Examining disparities in diet quality between SNAP participants and non-participants using Oaxaca-Blinder decomposition analysis

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ARTICLE INFO

ABSTRACT

Recent studies have reported that SNAP participants have poorer diet quality than non-participants. This study aimed to examine how differences in socio-demographic, household, and health-related measures explain disparities in diet quality between SNAP participants and non-participants using Oaxaca-Blinder decomposition analysis.

We analyzed cross-sectional data on 14,331 adult respondents of the National Health and Nutrition Examination Survey (NHANES) 2009 – 2014. To measure diet quality, we applied the Healthy Eating Index (HEI)-2015 to respondents' 24-hour dietary recall data (scale: 0–100 points). We used Oaxaca-Blinder decomposition analysis to determine how much of the disparity in HEI-2015 total score between SNAP participants and non-participants was explained by socio-demographic (e.g., age, race/ethnicity, educational), household (e.g., household size, food security status), and health-related measures (e.g., BMI, smoking status).

Analyses performed revealed significant differences in HEI-2015 total score by SNAP participation status (p < 0.001). We found that the total gap in HEI-2015 total score between SNAP participants and income-ineligible non-participants was 6.30 points. Socio-demographic measures alone explained 72.40% of the disparity. All measures together explained 86.31% of the disparity. The total gap between SNAP participants and income-eligible non-participants was 3.24 points. Socio-demographic measures alone explained 35.51% of this disparity while all measures together explained 56.86%.

We observed disparities in diet quality between SNAP participants and non-participants. Socio-demographic, household, and health-related measures explained a significant amount of the disparity that existed between SNAP participants and income-ineligible non-participants; they explained less of the disparity between SNAP participants and income-eligible non-participants.

1. Introduction

The Supplemental Nutrition Assistance Program (SNAP), formerly titled the Food Stamp Program, is the largest federally-funded food assistance program in the United States (Committee on Examination of the Adequacy of Food Resources and SNAP Allotments, 2013). In 2017, the program provided monetary benefits to over 40 million individuals in an effort to alleviate the public health burden of food insecurity and hunger (Center on Budget and Policy Priorities, 2018). The dollar amount of benefits an individual receives depends on their net monthly income based on gross income, pre-determined household expenses, and total number of household members (U.S. Department of Agriculture 2018). SNAP participation has been linked to positive outcomes among low-income adults including increased food security,

lower healthcare costs, and improved long-term health (Center on Budget and Policy Priorities, 2018; Bartfield et al., 2015; Gregory and Deb, 2015; Berkowitz et al., 2017; Mabli and Ohls, 2015).

In recent years, studies have reported that adults participating in SNAP have poorer diet quality (as measured by the Healthy Eating Index) than income-ineligible non-participants, and in some cases, income-eligible non-participants (Andreyeva et al., 2015; Leung et al., 2012; Hilmers et al., 2014; Nguyen et al., 2014; Nguyen et al., 2015). Furthermore, a recent study by Zhang and colleagues revealed that disparities in diet quality between SNAP participants and non-participants persisted between 1999 and 2014 despite a slight overall improvement in diet quality among adults in the US (Zhang et al., 2018). Given that SNAP aims to mitigate food insecurity so program participants can attain a healthier diet (Committee on Examination of the Adequacy of Food Resources and SNAP Allotments, 2013; Center on Budget and Policy Priorities, 2018), there is a need to better understand the disparities in diet quality that exist between SNAP participants and non-participants in order to improve the health and nutritional status of low-income populations in the U.S.

There is a large body of scientific literature that documents the differences between SNAP participants and non-participants in regards to socio-demographic, household, and health-related factors (Smith et al., 2017; U.S. Department of Agriculture, 2017; Vega et al., 2017; Gummon and Tallie, 2017; Andreyeva et al., 2012; Tallie et al., 2018). For example, working individuals who participate in SNAP are more likely to be younger, women, minorities, and have children compared to those not participating (Smith et al., 2017; U.S. Department of Agriculture, 2017). These factors may explain, in part, the disparities in diet quality that exist between SNAP participants and non-participants. To our knowledge, no study conducted to date has attempted to quantify 1) how much of the disparity in diet quality that exists between SNAP participants and non-participants is explained by key socio-demographic, household, and health-related factors and 2) how much this disparity would be attenuated if SNAP participants had similar characteristics as non-participants.

The objective of this research is to examine disparities in diet quality between SNAP participants and non-participants (both income-eligible and income-ineligible) using Oaxaca-Blinder decomposition analysis (Jann, 2008) – a regression-based analytical approach that has been previously utilized to evaluate disparities in obesity and nutrition (Sen, 2014; Singleton et al., 2016; Powell et al., 2012; Ciaian et al., 2017). By utilizing Oaxaca-Blinder decomposition analysis, we can calculate how much differences in socio-demographic, household, and health-related measures explain observed disparities in diet quality between SNAP participants and non-participants. Furthermore, we can estimate how the diet quality of SNAP participants may improve if they had similar mean characteristics as non-participants. We hypothesize that socio-demographic measures will explain a significant amount of disparity in diet quality between SNAP participants and non-participants.

2. Methods

2.1. Data source

We obtained cross-sectional data from the National Health and Nutrition Examination Survey (NHANES) cycles 2009–2010, 2011–2012, and 2013–2014. Detailed information about NHANES is available online (Centers for Disease Control and Prevention, 2017). To summarize, NHANES is a program of the National Center for Health Statistics that aims to assess the health and nutritional status of a nationally-representative sample of U.S. citizens (Centers for Disease Control and Prevention, 2017). NHANES employs a series of interview-administered questionnaires and physical examinations to collect a wide-range of socio-demographic, dietary, and health information from respondents (Centers for Disease Control and Prevention, 2017). A complex sampling scheme is used to identify eligible adults and children each year (Johnson et al., 2014). NHANES oversampled non-Hispanic blacks and Hispanics from 2009 to 2014 and non-Hispanic Asians from 2011 to 2014 to support precise estimates for these demographic groups (Johnson et al., 2014). There were 30,468 respondents in the selected cycles. After excluding respondents who were < 18 years old (n = 11,964), had inadequate 24-hour recall data (n = 2,020), and were missing information on receipt of SNAP benefits in the prior year and/or poverty-to-income ratio (PIR) (n = 2,153), we derived a final analytical sample of 14,331 adult respondents. Institutional Review Board at the University of Illinois at Chicago approved this research.

3. Measures

3.1. SNAP eligibility & participation status

We categorized respondents into the following three groups: current SNAP participant, income-eligible non-participant, and income-ineligible non-participant. We used the measures receipt of SNAP benefits in the prior year and PIR to estimate SNAP eligibility and participation status for each NHANES participant. The measure receipt of SNAP benefits is self-reported (yes vs. no) and assessed at the household level. It is important to note that the SNAP program employs several criteria to determine eligibility (e.g., income, household size, age of household members, disability status, etc.) (Center on Budget and Policy Priorities, 2018). Thus, SNAP eligibility and participation status can only be estimated with these data. It is likely that some NHANES participants are misclassified by SNAP eligibility and participation status.

To be considered a current SNAP participant, a respondent had to self-report that they, or a household member, received any amount of SNAP benefits in the prior 12 months regardless of income. A respondent had to have a PIR < 1.3 (i.e., 130% of the federal poverty line) but not self-report they received SNAP benefits in the prior year to be labeled an income-eligible non-participant. We selected this cut point for PIR because the SNAP administration uses it to identify individuals who qualify for participation according to income (Center on Budget and Policy Priorities, 2018). We considered all other respondents income-ineligible non-participants. Of the 14,331 respondents in the sample, 3,641 (18.30%) were labeled SNAP participants, 2,356 (11.52%) were income-eligible non-participants, and 8,334 (70.18%) were income-ineligible non-participants.

3.2. Diet quality

The outcome measure was diet quality as measured by the Healthy Eating Index 2015 (HEI-2015). We calculated HEI-2015 total score using the first day of each respondent's 24-hour recall data. The United States Department of Agriculture and the National Cancer Institute collaborated to develop the HEI-2015 to align with the 2015–2020 Dietary Guidelines for Americans (DGAs) (United States, 2015). Studies on the details of HEI-2015 are available in the literature (Krebs-Smith et al., 2018; Reedy et al., 2018). To summarize, HEI-2015 total score is the sum of thirteen component scores (Krebs-Smith et al., 2018). The total score ranges from 0 to 100 points; a higher score indicates better diet quality (Krebs-Smith et al., 2018). Nine components are adequacy components (i.e., greater consumption of these foods will increase an individual's HEI-2015 total score): total fruits (maximum of 5 pts), whole fruits (5 pts), total vegetables (5 pts), greens and beans (5 pts), whole grains (10 pts), dairy (10 pts), total protein foods (5 pts), seafood and plant proteins (5 pts), and fatty acids (10 pts). Four components are moderation components (i.e., lower consumption of these foods will increase an individual's HEI-2015 total score): refined grains (10 pts), sodium (10 pts), added sugars (10 pts), and saturated fats (10 pts). HEI-2015 is considered a valid and reliable measure of diet quality (Reedy et al., 2018). A HEI-2015 total score < 59 is considered poor diet quality (Krebs-Smith et al., 2018).

Table 1
Demographic, Household, and Health Characteristics of NHANES 2009–2014 Respondents, N (Weighted %).

Characteristic:	All Participants N = 14,331	SNAP Participants 3,641 (18.30)	Income-Eligible Non-Participants 2,356 (11.52)	Income-Ineligible Non-Participants 8,334 (70.18)	P Value
Demographics					
Age, years	46.29 (± 0.39)[a]	41.06 (± 0.43)	42.76 (1.72)	48.23 (± 0.38)	< 0.0001
Sex:	7,023 (48.84)				
Male	7,308 (51.16)	1,625 (44.36)	1,151 (48.08)	4,247 (50.13)	< 0.0001
Female		2,016 (55.64)	1,205 (51.92)	4,087 (49.87)	
Race/Ethnicity:					
Non-Hispanic White	6,393 (68.74)	1,255 (48.37)	948 (53.77)	4,190 (76.51)	
Non-Hispanic Black	2,981 (10.68)	1,167 (23.35)	360 (11.02)	1,454 (7.33)	< 0.0001
Hispanic	3,341 (13.59)	970 (22.12)	776 (26.62)	1,595 (9.22)	
Other	1,616 (6.99)	249 (6.16)	272 (8.60)	1,095 (6.94)	
Marital Status:					
Married or Living with Partner	7,953 (62.96)	1,539 (46.48)	1,043 (47.89)	5,371 (69.53)	< 0.0001
Other	5,630 (37.04)	1,861 (53.52)	1,113 (52.11)	2,656 (30.47)	
Educational Attainment:					
< High School	3,436 (16.46)	1,436 (34.11)	849 (31.06)	1,151 (9.46)	
High School or Equivalent	3,228 (21.67)	1,024 (29.45)	551 (23.62)	1,653 (19.33)	< 0.0001
Some College	4,277 (31.63)	977 (30.18)	684 (32.24)	2,616 (31.91)	
≥ College Degree	3,374 (30.24)	197 (6.27)	269 (13.08)	2,908 (39.30)	
Household					
Number of Household Members	3.05 (± 0.03)	3.83 (± 0.08)	3.17 (± 0.08)	2.83 (± 0.03)	< 0.0001
Poverty-to-Income Ratio	2.99 (± 0.06)	1.22 (± 0.05)	0.85 (± 0.02)	3.75 (± 0.04)	< 0.0001
Food Security Status:	9,838 (76.49)	1,365 (39.36)	1,340 (59.79)	7,133 (88.91)	< 0.0001
Food Secure	1,621 (9.10)	666 (18.23)	357 (14.44)	598 (5.85)	
Marginal Food Security	1,759 (8.72)	942 (23.67)	392 (15.53)	425 (3.71)	
Low Food Security	1,111 (5.69)	667 (18.74)	266 (10.24)	178 (1.54)	
Very Low Food Security					
Number of Meals Prepared Away from Home, past 7 days:	3.74 (± 0.07)	2.88 (± 0.10)	3.79 (± 0.47)	3.95 (± 0.06)	< 0.0001
Health					
BMI, kg/m^2	28.78 (± 0.10)	30.22 (± 0.26)	28.33 (± 0.23)	28.48 (± 0.12)	< 0.0001
Health Insurance Status:	11,072 (81.47)	2,344 (62.37)	1,514 (65.88)	7,214 (89.01)	
Insured	3,246 (18.53)	1,290 (37.63)	839 (34.12)	1,117 (10.99)	< 0.0001
Uninsured					
Cigarette Smoking Status:	2,787 (19.20)	1,292 (39.63)	437 (21.57)	1,058 (13.58)	< 0.0001
Current Smoker	11,048 (80.79)	2,188 (60.37)	1,786 (78.43)	7,074 (86.42)	
Non-Smoker					
Dietary					
HEI-2015 Total Score, 100	51.68 (± 0.25)	47.10 (± 0.38)	49.88 (± 0.42)	53.23 (± 0.28)	< 0.0001

BMI: Body Mass Index; NHANES: National Health and Nutrition Examination Survey; SNAP: Supplemental Nutrition Assistance Program.

Cell counts may not equal the sample size due to missing information.

Statistical test adjusted for the NHANES sampling scheme.

Chi-square test and ANOVA used to calculate P values.

a. Mean (± standard error) for continuous variables.

3.3. Measures selected for Oaxaca-Blinder decomposition analysis

We selected a variety of socio-demographic, household, and health-related measures for inclusion in the Oaxaca-Blinder decomposition analysis. The selection of these measures was guided by 1) prior nutrition research on significant predictors of poor diet quality among US adults (Hiza et al., 2013; Darmon and Drewnowski, 2008; Monsivais et al., 2012; Leung et al., 2014; Bittoni et al., 2015; Fulkerson, 2018; MacLean et al., 2018; Leung and Villamor, 2010) and 2) the Household Production Theory as described in the Institute of Medicine's 2013 report titled *"Supplemental Nutrition Assistance Program: Examining the Evidence to Define Benefit Adequacy"* (IOM, 2013). The Household Production Theory states that consumers choose foods for consumption within the context of their family's characteristics, food preferences, available resources, and time constraints (IOM, 2013). Thus, this theory provides a framework for studying the factors that drive consumer choice for food consumption (IOM, 2013). We attempted to determine how NHANES participants' characteristics (e.g., educational attainment, household size), available resources (e.g., food security status, PIR) and time constraints (e.g., frequency of prepared meal acquisition) are associated with disparities in diet quality by SNAP participation status.

Among the socio-demographic measures included in the Oaxaca-

Blinder decomposition analysis were age (years), sex (male or female), race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, or other), educational attainment (< high school, high school or equivalent, some college, or ≥ college degree), and marital status. For marital status, we compared respondents who self-reported they were married or living with a partner to respondents who were single, divorced, or widowed. The household and health-related measures selected include number of household members, household food security status, number of meals acquired that were prepared away from home, body mass index (BMI), health insurance status (insured or uninsured), and cigarette smoking status (current smoker or non-smoker). Each respondent's household food security status was evaluated by NHANES using the U.S. Food Security Survey Module (United States, 2012); the measure was categorized as food secure, marginal food security, low food security, and very low food security. Number of meals prepared away from home corresponds to the total number of meals the respondent, or his or her spouse, acquired in the prior 7 days that were prepared in places such as restaurants, grocery stores, cafeterias, etc. We calculated BMI (kg/m^2) from each respondent's measured height and weight. We labeled a respondent as health insured if a respondent answered "yes" to whether or not they were covered by some kind of health insurance (including government programs such as Medicare).

Table 2

Results from Oaxaca-Blinder Analysis Decomposing the Disparity in HEI-2015 Total Score between SNAP Participants and Income-Eligible Non-Participants (Socio-Demographic Measures Only).

Measure:	Coefficient SNAP Participants	Standard Error	Coefficient Income-Eligible Non-Participants	Standard Error	Contribution to "Explained Gap"	Contribution to "Unexplained Gap"
Age	0.15***	0.02	0.13***	0.02	0.26	−1.01
Male Sex	−0.03	0.53	−3.06***	0.54	−0.04	−1.42***
Race/Ethnicity:						
Non-Hispanic White	REF	REF	REF	REF	REF	REF
Non-Hispanic Black	1.51*	0.66	−0.35	0.95	−0.12	−0.26
Hispanic	4.91***	0.88	5.00***	1.01	0.26*	0.23
Other	3.45*	1.56	6.50***	1.26	0.16*	0.23
Married or Living with Partner	−0.37	0.68	−0.96	0.83	−0.01	−0.27
Educational Attainment:						
< High School	0.35	0.61	−0.94	0.87	0.003	−0.41
High School or	REF	REF	REF	REF	REF	REF
Equivalent	1.87	0.97	2.28*	1.03	0.02	0.13
Some College	7.60***	1.72	7.61***	1.28	0.66***	−0.01
≥ College Degree						
Poverty-to-Income Ratio	0.18	0.27	−0.19	1.14	−0.04	−0.33
Predicted Value of HEI-2015 Total Score	**47.10**	**0.41**	**50.35**	**0.42**		
Total Gap in HEI-2015 Total Score					**3.24**	
Total Explained by Selected Measures					**1.14**	
Total Unexplained by Selected Measures					**2.10**	
Proportion of Total Explained					**35.51%**	

BMI: Body Mass Index; HEI: Healthy Eating Index; SNAP: Supplemental Nutrition Assistance Program.
*p-value < 0.05, **p-value < 0.01, ***p-value < 0.001.

3.4. Statistical analysis

We utilized NHANES sampling weights in all analyses performed to account for the complex sampling scheme. We adjusted the sampling weights to account for inclusion of three waves of NHANES data (Centers for Disease Control and Prevention, 2019). Descriptive statistics (i.e., means and frequencies) were examined for selected measures among all participants and stratified by SNAP participation status. Chi-square and analysis of variance (ANOVA) tests were used to identify significant differences in selected measures among SNAP participants, income-eligible non-participants, and income-ineligible non-participants. We considered *P*-values < 0.05 to be statistically significant.

The main objective of our analyses was to use Oaxaca-Blinder decomposition analysis to examine disparities in diet quality between SNAP participants and non-participants. Other studies have also employed Oaxaca-Blinder decomposition analysis to examine disparities in outcomes such as diet, BMI, and food access (Sen, 2014; Singleton et al., 2016; Powell et al., 2012; Ciaian et al., 2017). For example, Powell and colleagues used Oaxaca-Blinder decomposition analysis to evaluate racial/ethnic disparities in BMI among adolescents (Powell et al., 2012), and Ciaian and colleagues used it to examine disparities in diet diversity in Romania (Ciaian et al., 2017).

We used two-fold Oaxaca-Blinder decomposition analysis as described in the paper by Ben Jann for this research (Jann, 2008). Specifically, we used the "OAXACA" command with the pooled regression option in Stata version 14 (Jann, 2008). This approach partitions the mean gap in HEI-2015 total score between SNAP participants and non-participants into a portion "explained" by selected measures and a portion "unexplained" by selected measures. For each decomposition analysis performed, we assessed the selected measures to determine if they were significantly associated with the explained and unexplained portions of the gap in HEI-2015 total score.

We aimed to compare how much differences in socio-demographic measures alone explained the mean differential in HEI-2015 score to all measures together. Thus, we conducted four Oaxaca-Blinder decomposition analyses. The first calculated the portion of the gap in HEI-

2015 total score explained solely by socio-demographic measures between SNAP participants and income-eligible non-participants while the second calculated the portion explained by all measures. The third calculated the portion of the gap in HEI-2015 total score explained solely by socio-demographic measures between SNAP participants and income-ineligible non-participants while the fourth calculated the portion explained by all measures.

4. Results

Table 1 displays descriptive characteristics of NHANES 2009–2014 adult respondents. Analyses performed revealed statistically significant differences by SNAP participation status for all measures of interest. On average, HEI-2015 total score was lower among SNAP participants (47.10 ± 0.38) compared to income-eligible non-participants (49.88 ± 0.42) and ineligible non-participants (53.23 ± 0.28) (p < 0.0001). SNAP participants were, on average, younger, had more household members, had a greater BMI, and purchased fewer prepared meals compared to income-eligible non-participants and income-ineligible non-participants. Furthermore, a larger percentage of SNAP participants were non-Hispanic black, Hispanic, food insecure, uninsured, and a current smoker compared to income-eligible non-participants and income-ineligible non-participants.

Tables 2 and 3 display results from Oaxaca-Blinder decomposition analyses that examined the disparity in HEI-2015 total score between SNAP participants and income-eligible non-participants. The analysis presented in Table 2 included only socio-demographic measures while the analysis in Table 3 included all measures. The total gap in HEI-2015 total score between SNAP participants and income-eligible non-participants was about 3.24 points. Socio-demographic measures alone explained 1.14 points (35.51% of the total gap). The measures for Hispanic and ≥ a college degree significantly contributed to the explained gap in this model. All measures combined explained 1.84 points (56.86% of the total gap). Race/ethnicity, having ≥ a college degree, BMI, and smoking status significantly contributed to the explained gap in the model that included all measures.

Table 3

Results from Oaxaca-Blinder Analysis Decomposing the Disparity in HEI-2015 Total Score between SNAP Participants and Income-Eligible Non-Participants (All Measures).

Characteristic:	Coefficient SNAP Participants	Standard Error	Coefficient Income-Eligible Non-Participants	Standard Error	Contribution to "Explained Gap"	Contribution to "Unexplained Gap"
Demographics						
Age	0.14***	0.02	0.09***	0.03	0.21	−2.08
Male Sex	−0.11	0.58	−2.65***	0.58	−0.04	−1.19**
Race/Ethnicity:						
Non-Hispanic White	REF	REF	REF	REF	REF	REF
Non-Hispanic Black	1.16	0.66	−0.25	0.90	−0.08	−0.21
Hispanic	3.98***	0.90	4.78***	0.96	0.22*	0.21
Other	2.97*	1.48	5.97***	1.30	0.14*	0.23
Married or Living with Partner	−0.07	0.72	−0.63	0.86	−0.01	−0.26
Educational Attainment:						
< High School	0.39	0.67	−0.90	0.89	−0.002	−0.41
High School or Equivalent	REF	REF	REF	REF	REF	REF
Some College	1.74	0.91	1.89	0.99	−0.03	0.04
≥ College Degree	6.88***	1.67	5.94***	1.40	0.57***	−0.13
Poverty-to-Income Ratio	0.24	0.26	−0.34	1.17	−0.04	−0.53
Household						
Number of Household Members	−0.06	0.20	−0.46*	0.23	0.11	−1.32
Food Security Status:						
Food Secure	REF	REF	REF	REF	REF	REF
Marginal Food Security	0.65	0.90	0.26	0.94	−0.01	−0.06
Low Food Security	1.08	0.76	−0.96	0.96	−0.02	−0.38*
Very Low Food Security	2.43*	1.04	−2.42*	1.16	−0.09	−0.65**
Number of Meals Prepared Away from Home, past 7 days	−0.12	0.12	−0.19*	0.09	−0.14	−0.23
Health						
BMI	−0.16***	0.04	−0.08	0.06	0.25**	2.32
Health Insured	0.15	0.69	−0.15	0.80	0.002	−0.19
Current Smoker	−3.64***	0.49	−4.03***	1.04	0.75***	−0.10
Predicted Value of HEI-2015 Total Score	**47.11**	**0.41**	**50.35**	**0.43**		
Total Gap in HEI-2015 Total Score					**3.24**	
Total Explained by Selected Measures					**1.84**	
Total Unexplained by Selected Measures					**1.40**	
Proportion of Total Explained					**56.86%**	

BMI: Body Mass Index; HEI: Healthy Eating Index; SNAP: Supplemental Nutrition Assistance Program.

*p-value < 0.05, **p-value < 0.01, ***p-value < 0.001.

Tables 4 and 5 present results from Oaxaca-Blinder decomposition models that examined the disparity in HEI-2015 total score between SNAP participants and income-ineligible non-participants. The analysis presented in Table 4 included socio-demographic measures only. All measures were included in the analysis presented in Table 5. The total gap in HEI-2015 total score between SNAP participants and income-ineligible non-participants was approximately 6.30 points. Socio-demographic measures alone explained 4.56 points (72.40% of the total gap). The measures age, male sex, Hispanic, marital status, ≥ a college degree and PIR made significant contributions to the explained portion of the gap in this model. The analysis with all measures indicated that all measures combined explained 5.42 points (86.31% of the total gap). Age, sex, Hispanic, marital status, ≥ a college degree, PIR, number of meals prepared away from home, BMI, and smoking status made significant contributions to the explained portion of the gap in this model.

5. Discussion

Like previous literature, we observed that the diet quality of SNAP participants, as measured by HEI, is poorer than income-eligible non-participants and income-ineligible non-participants (Andreyeva et al., 2015; Leung et al., 2012; Gregory et al., 2013). A variety of individual and household-level factors have been linked to poor diet quality in US adults (Hiza et al., 2013; Darmon and Drewnowski, 2008; Monsivais et al., 2012; Leung et al., 2014; Bittoni et al., 2015; Fulkerson, 2018; MacLean et al., 2018; Leung and Villamor, 2010); however, prior to this study, there was limited knowledge of the extent to which socio-

demographic, household, and health-related factors were related the disparities in diet quality that exist between SNAP participants and non-participants. Our Oaxaca-Blinder decomposition analyses addressed this gap in knowledge and demonstrated how the diet quality of SNAP participants is predicted to improve if they had similar mean characteristics as non-participants.

5.1. SNAP participants vs. Income-Ineligible Non-Participants

As hypothesized, differences in socio-demographic characteristics explained a large proportion of the disparity between SNAP participants and income-ineligible non-participants. If SNAP participants had similar mean socio-demographic characteristics as income-ineligible non-participants, their mean HEI-2015 total score would increase by 4.56 points. Several studies, including a national assessment conducted by Hiza and colleagues, reported that socio-demographic characteristics, including age, sex, race/ethnicity, and educational attainment, are highly associated with diet quality among adults (Hiza et al., 2013; Darmon and Drewnowski, 2008; Monsivais et al., 2012). Educational attainment, specifically attaining a college degree, explained much of the disparity we observed between SNAP participants and income-ineligible non-participants. Education is highly correlated with both income and nutrition literacy, two strong predictors of dietary intake and health outcomes (Mantwill et al., 2015; Spronk et al., 2014). Addressing educational gaps in low-income populations may be a promising approach to reducing diet quality disparities.

Looking beyond socio-demographics, the household and health-

Table 4

Results from Oaxaca-Blinder Analysis Decomposing the Disparity in HEI-2015 Total Score between SNAP Participants and Income-Ineligible Non-Participants (Socio-Demographic Measures Only).

Characteristic:	Coefficient SNAP Participants	Standard Error	Coefficient Income-Ineligible Non-Participants	Standard Error	Contribution to "Explained Gap"	Contribution to "Unexplained Gap"
Age	0.15***	0.02	0.15***	0.01	1.04***	0.08
Male Sex	−0.03	0.53	−2.31***	0.30	−0.10***	−1.04**
Race/Ethnicity:					REF	
Non-Hispanic White	REF	REF	REF	REF	0.03	REF
Non-Hispanic Black	1.51*	0.66	−0.88	0.50	−0.27**	−0.44**
Hispanic	4.91***	0.88	1.11	0.66	0.04	−0.66***
Other	3.45*	1.56	2.40***	0.61		−0.06
Married or Living with Partner	−0.37	0.68	1.26*	0.53	0.23*	0.80*
Educational Attainment:						
< High School	0.35	0.61	0.50	0.66	−0.12	0.05
High School or Equivalent	REF	REF	REF	REF	REF	REF
Some College	1.87	0.97	1.85***	0.53	0.03	−0.01
≥ College Degree	7.60***	1.72	6.07***	0.74	2.12***	−0.17
Poverty-to-Income Ratio	0.18	0.27	0.66**	0.19	1.57***	0.69
Predicted Value of HEI-2015 Total Score	**47.10**	**0.41**	**53.40**	**0.27**		
Total Gap in HEI-2015 Total Score					**6.30**	
Total Explained by Selected Measures					**4.56**	
Total Unexplained by Selected Measures					**1.74**	
Proportion of Total Explained					**72.40%**	

BMI: Body Mass Index; HEI: Healthy Eating Index; SNAP: Supplemental Nutrition Assistance Program.

*p-value < 0.05, **p-value < 0.01, ***p-value < 0.001.

related measures increased the explained portion of the gap in HEI-2015 total score between SNAP participants and income-ineligible non-participants, but not by much (about 14 percentage points). Both smoking status and BMI explained a portion of the disparity between SNAP participants and income-ineligible non-participants. Leung and colleagues reported that SNAP participation was associated with increased risk for obesity among a large cohort of adults in California (Leung and Villamor, 2010); A recent study published by MacLean and colleagues found that any amount of cigarette smoking was associated with poor diet among adults participating in NHANES 2013–2014 (MacLean et al., 2018). The high prevalence of smoking and obesity among SNAP participants in the sample suggests that their health behaviors, and arguably health literacy, may be poorer than non-participants (Mantwill et al., 2015; Spronk et al., 2014). Developing strategies that aim to broadly improve health literacy and the health behaviors associated with poor diet among low-income populations may decreased disparities in diet quality between SNAP participants and income-ineligible non-participants.

5.2. SNAP participants vs. Income-Eligible Non-Participants

As expected, the disparity in HEI-2015 total score between SNAP participants and income-eligible non-participants was substantially smaller than the disparity between SNAP participants and income-ineligible non-participants (3.24 vs. 6.30 points). Although adding household and health-related measures to the model increased the portion explained, nearly 50% of the gap in HEI-2015 total score between SNAP participants and income-eligible non-participants remained unexplained. It is clear that observable characteristics, such as income and education level, explain most of the disparity in HEI-2015 total score between SNAP participants in income-ineligible non-participants. Since SNAP participants and income-eligible non-participants are demographically similar, it is likely that unobserved characteristics are explaining the disparity in diet quality between these two groups (Center on Budget and Policy Priorities, 2018; Center on Budget and Policy Priorities, 2018; Smith et al., 2017; U.S. Department of Agriculture, 2017; Vega et al., 2017).

Literature on demographic, health, and behavioral differences between SNAP participants and income-eligible non-participants provide some context to the diet disparity (Gregory and Deb, 2015; Smith et al., 2017; U.S. Department of Agriculture, 2017; Center on Budget and Policy Priorities, 2018; Ziliak, 2016). It is possible that income-eligible non-participants receive informal support (either socially or financially) from other sources (e.g., family, friends, community, etc.), which helps them achieve a more optimal diet (Ziliak, 2016). Income-eligible non-participants may have better overall health or be more health conscious (Gregory and Deb, 2015) A study by Gregory and Deb found that SNAP participants rated their health as poorer and reported more sick days than income-eligible non-participants (Gregory and Deb, 2015). If income-eligible non-participants are healthier than SNAP participants, they may make healthier decisions about their diet. The study by Gregory and Deb also reported that SNAP participants are more likely to participate in several other government assistance programs and receive unemployment benefits compared to income-eligible non-participants (Gregory and Deb, 2015). Income-eligible non-participants may have negative views about participating in government-funded public assistance program or consider their low-income status is temporary (i.e., they have fallen on hard times). Overall, there appears to be a need for more research on differences between SNAP participants and income-eligible non-participants in regards to the attitudes, beliefs, and health behaviors that influence dietary intake. This research will expand the field's understanding of the factors that drive diet disparities by SNAP participation status.

5.3. Limitations

It is important to note the limitations of Oaxaca-Blinder decomposition analysis. First, these findings do not imply causation. They simply show how selected measures are explaining the calculated HEI-2015 total score differential. Much of the differential was unexplained by the selected measures. It is likely that the unexplained portion is due to measurement error and/or omitted measures (Jann, 2008).

Table 5
Results from Oaxaca-Blinder Analysis Decomposing the Disparity in HEI-2015 Total Score between SNAP Participants and Income-Ineligible Non-Participants (All Measures).

Characteristic:	Coefficient SNAP Participants	Standard Error	Coefficient Income-Ineligible Non-Participants	Standard Error	Contribution to "Explained Gap"	Contribution to "Unexplained Gap"
Demographics						
Age	0.14***	0.02	0.11***	0.01	0.82***	−0.96
Male Sex	−0.11	0.58	−1.42***	0.30	−0.07***	−0.59
Race/Ethnicity:					REF	
Non-Hispanic White	REF	REF	REF	REF	−0.01	REF
Non-Hispanic Black	1.16	0.66	−0.24	0.45	−0.24**	−0.27*
Hispanic	3.98***	0.90	1.20	0.65	0.03	−0.49*
Other	2.97*	1.48	1.71**	0.61	0.03	−0.08
Married or Living with Partner	−0.07	0.72	0.91	0.53	0.19*	0.47
Educational Attainment:						
< High School	0.39	0.67	0.58	0.65	−0.11	0.03
High School or Equivalent	REF	REF	REF	REF	REF	REF
Some College	1.74	0.91	1.82***	0.46	0.03	0.02
≥ College Degree	6.88***	1.67	5.23***	0.71	1.84***	−0.19
Poverty-to-Income Ratio	0.24	0.26	0.58***	0.17	1.56***	0.32
Household						
Number of Household Members	−0.06	0.20	−0.18	0.18	0.13	−0.40
Food Security Status:						
Food Secure	REF	REF	REF	REF	REF	REF
Marginal Food Security	0.65	0.90	−1.59	1.16	0.13	−0.33
Low Food Security	1.08	0.76	−2.28*	1.00	0.16	−0.49**
Very Low Food Security	2.43*	1.04	−3.57*	1.51	−0.01	−0.53***
Number of Meals Prepared Away from Home, past 7 days	−0.12	0.12	−0.47***	0.05	−0.52***	−1.03*
Health						
BMI	−0.16***	0.04	−0.28***	0.03	0.44***	−3.57*
Health Insured	0.15	0.69	−0.72	0.59	−0.13	−0.41
Current Smoker	−3.64***	0.49	−3.11***	0.61	0.91***	0.14
Predicted Value of HEI-2015 Total Score	**47.11**	**0.41**	**53.40**	**0.27**		
Total Gap in HEI-2015 Total Score					**6.29**	
Total Explained by Selected Measures					**5.42**	
Total Unexplained by Selected Measures					**0.87**	
Proportion of Total Explained					**86.31%**	

BMI: Body Mass Index; HEI: Healthy Eating Index; SNAP: Supplemental Nutrition Assistance Program.
*p-value < 0.05, **p-value < 0.01, ***p-value < 0.001.

Measurement error suggests that differences may exist between SNAP participants and non-participants in regards to what a variable actually measures. For example, the prepared food acquisition measure could actually be measuring 1) time allotted in an individual's schedule to cook at home or 2) financial resources needed to acquire prepared meals. Given that time use and financial resources can vary substantially between SNAP participants and non-participants, this measure may introduce measurement error to the analysis.

As previously mentioned, unobserved measures omitted from the analysis may explain the unexplained gap (Jann, 2008). Several measures may offer further explanation for the disparity in diet quality between SNAP participants and non-participants: geographic access to a supermarket, stress, social support, etc. NHANES does not collect information on each respondent's proximity to retailers that sell healthy food, such as large chain supermarkets, so we could not include this measure in the analysis. Studies have shown that low-income household are more likely to reside in food deserts compared to higher income household, which imply they have limited access to healthy food retailers (Larson et al., 2009). Thus, including a measure for geographic access to a supermarket the analysis could have increased the explained portion of the disparity between SNAP participants and income-ineligible non-participants (Caspi et al., 2012). Psychosocial factors such as stress and social support have been linked to dietary intake (Isasi et al., 2015; Strom and Egede, 2012). If SNAP participants and income-eligible non-participants experience varying levels of stress and social support, these two factors may be contributing to the unexplained portion of the disparity in diet quality between these two groups.

Unfortunately, Oaxaca-Blinder decomposition analysis does not provide any insight to what specifically factors contribute to the unexplained portion of the disparity.

Several limitations to our analysis are related to the data. We only analyzed day 1 of the 24-hour recall data because several participants were missing data for day 2. While analyzing two days of dietary intake can provide insight into the dietary intake of an individual or small subsamples, random errors associated with dietary recall are generally understood to cancel out in sufficient sample sizes (Ahluwalia et al., 2016). In the methods section, we mentioned that NHANES participants may be misclassified by SNAP eligibility and participation status. To be specific, if SNAP participants failed to report that they, or a member of their household, received benefits in the prior 12 months, it is likely that they are included in one of the groups for non-participants. If this is true, the mean differential in HEI-2015 total score between SNAP participants and both groups of non-participants is smaller than we estimated. On the other hand, income-eligible non-participants may have been misclassified as income-ineligible non-participants because SNAP uses other factors, such as disability status, to determine eligibility. Assuming income-eligible participants have poorer diet quality compared to income-ineligible participants, it is likely that the observed disparity in HEI-2015 total score between SNAP participants and income-ineligible non-participants in greater than we estimated.

Other limitations to this research should be noted. Self-selection bias may have affected our findings. Because low-income households are able to self-select SNAP participation, evaluating the influence of SNAP participation on health outcomes is difficult. Studies have shown

that food insecure low-income household are more likely to enroll in SNAP (Nord and Golla, 2009). Although we included a measure for food security status in the Oaxaca-Blinder decomposition analysis, it is likely that self-selection bias is still an issue. Many of the measures we analyzed were collected via self-report, so they may be subject to reporting errors. Lastly, NHANES measures may not represent a participant's usual behavior and characteristics because of the cross-sectional nature of the study. For example, a participant's diet, health behaviors, and SNAP participation status may fluctuate over the course of a year.

6. Conclusion

In summary, we observed disparities in diet quality between SNAP participants and non-participants. This is a key public health concern that has garnered much attention in recent years (Andreyeva et al., 2015; Leung et al., 2012; Mulik and Haynes-Maslow, 2017; Collins and Klerman, 2017). The results from the Oaxaca-Blinder decomposition analyses offers additional insight to what factors may explain disparities in diet quality between SNAP participants and non-participants. Overall, the findings demonstrate that there is an ongoing need for programs that aim to improve the education, health behaviors, and dietary intake of SNAP participants. This study highlights the paucity of information in the scientific literature on income-eligible non-participants. Future research should examine differences in the behaviors, attitudes, and beliefs between SNAP participants and eligible non-participants. This presents a promising line of continued research for those who examine factors that influence SNAP participation among low-income individuals in the U.S.

CRediT authorship contribution statement

Chelsea R. Singleton: Conceptualization, Methodology, Software, Formal analysis, Writing - original draft. **Sabrina K. Young:** Formal analysis, Writing - review & editing. **Nicollette Kessee:** Data curation, Formal analysis. **Sparkle E. Springfield:** Writing - original draft. **Bisakha Sen:** Supervision, Writing - review & editing.

Declaration of Competing Interest

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

Acknowledgements

Author contributions

C.R.S. conceptualized the research project. S.K.Y. analyzed the NHANES 24-hour recall data to calculate HEI-2015 scores. C.R.S. performed the Oaxaca-Blinder decomposition analysis. BS oversaw the statistical analyses. C.R.S. and N.K. led the writing of the manuscript. All authors were involved in developing the final content presented in this manuscript. All authors were involved in editing and approving the final version for submission.

References

Committee on Examination of the Adequacy of Food Resources and SNAP Allotments, Food and Nutrition Board, Committee on National Statistics, Institute of Medicine; National Research Council, Caswell JA, Yaktine AL, editors. Supplemental Nutrition Assistance Program: Examining the Evidence to Define Benefit Adequacy. Section 2: History, Background, and Goals of the Supplemental Nutrition Assistance Program. Washington, DC: The National Academy Press, 2013.

Center on Budget and Policy Priorities. The Supplemental Nutrition Assistance Program (SNAP). Internet: https://www.cbpp.org/sites/default/files/atoms/files/policy-basics-foodstamps.pdf (accessed 26 August 2018).

U.S. Department of Agriculture, Food and Nutrition Service. Am I Eligible for SNAP? Version current 27 June 2018. Internet: https://www.fns.usda.gov/snap/eligibility (accessed 26 August 2018).

Center on Budget and Policy Priorities, Carlson S, Keith-Jennings B. SNAP is Linked with Improved Nutrition Outcomes and Lower Health Care Costs. Internet: https://www.cbpp.org/sites/default/files/atoms/files/1-17-18fa.pdf. (accessed 25 September 2018).

Bartfield, J., Gunderson, C., Smeeding, T., Ziliak, J.P., 2015. SNAP Matters: How Food Stamps Affect Health and Well-Being, 1st ed. Stanford University Press, Redwood City, CA.

Gregory, C.A., Deb, P., 2015. Does SNAP improve your health? Food Policy 50, 11–19.

Berkowitz, S.A., Seligman, H.K., Rigdon, J., 2017. Supplemental nutrition assistance program (snap) participation and health care expenditures among low-income adults. JAMA 177, 1642–1649.

Mabli, J., Ohls, J., 2015. Supplemental Nutrition Assistance Program participation is associated with an increase in household food security in a national evaluation. J. Nutr. 145, 344–351.

Andreyeva, T., Tripp, A.S., Schwartz, M.B., 2015. Dietary quality of americans by supplemental nutrition assistance program participation status: a systematic review. Am. J. Prev. Med. 49, 594–604.

Leung, C.W., Ding, E.L., Catalano, P.J., Vallamor, E., Rimm, E.B., Willett, W.C., 2012. Dietary intake and dietary quality of low-income adults in the Supplemental Nutrition Assistance Program. Am. J. Clin. Nutr. 96, 977–988.

Hilmers, A., Chen, T.A., Dave, J.M., Thompson, D., Cullen, K.W., 2014. Supplemental Nutrition Assistance Program participation did not help low income Hispanic women in Texas meet the dietary guidelines. Prev. Med. 62, 44–48.

Nguyen, B.T., Shuval, K., Njike, V.Y., Katz, D.L., 2014. The Supplemental Nutrition Assistance Program and dietary quality among US adults: findings from a nationally representative survey. Mayo Clin. Proc. 89, 1211–1219.

Nguyen, B.T., Shuval, K., Bertmann, F., Yaroch, A.L., 2015. The Supplemental Nutrition Assistance Program, Food Insecurity, Dietary Quality, and Obesity among US Adults. Am. J. Public Health 105, 1453–1459.

Zhang, F.F., Liu, J., Rehm, C.D., 2018. Trends and Disparities in Diet Quality Among US Adults by Supplemental Nutrition Assistance Program Participation Status. JAMA 1, e180237.

Smith, T.M., Bertmann, F.M.W., Pinard, C.A., Schober, D.J., Shuval, K., Nguyen, B.T., Fricke, H.E., Yaroch, A.L., 2017. Factors Associated with Supplemental Nutrition Assistance Program Participation Among the Working Poor: Findings From 2012 American Community Survey. J. Hunger Environ. Nutr. 12, 169–180.

U.S. Department of Agriculture, Food and Nutrition Service. Characteristics of Supplemental Nutrition Assistance Program Households: Fiscal Year 2017. Internet: https://fns-prod.azureedge.net/sites/default/files/ops/Characteristics2017.pdf. (accessed 15 April 2019).

Vega, S.S., Hinojosa, M.S., Nguyen, J., 2017. Using Anderson's Behavioral Model to Predict Participation in the Supplemental Nutrition Assistance Program (SNAP) Among US Adults. J. Hunger Environ. Nutr. 12, 193–208.

Gummon, A.H., Tallie, L.S., 2017. Nutritional profile of Supplemental Nutrition Assistance Program household food and beverage purchases. Am. J. Clin. Nutr. 105, 1433–1442.

Andreyeva, T., Luedicke, J., Henderson, K.E., Tripp, A.S., 2012. Grocery store beverage choices by participants in federal food assistance and nutrition programs. Am. J. Prev. Med. 42, 411–418.

Tallie, L.S., Grummon, A.H., Miles, D.R., 2018. Nutritional Profile of Purchases by Store Type: Disparities by Income of Food Program Participation. Am. J. Prev. Med. 55, 167–177.

Jann, B., 2008. The Blinder-Oaxaca decomposition for linear regression models. The Stata J. 8, 453–479.

Sen, B., 2014. Using the oaxaca-blinder decomposition as an empirical tool to analyze racial disparities in obesity. Obesity 22, 1750–1755.

Singleton, C.R., Affuso, O., Sen, B., 2016. Decomposing Racial Disparities in Obesity Prevalence: Variations in Retail Food Environment. Am. J. Prev. Med. 50, 365–372.

Powell, L.M., Wada, R., Krauss, R.C., Wang, Y., 2012. Ethnic disparities in adolescent body mass index in the United States: The role of parental socioeconomic status and economic contextual factors. Soc. Sci. Med. 75, 469–476.

Ciaian, P., Cupák, A., Pokrivčák, J., Rizov, M., 2017. Food consumption and diet quality choices of Roma in Romania: a counterfactual analysis. Food Security 10, 437–456.

Centers for Disease Control and Prevention, National Center for Health Statistics. About the National Health and Nutrition Examination Survey. Version current 15 September 2017. Internet: https://www.cdc.gov/nchs/nhanes/about_nhanes.htm. (accessed 12 October 2018).

Johnson, C.L., Dohrmann, S.M., Burt, V.L., Mohadjer, L.K. National Health and Nutrition Examination Survey: Sample design, 2011-2014. National Center for Health Statistics. Vital Health Stat 2014;2(162).

Center on Budget and Policy Priorities. A Quick Guide to SNAP Eligibility and Benefits.

Version current 7 February 2018. Internet: https://www.cbpp.org/sites/default/files/atoms/files/11-18-08fa.pdf. (accessed 12 October 2018).

United States Department of Health and Human Services, United States Department of Agriculture. 2015-2020 Dietary Guidelines for Americans. Version current December 2015. Internet: https://health.gov/dietaryguidelines/2015/resources/2015-2020_Dietary_Guidelines.pdf. (accessed 12 October 2018).

Krebs-Smith, S.M., Pannucci, T.E., Subar, A.F., Kirkpatrick, S.I., Lerman, J.L., Tooze, J.A., Wilson, M.M., Reedy, J., 2018. Update of Health Eating Index: HEI-2015. J. Acad. Nutr. Diet 118, 1591–1602.

Reedy, J., Lerman, J.L., Krebs-Smith, S.M., Kirkpatrick, S.I., Pannucci, T.E., Wilson, M.M., Subar, A.F., Kahle, L.L., Tooze, J.A., 2018. Evaluation of the Health Eating Index-2015. J. Acad. Nutr. Diet. 118, 1622–1633.

Hiza, H.A.B., Casavale, K.O., Guenther, P.M., Davis, C.A., 2013. Diet quality of americans differs by age, sex, race/ethnicity, income, and education level. J. Acad. Nutr. Diet. 113, 297–306.

Darmon, N., Drewnowski, A., 2008. Does social class predict diet quality? Am. J. Clin. Nutr. 87, 1107–1117.

Monsivais, P., Aggarwal, A., Drewnowski, A., 2012. Are socio-economic disparities in diet quality explained by diet cost? J. Epidemiol. Community Health 66, 530–535.

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

Bittoni, M.A., Wexler, R., Spees, C.K., Clinton, S.K., Taylor, C.A., 2015. Lack of private health insurance is associated with higher mortality from cancer and other chronic diseases, poor diet quality, and inflammatory biomarkers in the United States. Prev. Med. 81, 420–426.

Fulkerson, J.A., 2018. Fast food in the diet: Implications and solutions for families. Physiol. Behav. 193, 252–256.

MacLean, R.R., Cowan, A., Vernarelli, J.A., 2018. More to gain: dietary energy density is related to smoking status in US adults. BMC Public Health 18, 365.

Leung, C.W., Villamor, E., 2010. Is participation in food and income assistance programmes associated with obesity in California adults? Results from a state-wide survey. Public Health Nutr. 14, 645–652.

IOM (Institute of Medicine) and NRC (National Research Council). Supplemental Nutrition Assistance Program: Examining the Evidence to Define Benefit Adequacy. Washington, DC: The National Academies Press. 2013.

United States Department of Agriculture. U.S. Adult Food Security Survey Module. Version current September 2012. Internet: https://www.ers.usda.gov/media/8279/ad2012.pdf. (accessed 31 October 2018).

Centers for Disease Control and Prevention, National Center for Health Statistics. National Health and Nutrition Examination Survey: Module 3, Weighting. Internet: https://wwwn.cdc.gov/nchs/nhanes/tutorials/module3.aspx. (accessed 15 April 2019).

Gregory, C., Ver Ploeg, M., Andrews, M., Coleman-Jensen, A. Supplemental Nutrition Assistance Program (SNAP) Participation Leads to Modest Changes in Diet Quality. ERR-147, U.S. Department of Agriculture, Economic Research Service. Version Current April 2013. https://www.ers.usda.gov/webdocs/publications/45059/36939_err147.pdf?v=0. (accessed 14 August 2019).

Mantwill, S., Monestel-Umana, S., Schulz, P.J., 2015. The relationship between health literacy and health disparities: a systematic review. PLoS ONE 10, e0145455.

Spronk, I., Kullen, C., Burdon, C., O'Connor, H., 2014. Relationship between nutrition knowledge and dietary intake. Public Health Nutr. 111, 1713–1726.

Center on Budget and Policy Priorities, Greenstein R, Keith-Jennings B, Rosenbaum D. Factors Affecting SNAP Caseloads. Version current August 2018. Internet: https://www.cbpp.org/sites/default/files/atoms/files/8-8-18fa.pdf. (accessed 6 December 2018).

Ziliak, J.P. Modernizing SNAP Benefits. Version current May 2016. Internet: http://www.hamiltonproject.org/assets/files/ziliak_modernizing_snap_benefits.pdf. (accessed 10 January 2019).

Larson, N.I., Story, M.T., Nelson, M.C., 2009. Neighborhood Environments: Disparities in Access to Healthy Foods in the U.S. Am. J. Prev. Med. 36, 74–81.

Caspi, C.E., Sorensen, G., Subramanian, S.V., Kawachi, I., 2012. The local food environment and diet: A systematic review. Health Place 18, 1172–1187.

Isasi, C.R., Parrinello, C.M., Jung, M.M., Carnethon, M.R., Birnbaum-Weitzman, O., Espinoza, R.A., Penedo, F.J., Perreira, K.M., Schneiderman, N., Sotres-Alvarez, D., Van Horn, L., Gallo, L.C., 2015. Psychosocial stress is associated with obesity and diet quality in Hispanic/Latino adults. Ann. Epidemiol. 25, 84–89.

Strom, J., Egede, L.E., 2012. The Impact of Social Support on Outcomes in Adult Patients with Type 2 Diabetes: A Systematic Review. Curr Diab Rep 16, 769–781.

Ahluwalia, N., Dwyer, J., Terry, A., Moshfegh, A., Johnson, C., 2016. Update on NHANES Dietary Data: Focus on Collection, Release, Analytical Considerations, and Uses to Inform Public Policy. Adv Nutr 7, 121–134.

Nord M, Golla AM. Does SNAP Decrease Food Insecurity? Untangling the Self-Selection Effect. EER-85, U.S. Department of Agriculture, Economic Research Service. Version Current October 2009. https://ageconsearch.umn.edu/record/55955/. (accessed 15 August 2019).

Mulik, K., Haynes-Maslow, L., 2017. The Affordability of MyPlate: An Analysis of SNAP Benefits and the Actual Cost of Eating According to the Dietary Guidelines. J Nutr Edu Behav 49, 623–631.

Collins, A.M., Klerman, J.A., 2017. Improving Nutrition by Increasing Supplemental Nutrition Assistance Program Benefits. Am. J. Prev. Med. 52, S179–S185.