4-item measure used by Tucker (Tucker et al., 2024), the screener may be sub-optimal and a factor contributing to our null findings. Given that the measurement of nutrition security in the U.S. is still in its nascency, and there is a lack of consensus on the measure used, additional research around the conceptualization and measurement of nutrition security is warranted.

This study has several limitations. First, these data are cross-sectional; thus, results should be interpreted as associations and not causal. Second, like all dietary recall methods, the data collected via FFQ are self-reported and subject to recall and social desirability bias. Third, our sample included predominantly women (>90 %) and most participants were also receiving WIC benefits (~70 %). Fourth, the timing of data collection could affect the kinds of foods consumed, and we would expect fruit and vegetable consumption to be higher in the summer months. While our results were robust to the inclusion of WIC participation as a covariate, the latter two limitations could affect the generalizability of our findings. Fifth, nutrition security was assessed using a 1-item screener that has not yet been used extensively in the literature. Finally, food access barriers and the neighborhood food environment were subjectively versus objectively measured. Nevertheless, there are several strengths of this study, including the use of a large sample of participants with low-income, fielding the survey in both English and Spanish, the assessment of non-sociodemographic correlates, and assessing diet via an FFQ.

5. Conclusions

We find that perceived food access barriers are associated with food and nutrition insecurity among SNAP participants. These findings highlight the importance of addressing financial and structural barriers to improve food access and promote healthier eating behaviors. However, we did not observe statistically significant associations between food or nutrition insecurity and overall diet quality, although associations observed were in the expected direction. Given that nutrition insecurity is a plausible determinant of diet quality, and improving diet quality is critical to reducing disease burden, future studies should investigate associations using other measures of nutrition security and in other populations.

Author contribution

The authors' responsibilities were as follows – LMP acquired funding; VMO, JL, LMP, MV, AT designed the research; MV, AT, EE led the data collection; JL analyzed the data; VMO drafted the paper; all authors interpreted the data; VMO and LMP have primary responsibility for the final content; and all authors: edited, read, and approved the final manuscript.

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CRediT authorship contribution statement

Vanessa M. Oddo: Writing – original draft, Methodology, Conceptualization. **Julien Leider:** Writing – review & editing, Methodology, Formal analysis. **Alison Tovar:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Lisa M. Powell:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **Emily Elenio:** Writing – review & editing, Project administration, Data curation. **Maya K. Vadiveloo:** Writing – review & editing, Methodology, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Lisa Powell reports financial support was provided by Bloomberg Philanthropies Support LLC. If there are other authors, they 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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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2025.103002.

Data availability

Data will be made available on request.

References

Antrum, C.J., Waring, M.E., Cooksey, Stowers K., 2023. Personal vehicle use and food security among US adults who are primary shoppers for households with children. Discov. Food 3 (1), 9.

Basiotis, P.P., Lino, M., 2003. Insight 26: July 2002: food insufficiency and prevalence of overweight among adult women. Fam. Econ. Nutr. Rev. 15 (2), 55–58.

Berkowitz, S.A., Seligman, H.K., Palakshappa, D., 2024. Understanding food insecurity risk in the United States: a longitudinal analysis. SSM-Popul. Health 25, 101569.

Bhattacharya, J., Currie, J., Haider, S., 2004. Poverty, food insecurity, and nutritional outcomes in children and adults. J. Health Econ. 23 (4), 839–862.

Bonanno, A., Li, J., 2015. Food insecurity and food access in US metropolitan areas. Appl. Econ. Perspect. Policy 37 (2), 177–204.

Byker Shanks, C., Gordon, N.P., 2024. Screening for food and nutrition insecurity in the healthcare setting: a cross-sectional survey of non-Medicaid insured adults in an integrated healthcare delivery system. J. Prim. Care Community Health 15, 21501319241258948.

Calloway, E.E., Carpenter, L.R., Gargano, T., Sharp, J.L., Yaroch, A.L., 2022. Development of new measures to assess household nutrition security, and choice in dietary characteristics. Appetite 179, 106288.

Calloway, E.E., Coakley, K.E., Carpenter, L.R., Gargano, T., Yaroch, A.L., 2024. Benefits of using both the Hunger Vital Sign and brief nutrition security screener in health-related social needs screening. Transl. Behav. Med. 14 (8), 445–451.

Cantor, J., Beckman, R., Collins, R.L., Dastidar, M.G., Richardson, A.S., Dubowitz, T., 2020. SNAP participants improved food security and diet after a full-service supermarket opened in an urban food desert: study examines impact grocery store opening had on food security and diet of supplemental nutrition assistance program participants living in an urban food desert. Health Aff. (Millwood) 39 (8), 1386–1394.

Centers for Disease Control and Prevention, 2024. National diabetes statistics. report [Internet]. Available from. https://www.cdc.gov/diabetes/php/data-research/index.html.

Choi, Y.J., Crimmins, E.M., Ailshire, J.A., 2022. Food insecurity, food environments, and disparities in diet quality and obesity in a nationally representative sample of community-dwelling older Americans. Prev. Med. Rep. 29, 101912.

Clogg, C.C., Petkova, E., Haritou, A., 1995. Statistical methods for comparing regression coefficients between models. Am. J. Sociol. 100 (5), 1261–1293.

Coleman-Jensen, A., 2020. US food insecurity and population trends with a focus on adults with disabilities. Physiol. Behav. 220, 112865.

Coleman-Jensen, A., Nord, M., 2013. Food Insecurity among Households with Working-Age Adults with Disabilities. USDA-ERS Econ. Res. Rep. vol. 144.

Cowan, A.E., Jun, S., Tooze, J.A., Eicher-Miller, H.A., Dodd, K.W., Gahche, J.J., et al., 2019. Total usual micronutrient intakes compared to the dietary reference intakes among US adults by food security status. Nutrients 12 (1), 38.

Doar, R., 2016. Freedom from hunger: an achievable goal for the United States of America-recommendations of the National Commission on Hunger to Congress and the Secretary of the Department of Agriculture. [Internet]. Available from: https://www.aei.org/wp-content/uploads/2016/01/Hunger_Commission_Final_Report.pdf?x850.

Drewnowski, A., 2022. Food insecurity has economic root causes. Nat. Food 3 (8), 555–556.

Dubowitz, T., Ghosh-Dastidar, M., Cohen, D.A., Beckman, R., Steiner, E.D., Hunter, G.P., et al., 2015. Changes in diet after introduction of a full service supermarket in a food desert. Health Aff. Proj. Hope. 34 (11), 1858.

Executive Office of the President of the United States, 2022. Biden-Harris administration national strategy on hunger, nutrition, and health [Internet]. Available from: https://www.whitehouse.gov/wp-content/uploads/2022/09/White-House-National-Strategy-on-Hunger-Nutrition-and-Health-FINAL.pdf.

Gearing, M., Dixit-Joshi, S., May, L., 2021. Barriers that constrain the adequacy of supplemental nutrition assistance program (SNAP) allotments: survey findings [Internet]. Available from: https://fns-prod.azureedge.us/sites/default/files/resource-files/SNAP-Barriers-SurveyFindings.pdf.

Gretchen Swanson Center for Nutrition, 2022. Optional modules for participant-level surveys [Internet]. Aug. Available from. https://www.nutritionincentivehub.org/resources/resource-item?resource=028b0da7-dbca-4a66-baae-b2c8071ccb14.

Hanson, K.L., Connor, L.M., 2014. Food insecurity and dietary quality in US adults and children: a systematic review. Am. J. Clin. Nutr. 100 (2), 684–692.

Hartline-Grafton, H., 2019. Hunger is a health issue for older adults: food security, health, and the federal nutrition programs [Internet]. Available from: https://frac.org/wp-content/uploads/hunger-is-a-health-issue-for-older-adults-1.pdf.

Huang, J., Guo, B., Kim, Y., 2010. Food insecurity and disability: do economic resources matter? Soc. Sci. Res. 39 (1), 111–124.

Jardim, T.V., Mozaffarian, D., Abrahams-Gessel, S., Sy, S., Lee, Y., Liu, J., et al., 2019. Cardiometabolic disease costs associated with suboptimal diet in the United States: a cost analysis based on a microsimulation model. PLoS Med. 16 (12), e1002981.

Krebs-Smith, S.M., Pannucci, T.E., Subar, A.F., Kirkpatrick, S.I., Lerman, J.L., Tooze, J.A., et al., 2018. Update of the healthy eating index: HEI-2015. J. Acad. Nutr. Diet. 118 (9), 1591–1602.

Kristal, A.R., Kolar, A.S., Fisher, J.L., Plascak, J.J., Stumbo, P.J., Weiss, R., et al., 2014. Evaluation of web-based, self-administered, graphical food frequency questionnaire. J. Acad. Nutr. Diet. 114 (4), 613–621.

Leung, C.W., Tester, J.M., 2019. The association between food insecurity and diet quality varies by race/ethnicity: an analysis of National Health and Nutrition Examination Survey 2011-2014 results. J. Acad. Nutr. Diet. 119 (10), 1676–1686.

Leung, C.W., Wolfson, J.A., 2021. Food insecurity among older adults: 10-year national trends and associations with diet quality. J. Am. Geriatr. Soc. 69 (4), 964–971.

Leung, C.W., Epel, E.S., Ritchie, L.D., Crawford, P.B., Laraia, B.A., 2014. Food insecurity is inversely associated with diet quality of lower-income adults. J. Acad. Nutr. Diet. 114 (12), 1943–1953.

Mayer, V.L., Hillier, A., Bachhuber, M.A., Long, J.A., 2014. Food insecurity, neighborhood food access, and food assistance in Philadelphia. J. Urban Health 91, 1087–1097.

National Center for Health Statistics, 2022. Leading Causes of Death [Internet].. Available from: https://www.cdc.gov/nchs/fastats/leading-causes-of-death.htm.

National Institute on Minority Health and Health Disparities, 2024. Food accessibility, insecurity and health outcomes [Internet]. Available from. https://www.nimhd.nih.gov/resources/understanding-health-disparities/food-accessibility-insecurity-and-health-outcomes.html.

Odoms-Young, A., Bruce, M.A., 2018. Examining the impact of structural racism on food insecurity: implications for addressing racial/ethnic disparities. Fam. Commun. Health 41, S3–S6.

Ostchega, Y., Fryar, C.D., Nwankwo, T., Nguyen, D.T., 2020. Hypertension prevalence among adults aged 18 and over: United States, 2017–2018 [Internet]. Available from: https://www.cdc.gov/nchs/data/databriefs/db364-h.pdf.

Ploeg, M., Breneman, V., Farrigan, T., Hamrick, K., Hopkins, D., Kaufman, P., et al., 2009. Access to Affordable and Nutritious Food-Measuring and Understanding Food Deserts and their Consequences: Report to Congress [Internet]. . Available from: http://www.ers.usda.gov/publications/pub-details/?pubid=42729This link is external to health.gov.

Powell, L.M., Slater, S., Mirtcheva, D., Bao, Y., Chaloupka, F.J., 2007. Food store availability and neighborhood characteristics in the United States. Prev. Med. 44 (3), 189–195.

Rabbitt, M.P., Hales, L.J., Burke, M.P., Coleman-Jensen, A., 2023. Household food security in the United States in 2022 [Internet]. Available from: https://www.ers.usda.gov/publications/pub-details/?pubid=107702.

Schwartz, N., Buliung, R., Wilson, K., 2019. Disability and food access and insecurity: a scoping review of the literature. Health Place 57, 107–121.

Seligman, H.K., Schillinger, D., 2010. Hunger and socioeconomic disparities in chronic disease. N. Engl. J. Med. 363 (1), 6–9.

Seligman, H.K., Levi, R., Adebiyi, V.O., Coleman-Jensen, A., Guthrie, J.F., Frongillo, E.A., 2023. Assessing and monitoring nutrition security to promote healthy dietary intake and outcomes in the United States. Annu. Rev. Nutr. 43, 409–429.

Thorndike, A.N., Gardner, C.D., Kendrick, K.B., Seligman, H.K., Yaroch, A.L., Gomes, A.V., et al., 2022. Strengthening US food policies and programs to promote equity in nutrition security: a policy statement from the American Heart Association. Circulation 145 (24), e1077–e1093.

Tucker, A.C., Bresnahan, C., John, S., Johnson, J., Leung, C.W., Mui, Y., et al., 2024. Food (in) security in relation to nutrition (in) security in a national cross-sectional sample of Supplemental Nutrition Assistance Program participants: considerations of an emerging construct. Am. J. Clin. 119, 1475–1484.

U.S. Department of Health and Human Services, 2025.. Food Insecurity [Internet]. Available from: https://health.gov/healthypeople/priority-areas/social-determinants-health/literature-summaries/food-insecurity#cit10.

USDA, 2024. Food and nutrition security [Internet]. May. Available from. https://www.usda.gov/nutrition-security.

USDA, Food and Nutrition Service, 2024a. USDA Actions on Nutrition Security [Internet]. Available from: https://www.fns.usda.gov/factsheet/food-nutrition-security.

USDA, Food and Nutrition Service, Center for Nutrition Policy and Promotion, 2023. In: Average Healthy Eating Index-2020 Scores for the U.S. Population - Total Ages 2 and Older and by Age Groups, WWEIA, NHANES 2017-2018. Available from: https://www.fns.usda.gov/cnpp/hei-scores-americans.

Vadiveloo, M.K., Elenio, E., Leider, J., Oddo, V.M., Pipito, A.A., Powell, L.M., Tovar, A., 2024. Design of the What's On Your Plate SNAP study [Internet] Research Brief, No. 139. Available from: https://p3rc.uic.edu/research-evaluation/ evaluation-of-food-policies/.

Wolfson, J.A., Ramsing, R., Richardson, C.R., Palmer, A., 2019. Barriers to healthy food access: associations with household income and cooking behavior. Prev. Med. Rep. 13, 298–305.