HHS Public Access

Author manuscript

Am J Prev Med. Author manuscript; available in PMC 2018 February 01.

Published in final edited form as:

Am J Prev Med. 2017 February ; 52(2 Suppl 2): S127–S137. doi:10.1016/j.amepre.2016.06.011.

SNAP Participation and Diet-Sensitive Cardiometabolic Risk Factors in Adolescents

Cindy W. Leung, ScD, MPH[1], **June M. Tester, MD, MPH**[2], **Eric B. Rimm, ScD**[3,4], and **Walter C. Willett, MD, DrPH**[3,4]

[1]Center for Health and Community, University of California, San Francisco, San Francisco, California

[2]University of California, San Francisco Benioff Children's Hospital Oakland, Oakland, California

[3]Departments of Nutrition and Epidemiology, Harvard T.H. Chan School of Public Health, Boston, Massachusetts

[4]Channing Division of Network Medicine, Department of Medicine, Brigham and Women's Hospital, Harvard Medical School; Boston, Massachusetts

Abstract

Introduction—Previous research suggests participation in the Supplemental Nutrition Assistance Program (SNAP) is associated with poorer adult cardiometabolic health; the extent to which these associations extend to adolescents is unknown. Differences in diet quality, obesity, and cardiometabolic risk factors were examined among SNAP participants, income-eligible nonparticipants, and higher-income adolescents.

Methods—The study population comprised 4,450 adolescents ≤300% federal poverty level from the 2003–2010 National Health and Nutrition Examination Survey. Generalized linear models were used to examine associations between SNAP participation and the Alternate Healthy Eating Index-2010. Linear and logistic regression models were used to examine associations between SNAP participation, obesity, and risk factors comprising the metabolic syndrome. Data were analyzed in 2015.

Results—All surveyed adolescents consumed inadequate amounts of vegetables, fruits, whole grains, and long-chain fatty acids, while exceeding limits for sugary beverages, processed meats, and sodium. Although there were few dietary differences, SNAP participants had 5% lower Alternate Healthy Eating Index-2010 scores versus income-eligible nonparticipants (95% CI= −9%, −1%). SNAP participants also had higher BMI-for-age Z scores (β=0.21, 95% CI=0.01, 0.41), waist circumference Z scores (β=0.21, 95% CI=0.03, 0.39), and waist-to-height ratios (β=0.02, 95% CI=0.00, 0.03) than higher-income nonparticipants. SNAP participation was not associated with most cardiometabolic risk factors; however, SNAP participants did have higher overall cardiometabolic risk Z scores than higher-income nonparticipants (β=0.75, 95% CI=0.02, 1.49) and income-eligible nonparticipants (β=0.55, 95% CI=0.03, 1.08).

Address correspondence to: Cindy W. Leung, ScD, MPH, Center for Health and Community, University of California, San Francisco, 3333 California Street, Suite 465, San Francisco CA 94118. cindyleung@post.harvard.edu.

No financial disclosures were reported by the authors of this paper.

Conclusions—Adolescent SNAP participants have higher levels of obesity, and some poorer markers of cardiometabolic health compared with their low-income and higher-income counterparts.

Introduction

The Supplemental Nutrition Assistance Program (SNAP) is the largest federal food program that aims to alleviate food insecurity and improve the nutritional outcomes of low-income children and families. In 2014, a total of 46.7 million individuals participated in SNAP: roughly 14% were preschool-age children, 19% were school-age children, and 12% were adolescents.[1]

Several studies have established the protective role that SNAP plays against food insecurity.[2–4] However, the relation between the program and participants' ability to eat "a more nutritious diet" is less clear.[5] Unlike other federal food programs, SNAP places little restrictions on foods purchased with program benefits.[6] Other than SNAP-Ed, there are few policies/programs that aim to improve the SNAP participants' nutritional intake. A recent systematic review found few differences among SNAP participants with respect to diet quantity (i.e., total energy, macronutrients) compared to income-eligible nonparticipants and higher-income nonparticipants, but consistent results showing lower diet quality among SNAP participants relative to both nonparticipant groups.[7] These relationships were less evident for children (aged ≤19 years), though children's dietary outcomes have only been examined in four studies to date.[8–11]

Although studies have examined the association between SNAP participation and childhood obesity, the results have been inconsistent.[12–15] A limitation of prior studies is that many employed data from longitudinal studies initiated in the 1960s and 1970s, and thus have not been able to capture the changes in poverty and food insecurity that have occurred during the past decade. Studies using more-recent data are needed to understand how SNAP participation may influence children's weight in the current environment. Aside from obesity, little is known about the relation between SNAP participation and cardiometabolic risk factors among children and adolescents, although these associations have been found in adults.[16] If SNAP participation is associated with children's dietary intake, then its relation to broader cardiometabolic health deserves investigation.

This analysis focused on adolescence because it is a critical period for physical, cognitive, emotional, social, and behavioral development.[17] Furthermore, few studies of SNAP participation have examined this age group, the metabolic syndrome phenotype among adolescents has increased in recent years,[18, 19] and adolescent diet quality and weight status track into adulthood,[20, 21] influencing lifelong risk of Type 2 diabetes, cancer, and cardiometabolic health.[22–25] In addition, contextual factors like regular family meals and food preparation during adolescence predict higher diet quality in adulthood,[26–28] while psychosocial factors like dieting and disordered eating during adolescence persist into early adulthood.[29] Given the significance of the adolescent period, this study examined whether SNAP participation was associated with diet quality, obesity, and cardiometabolic risk factors in a large sample of lower-income adolescents.

Methods

Study Population

The National Health and Nutrition Examination Survey (NHANES) is an ongoing, multistage survey representative of the civilian, non-institutionalized U.S. population. This analysis combined data from the 2003–2010 surveys to include a sufficient representation of SNAP participants, income-eligible nonparticipants, and higher-income individuals. The analytic sample was restricted to 4,450 adolescents (aged 12–19 years), with household incomes ≤300% of the federal poverty level (FPL). However, there was variation in the sample size across analytic models, as certain outcomes were collected among a subset of study participants.

Measures

Household SNAP participation was defined as the receipt of SNAP benefits within the last 12 months. Adolescents were categorized into three groups: 1,209 SNAP participants with household incomes ≤130% FPL (i.e., SNAP participants), 1,468 nonparticipants with household incomes ≤130% FPL (i.e., income-eligible nonparticipants), and 1,773 nonparticipants with household incomes between 130% and 300% FPL (i.e., higher-income nonparticipants). SNAP participants with household incomes >130% FPL and adolescents with household incomes >300% FPL were excluded.

Dietary intake was assessed using two 24-hour dietary recalls, reported by the adolescent.[30] The first recall was administered in the Mobile Examination Center; the second recall was conducted by telephone. Incomplete dietary recalls (n=798) or recalls with implausible total energy intakes (<500 or >5,000 kcal/day; n=264) were excluded from analysis. Overall diet quality was assessed using the Alternate Healthy Eating Index (AHEI)-2010, a measure developed at the Harvard School of Public Health to be inversely related to chronic disease risk.[31] Data from the U.S. Department of Agriculture Food and Nutrient Database for Dietary Studies and the Food Patterns Equivalents Database were used to calculate the AHEI-2010. Consumption levels were compared with the 2010 Dietary Guidelines for Americans, the 2006 American Heart Association dietary guidelines for foods and food groups, and National Academy of Medicine's Dietary Reference Intakes. The AHEI-2010 was further modified by excluding trans fat, which was unavailable in NHANES, and alcohol, which was considered inappropriate for adolescent diet quality. The overall AHEI-2010 score was rescaled to the original 110 points.

Three anthropometric measures of adiposity were examined: BMI, waist circumference, and waist-to-height ratio (WHtR). Height, weight, and waist circumference were measured by trained personnel.[32] BMI was transformed into Z scores and age- and sex-specific percentiles using the 2000 Centers for Disease Control and Prevention growth charts.[33] Obesity was defined as having a BMI-for-age ≥95th percentile. Waist circumference Z scores were derived from the analytic sample. Elevated waist circumference was defined as having a waist circumference ≥90th percentile, specific to their age, sex, and ethnicity.[34] Elevated WHtR was defined as WHtR >0.5.[35, 36]

The following cardiometabolic risk factors were considered: high-density lipoprotein (HDL) cholesterol, systolic blood pressure, fasting triglycerides. and fasting glucose. HDL cholesterol and blood pressure were collected from NHANES participants in the Mobile Examination Center. Average systolic blood pressure was estimated from the first of three readings. Individuals were excluded if they had a partial or missing blood pressure status, or reported consuming alcohol, cigarettes, or coffee within the previous 30 minutes of testing. The International Diabetes Federation criteria were used to define age-appropriate cut offs for adolescents.[37] All cardiometabolic risk factors were converted to Z scores within the analytic sample to facilitate interpretation across risk factors. An overall cardiometabolic risk Z score was created by summing the Z scores; a higher score denoted higher cardiometabolic risk. Per the International Diabetes Federation criteria, metabolic syndrome was defined as waist circumference ≥90th percentile or BMI-for-age ≥95th percentile and the presence of two or more risk factors: elevated triglycerides (≥150 mg/dL), low HDL cholesterol (<40 mg/dL in boys, <50 mg/dL in girls), elevated blood pressure (≥130 mmHg), and elevated fasting glucose (≥100 mg/dL).

Covariates for multivariable models included adolescent's age, sex, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, other or multiple race/ethnicities); household reference (HR) person's birthplace (U.S. or outside of the U.S.), educational attainment (<12 years, high school graduate, any college, college graduate), marital status (married/ living with partner or not partnered); household income, household size, Women, Infants, and Children participation (participant, income-eligible nonparticipant, and higher-income nonparticipant), and household food insecurity (food secure, marginally food secure, and food insecure). Indicators accounted for missing data for HR's birthplace (n=155), HR's education (n=174), HR's marital status (n=331), and household food insecurity (n=597).

Statistical Analysis

Complex survey weights were used to account for the different sampling probabilities and participation rates of the various components of NHANES. Sociodemographic characteristics between SNAP participation and income groups were compared using chi-square tests for categorical variables and univariate regression for continuous variables. Means and distributions of dietary components were estimated using the National Cancer Institute statistical method for usual dietary intake, which accounts for the within-person variation of dietary intake while preserving the complex NHANES weighting scheme.[38] Generalized linear models, assuming a gamma distribution and a log link, were fit to estimate the relative difference in dietary quality.[39] Models adjusted for all study covariates and total energy intake. Dietary weights were used for all analyses of dietary outcomes.

To examine the associations between SNAP participation and cardiometabolic risk factors, multivariable linear and logistic regression models were fit for Z scores and clinical cutpoints, respectively. Mobile Examination Center weights were included in all analyses of BMI, waist circumference, WHtR, HDL cholesterol, and blood pressure. Fasting subsample weights were used in analyses of triglycerides, glucose, and overall cardiometabolic risk/the metabolic syndrome.

Data were analyzed in 2015. All statistical tests were two-sided and significance was considered at $p<0.05$. Statistical analyses were performed with SAS, version 9.3 and Stata SE, version 12.

Results

Of the 4,450 adolescents, 22.8% were SNAP participants, 29.5% were income-eligible nonparticipants, and 47.6% were higher-income nonparticipants. Individual and household-level differences between these groups are shown in Table 1. Adolescents participating in SNAP were, on average, younger than income-eligible nonparticipants but not higher-income nonparticipants. Approximately 86% of adolescents participating in SNAP lived below the FPL, compared with 65% of income-eligible nonparticipants. Adolescents participating in SNAP were also more likely to be racial/ethnic minorities, have a parent with fewer years of education, reside in a single-parent household, have a larger household size, and report higher levels of food insecurity than income-eligible and higher-income nonparticipant adolescents.

Compared with national dietary guidelines, very few adolescents consumed the recommended amounts of vegetables, fruits, whole grains, and long-chain fatty acids for optimal health (Table 2). Among all adolescents, the average intake of vegetables was 1.3–1.5 servings/day, of fruits was 0.8–1.0 servings/day, of whole grains was 0.4–0.5 servings/day, and of long-chain fatty acids was 0.04–0.05 g/day. Conversely, many adolescents exceeded the recommended limits for sugary beverages, processed meat, and sodium. The average intake of sugary beverages was 3.0–3.1 servings/day (24–25 fluid ounces/day); 10% of adolescents consumed more than 38–42 fluid ounces/day. For processed meats, the average intake was 0.4 servings/day, with only 40%–45% of adolescents meeting the American Heart Association's recommendation to consume <2 servings/week. The average intake of sodium ranged from 3,232 to 3,457 mg/day, which exceeds the National Academy of Medicine's tolerable upper limit of 2,300 mg/day. Of 110 total points, the average AHEI-2010 score was 33.5 for SNAP participants, 35.0 for income-eligible nonparticipants, and 34.2 for higher-income nonparticipants. Ninety-nine percent of all lower-income adolescents scored ≤50, less than half of the maximum score for optimal diet quality (data not shown).

When comparing SNAP participants with their income-eligible counterparts, SNAP participants consumed significantly less fruit juice (relative difference [RD]=0.72, 95% CI=0.59, 0.88), more processed meats (RD=1.25, 95% CI=1.02, 1.54), and had a lower AHEI-2010 score (RD=0.95, 95% CI=0.91, 0.99). Compared with higher-income nonparticipants, SNAP participants had a lower intake of fruit juice (RD=0.58, 95% CI=0.37, 0.91) and marginally higher intakes of fruit (RD=1.40, 95% CI=0.99, 1.98) and processed meats (RD=1.37, 95% CI=0.97, 1.96). SNAP participants did not differ significantly from either nonparticipant group with respect to intakes of vegetables, whole grains, sugary beverages, nuts and legumes, red meat, long-chain fatty acids, polyunsaturated fat, or sodium.

Associations between SNAP participation and anthropometric measures of adiposity are shown in Table 3. Among adolescent SNAP participants, 27.5% had a BMI-for-age ≥95th percentile, 33.6% had an elevated waist circumference, and 43.6% had an elevated WHtR. Compared with higher-income nonparticipants, adolescent SNAP participants had a higher BMI-for-age Z score (β=0.21, 95% CI=0.01, 0.41) and higher odds of obesity (OR=1.59, 95% CI=1.06, 2.39) after multivariate adjustment. These trends were also true for other measures: SNAP participants also had a higher waist circumference Z score (β=0.21, 95% CI=0.03, 0.39) and a higher WHtR (β=0.02, 95% CI=0.00, 0.03) than higher-income nonparticipants. When compared with income-eligible nonparticipants, adolescent SNAP participants had a marginally higher odds of obesity (OR=1.38, 95% CI=0.97, 1.96, p=0.07).

Associations between adolescent SNAP participation and cardiometabolic risk factors are shown in Table 4. Among SNAP participants, 30% had low HDL cholesterol, 11% had elevated fasting triglycerides, and 17% had elevated fasting glucose. Although there were no significant differences with respect to most risk factors, the mean values suggested trends consistent with poorer cardiometabolic health among SNAP participants, compared with both income-eligible and higher-income nonparticipants. After adjustment for sociodemographic factors and household food insecurity, there was a significantly higher overall cardiometabolic risk Z score relative to higher-income nonparticipants (β=0.75, 95% CI=0.02, 1.49) and income-eligible nonparticipants (β=0.55, 95% CI=0.03, 1.08).

Discussion

In this nationally representative sample of lower-income adolescents, most fell short of meeting dietary guidelines aimed at promoting health, and exceeded limits on foods and nutrients known to increase the risk of weight gain and chronic disease. Although most individual dietary components of the AHEI-2010 were not significantly different between groups, adolescent SNAP participants had a significantly lower AHEI-2010 score, compared with their income-eligible counterparts. These dietary results underscore the vast room for improvement and the importance of national programs and policies that can promote opportunities for healthier eating among all lower-income families.

Relative to both income-eligible and higher-income nonparticipants, adolescent SNAP participants had significantly higher levels of obesity, consistent across anthropometric measures of both central and overall adiposity. The economic, mental, and physical consequences of adolescent obesity have been well documented, including stark increases in the risks of obesity and coronary heart disease in adulthood.[40–43] In this study, adolescent SNAP participants did not differ clinically on most cardiometabolic risk factors, though they did have significantly higher overall cardiometabolic risk scores when compared with both ref groups. Although these associations with overall cardiometabolic risk were modest, the CIs for these results highlight the disparities across multiple cardiometabolic indicators that could be exacerbated among adolescent SNAP participants as they approach adulthood. Given this critical period, SNAP-like interventions that promote healthful eating behaviors and reduce obesity may be doubly important for their potential to improve dietary behaviors during adolescence and reduce future disparities in cardiometabolic disease.

The cross-sectional nature of the data precludes causal inferences. Although it is possible that the nature of SNAP participation facilitates dietary behaviors that promote chronic disease, particularly in the larger context of the low-income food environment,[44, 45] an equally plausible explanation may be that SNAP participation is a marker of severe vulnerability to poverty, food insecurity, and inadequate nutrition. The U.S. Department of Agriculture estimates that two thirds of all SNAP participants are children, elderly, or disabled people and the majority of SNAP participants live below the FPL.[1] In a study of Massachusetts SNAP participants, more than 70% of adults reported food insecurity at the time of SNAP enrollment.[46] Conversely, studies of eligible SNAP nonparticipants have found that many income-eligible nonparticipants live in married households and higher-income neighborhoods,[47] have other financial support, have higher educational attainment,[48] or simply report not needing SNAP despite meeting the income eligibility criteria.[49] Several of these demographic differences were observed in this study as well, indicating that this vulnerability extends to low-income adolescents as well as their adult caregivers. This suggests that SNAP serves low-income children and families who are truly in need of nutrition assistance and are also at the greatest risk for diet-related chronic disease.

Given that SNAP is already a national intervention aiming to improve food security and nutrition, policies have been proposed to strengthen its nutritional impact. These include providing incentives for healthful foods, removing sugary beverages from the list of products purchased with SNAP benefits, enhancing the nutrition education program, and providing more total benefits.[50] These policies have garnered majority support from key stakeholder groups,[51, 52] including SNAP participants.[46, 53, 54] Results of the Healthy Incentives Pilot demonstrated that providing financial incentives for fruits and vegetables can change purchasing and consumption patterns.[55] However, it is unlikely that incentives alone, like the Healthy Incentives Pilot, which resulted in a 0.24-cup daily increase in fruits and vegetables, can boost the diet and health behaviors of SNAP participants to the levels of income-eligible nonparticipants, much less to the levels needed to protect against the adverse effects of poverty on health. Similarly, there is evidence to suggest that SNAP benefit levels are inadequate, with many families running out of food before the end of the month.[56] Increasing SNAP benefit allotments is likely to have favorable effects on food insecurity and dietary intake. A 2013 IOM report recommended that the determination of SNAP benefit allotments should consider “specific individual, household, and environmental factors on [SNAP] participants’ purchasing power.”[57] To identify policies that would have the most beneficial impact both on participants’ health, an important next step is to conduct evidence-based interventions comparing multiple strategies against the status quo, such as incentives for healthful foods consistent with the dietary guidelines, restrictions of sugary beverages, and comprehensive nutrition education, all of which were recommended in a recent National Commission on Hunger report.[58]

Limitations

Other limitations of this study include the possibility for misclassification of SNAP participation status and unmeasured confounding by factors associated with food insecurity and cardiometabolic health. SNAP participation may be highly variable throughout the year —program participants can lose benefits because of changes in their income or other

circumstances, programmatic changes, or system errors. The unexpected loss of SNAP benefits has been associated with adverse children's developmental and health outcomes. Future studies should attempt to isolate these effects from the overall associations of SNAP participation and cardiometabolic health.[59, 60] Many prior studies have also found associations between food insecurity and children's mental health, including greater adversity,[61, 62] more behavioral problems,[63–66] worse psychosocial functioning,[67–69] and higher rates of depression and suicidal thoughts.[70] Similarly, environmental factors like the food environment, neighborhood walkability, and exposures to other environment stressors are often correlated with SES and may influence children's cardiometabolic health.[71–73] These psychosocial and neighborhood-level measures are not available in the NHANES public use data files but should be incorporated in future studies to better understand the complexities of the associations observed. Lastly, although 24-hour dietary recalls are self-reported and generally underestimate total energy intake,[74] there is no reason that this would be differential by SNAP participation status.

Conclusions

SNAP is a critical program that protects low-income families from food insecurity. However, the results of this study suggest that most lower-income adolescents have poor diet quality, high levels of obesity, and adverse cardiometabolic profiles, with some evidence that adolescent SNAP participants are at greater risk. Stakeholder-supported policies to strengthen the nutritional impact of SNAP deserve further consideration. With its broad reach, SNAP has the potential to influence the diets of millions of children and adolescents, and thus represents a unique opportunity to reduce disparities and improve the lifelong health of those most vulnerable to food insecurity and poor nutrition.

Acknowledgments

The authors were supported by grants 1K99HD84758 (Leung) and 1K23HD075852 (Tester) from NIH. Publication of this article was supported by the Physicians Committee for Responsible Medicine.

REFERENCES

1. Gray, KF., Kochhar, S. Characteristics of Supplemental Nutrition Assistance Program Households: Fiscal Year 2014. Alexandria, VA: Food and Nutrition Service, U.S. Department of Agriculture; 2015. Report No. SNAP-15-CHAR
2. Nord M, Golla AM. Does SNAP Decrease Food Insecurity?. Untangling the Self-Selection Effect: Economic Research Service, U.S. Department of Agriculture. 2009 Report No.: 85.
3. Mabli, J., Ohls, J., Dragoset, LLC., Santos, B. Measuring the Effect of Supplemental Nutrition Assistance Program (SNAP) Participation on Food Security. Alexandria, VA: Food and Nutrition Service, U.S. Department of Agriculture; 2013.
4. Nord M. How much does the Supplemental Nutrition Assistance Program alleviate food insecurity? Evidence from recent programme leavers. Public Health Nutr. 2012; 15(5):811–817. [PubMed: 22015063]
5. As Amended Through P.L. 113–128, Enacted July 22, 2014. Washington, D.C.: Food and Nutrition Service, U.S. Department of Agriculture; 2014. Food and Nutrition Act of 2008.
6. [cited 2016 May 13] Supplemental Nutrition Assistance Program - Eligible Food Items. 2016. Available from: http://www.fns.usda.gov/snap/eligible-food-items

7. Andreyeva T, Tripp AS, Schwartz MB. Dietary Quality of Americans by Supplemental Nutrition Assistance Program Participation Status: A Systematic Review. Am J Prev Med. 2015; 49(4):594–604. [PubMed: 26238602]
8. Fox MK, Hamilton WL, Lin B-H. Effects of Food Assistance and Nutrition Programs on Nutrition and Health: Volume 3. Literature Review: Economic Research Service, U.S. Department of Agriculture. 2004
9. Leung CW, Blumenthal SJ, Hoffnagle EE, Jensen HH, Foerster SB, Nestle M, et al. Associations of food stamp participation with dietary quality and obesity in children. Pediatrics. 2013; 131(3):463–472. [PubMed: 23439902]
10. Cole, N., Fox, MK. Diet Quality of Americans by Food Stamp Participation Status: Data from the National Health and Nutrition Examination Surveys, 1999–2004. Alexandria, VA: Food and Nutrition Service, US Department of Agriculture; 2008.
11. Yen ST. The effects of SNAP and WIC programs on nutrient intakes of children. Food Policy. 2010; 35(6):576–583.
12. Gibson D. Long-term food stamp program participation is differentially related to overweight in young girls and boys. J Nutr. 2004; 134(2):372–379. [PubMed: 14747674]
13. Gibson D. Long-term Food Stamp Program participation is positively related to simultaneous overweight in young daughters and obesity in mothers. J Nutr. 2006; 136(4):1081–1085. [PubMed: 16549483]
14. Gibson, D. Food Stamp Program Participation and Health: Estimates from the NLSY97. In: Michael, RT., editor. Social Awakening: Adolescent Behavior as Adulthood Approaches. New York: Russell Sage Foundation; 2001. p. 258-296.
15. Hofferth SL, Curtin S. Poverty, food programs, and childhood obesity. J Policy Anal Manage. 2005; 24(4):703–726. [PubMed: 16201056]
16. Leung CW, Willett WC, Ding EL. Low-income Supplemental Nutrition Assistance Program participation is related to adiposity and metabolic risk factors. Am J Clin Nutr. 2012; 95(1):17–24. [PubMed: 22170370]
17. Gentry, JH., Campbell, M. Developing Adolescents: A Reference for Professionals. Washington, D.C.: American Psychological Association; 2002.
18. Cook S, Weitzman M, Auinger P, Nguyen M, Dietz WH. Prevalence of a metabolic syndrome phenotype in adolescents: findings from the third National Health and Nutrition Examination Survey, 1988–1994. Arch Pediatr Adolesc Med. 2003; 157(8):821–827. [PubMed: 12912790]
19. Ford ES, Li C, Zhao G, Pearson WS, Mokdad AH. Prevalence of the metabolic syndrome among U.S. adolescents using the definition from the International Diabetes Federation. Diabetes Care. 2008; 31(3):587–589. [PubMed: 18071007]
20. Craigie AM, Lake AA, Kelly SA, Adamson AJ, Mathers JC. Tracking of obesity-related behaviours from childhood to adulthood: A systematic review. Maturitas. 2011; 70(3):266–284. [PubMed: 21920682]
21. Singh AS, Mulder C, Twisk JW, van Mechelen W, Chinapaw MJ. Tracking of childhood overweight into adulthood: a systematic review of the literature. Obes Rev. 2008; 9(5):474–488. [PubMed: 18331423]
22. Michels KB. Early life predictors of chronic disease. J Womens Health (Larchmt). 2003; 12(2): 157–161. [PubMed: 12737714]
23. Malik VS, Sun Q, van Dam RM, Rimm EB, Willett WC, Rosner B, et al. Adolescent dairy product consumption and risk of type 2 diabetes in middle-aged women. Am J Clin Nutr. 2011; 94(3):854–861. [PubMed: 21753066]
24. Frazier AL, Ryan CT, Rockett H, Willett WC, Colditz GA. Adolescent diet and risk of breast cancer. Breast Cancer Res. 2003; 5(3):R59–R64. [PubMed: 12631400]
25. Ambrosini GL, Oddy WH, Huang RC, Mori TA, Beilin LJ, Jebb SA. Prospective associations between sugar-sweetened beverage intakes and cardiometabolic risk factors in adolescents. Am J Clin Nutr. 2013; 98(2):327–334. [PubMed: 23719557]
26. Larson N, Fulkerson J, Story M, Neumark-Sztainer D. Shared meals among young adults are associated with better diet quality and predicted by family meal patterns during adolescence. Public Health Nutr. 2013; 16(5):883–893. [PubMed: 22857517]

27. Larson NI, Perry CL, Story M, Neumark-Sztainer D. Food preparation by young adults is associated with better diet quality. J Am Diet Assoc. 2006; 106(12):2001–2007. [PubMed: 17126631]
28. Laska MN, Larson NI, Neumark-Sztainer D, Story M. Does involvement in food preparation track from adolescence to young adulthood and is it associated with better dietary quality? Findings from a 10-year longitudinal study. Public Health Nutr. 2012; 15(7):1150–1158. [PubMed: 22124458]
29. Neumark-Sztainer D, Wall M, Larson NI, Eisenberg ME, Loth K. Dieting and disordered eating behaviors from adolescence to young adulthood: findings from a 10-year longitudinal study. J Am Diet Assoc. 2011; 111(7):1004–1011. [PubMed: 21703378]
30. MEC In-person dietary interviews procedure manual: Centers for Disease Control and Prevention. 2002
31. Chiuve SE, Fung TT, Rimm EB, Hu FB, McCullough ML, Wang M, et al. Alternative dietary indices both strongly predict risk of chronic disease. J Nutr. 2012; 142(6):1009–1018. [PubMed: 22513989]
32. Anthropometry Procedures Manual: National Health and Nutrition Examination Survey. 2002
33. [cited 2015 December 23] A SAS Program for the 2000 CDC Growth Charts (ages 0 to <20 years). 2015. Available from: http://www.cdc.gov/nccdphp/dnpao/growthcharts/resources/sas.htm
34. Fernandez JR, Redden DT, Pietrobelli A, Allison DB. Waist circumference percentiles in nationally representative samples of African-American, European-American, and Mexican-American children and adolescents. J Pediatr. 2004; 145(4):439–444. [PubMed: 15480363]
35. Browning LM, Hsieh SD, Ashwell M. A systematic review of waist-to-height ratio as a screening tool for the prediction of cardiovascular disease and diabetes: 0.5 could be a suitable global boundary value. Nutr Res Rev. 2010; 23(2):247–269. [PubMed: 20819243]
36. McCarthy HD, Cole TJ, Fry T, Jebb SA, Prentice AM. Body fat reference curves for children. Int J Obes (Lond). 2006; 30(4):598–602. [PubMed: 16570089]
37. Zimmet P, Alberti KG, Kaufman F, Tajima N, Silink M, Arslanian S, et al. The metabolic syndrome in children and adolescents - an IDF consensus report. Pediatr Diabetes. 2007; 8(5): 299–306. [PubMed: 17850473]
38. [cited 2012 February 14] Usual Dietary Intakes: The NCI Method. 2011. Available from: http://riskfactor.cancer.gov/diet/usualintakes/method.html
39. McCullagh, P., Nelder, JA. Generalized Linear Models, Second Edition. Boca Raton, Florida: Chapman & Hall/CRC; 1989.
40. Simmonds M, Llewellyn A, Owen CG, Woolacott N. Predicting adult obesity from childhood obesity: a systematic review and meta-analysis. Obes Rev. 2016; 17(2):95–107. [PubMed: 26696565]
41. Bibbins-Domingo K, Coxson P, Pletcher MJ, Lightwood J, Goldman L. Adolescent overweight and future adult coronary heart disease. N Engl J Med. 2007; 357(23):2371–2379. [PubMed: 18057339]
42. Lightwood J, Bibbins-Domingo K, Coxson P, Wang YC, Williams L, Goldman L. Forecasting the future economic burden of current adolescent overweight: an estimate of the coronary heart disease policy model. Am J Public Health. 2009; 99(12):2230–2237. [PubMed: 19833999]
43. Gortmaker SL, Must A, Perrin JM, Sobol AM, Dietz WH. Social and economic consequences of overweight in adolescence and young adulthood. N Engl J Med. 1993; 329(14):1008–1012. [PubMed: 8366901]
44. Drewnowski A. Obesity and the food environment: dietary energy density and diet costs. Am J Prev Med. 2004; 27(3 Suppl):154–162. [PubMed: 15450626]
45. Drewnowski A, Specter SE. Poverty and obesity: the role of energy density and energy costs. Am J Clin Nutr. 2004; 79(1):6–16. [PubMed: 14684391]
46. Leung CW, Cluggish S, Villamor E, Catalano PJ, Willett WC, Rimm EB. Few changes in food security and dietary intake from short-term participation in the Supplemental Nutrition Assistance Program among low-income Massachusetts adults. J Nutr Educ Behav. 2014; 46(1):68–74. [PubMed: 24238909]

47. Chaparro MP, Harrison GG, Pebley AR. Individual and Neighborhood Predictors of Participation in the Supplemental Nutrition Assistance Program (SNAP) in Los Angeles County. J Hunger Environ Nutr. 2014; 9(4):498–511.
48. Cheng TC, Tang N. SNAP Out of It: A Study of Low-Income Families' Underutilization of Food Stamps. J Poverty. 2015 (In Press).
49. Kaiser L. Why do low-income women not use food stamps? Findings from the California Women's Health Survey. Public Health Nutr. 2008; 11(12):1288–1295. [PubMed: 18507889]
50. SNAP to Health: A Fresh Approach to Improving Nutrition in the Supplemental Nutrition Assistance Program. Washington, D.C.: Center for the Study of the Presidency and Congress; 2012.
51. Blumenthal SJ, Hoffnagle EE, Leung CW, Lofink H, Jensen HH, Foerster SB, et al. Strategies to improve the dietary quality of Supplemental Nutrition Assistance Program (SNAP) beneficiaries: an assessment of stakeholder opinions. Public Health Nutr. 2013:1–10.
52. Leung CW, Hoffnagle EE, Lindsay AC, Hoffman V, Lofink H, Turrell S, et al. A Qualitative Study of Diverse Experts' Views About Barriers and Strategies to Improve the Diets and Health of Supplemental Nutrition Assistance Program (SNAP) Beneficiaries. J Acad Nutr Diet. 2013; 113(1):70–76. [PubMed: 23260725]
53. Long MW, Leung CW, Cheung LW, Blumenthal SJ, Willett WC. Public support for policies to improve the nutritional impact of the Supplemental Nutrition Assistance Program (SNAP). Public Health Nutr. 2012:1–6. [PubMed: 23294865]
54. Leung CW, Ryan-Ibarra S, Linares A, Induni M, Sugerman S, Long MW, et al. Support for Policies to Improve the Nutritional Impact of the Supplemental Nutrition Assistance Program in California. Am J Public Health. 2015; 105(8):1576–1580. [PubMed: 26066922]
55. Bartlett, S., Klerman, J., Olsho, L., Logan, C., Blocklin, M., Beauregard, M., et al. Evaluation of the Healthy Incentives Pilot (HIP): Final Report. Alexandria: Food and Nutrition Service, U.S. Department of Agriculture; 2014.
56. The Council of Economic Advisers. Long-Term Benefits of the Supplemental Nutrition Assistance Program. Washington, D.C.: Executive Office of the President of the United States; 2015.
57. Institute of Medicine (IOM), National Research Council (NRC). Supplemental Nutrition Assistance Program: Examining the evidence to define benefit adequacy. Washington, D.C.: The National Academies Press; 2013.
58. Chilton M, Coates S, Doar R, Everett J, Finn SDF, et al. Freedom from Hunger: An Achievable Goal for the United States of America. 2015; 96 Available from: https://hungercommission.rti.org/.
59. Ettinger de Cuba, S., Harker, L., Weiss, I., Scully, K., Chilton, M., Coleman, S. Punishing Hard Work: The Unintended Consequences of Cutting SNAP Benefits. Boston, MA: Children's HealthWatch; 2013.
60. Chilton, M., Rabinowich, JR., Breen, A., Mouzon, S. When the systems fail: individual and household coping strategies related to child hunger. Washington, D.C.: Committee on National Statistics and Food and Nutrition Board; 2013.
61. Chilton M, Knowles M, Bloom SL. The Integernational Circumstances of Household Food Insecurity and Adversity. J Hunger Environ Nutr. 2016
62. Chilton MM, Rabinowich JR, Woolf NH. Very low food security in the USA is linked with exposure to violence. Public Health Nutr. 2014; 17(1):73–82. [PubMed: 23432921]
63. Melchior M, Chastang JF, Falissard B, Galera C, Tremblay RE, Cote SM, et al. Food insecurity and children's mental health: a prospective birth cohort study. PLoS One. 2012; 7(12):e52615. [PubMed: 23300723]
64. Slopen N, Fitzmaurice G, Williams DR, Gilman SE. Poverty, food insecurity, and the behavior for childhood internalizing and externalizing disorders. J Am Acad Child Adolesc Psychiatry. 2010; 49(5):444–452. [PubMed: 20431464]
65. Weinreb L, Wehler C, Perloff J, Scott R, Hosmer D, Sagor L, et al. Hunger: its impact on children's health and mental health. Pediatrics. 2002; 110(4):e41. [PubMed: 12359814]
66. Whitaker RC, Phillips SM, Orzol SM. Food insecurity and the risks of depression and anxiety in mothers and behavior problems in their preschool-aged children. Pediatrics. 2006; 118(3):e859–e868. [PubMed: 16950971]

67. Alaimo K, Olson CM, Frongillo EA Jr. Food insufficiency and American school-aged children's cognitive, academic, and psychosocial development. Pediatrics. 2001; 108(1):44–53. [PubMed: 11433053]

68. Jyoti DF, Frongillo EA, Jones SJ. Food insecurity affects school children's academic performance, weight gain, and social skills. J Nutr. 2005; 135(12):2831–2839. [PubMed: 16317128]

69. Murphy JM, Wehler CA, Pagano ME, Little M, Kleinman RE, Jellinek MS. Relationship between hunger and psychosocial functioning in low-income American children. J Am Acad Child Adolesc Psychiatry. 1998; 37(2):163–170. [PubMed: 9473912]

70. Alaimo K, Olson CM, Frongillo EA. Family food insufficiency, but not low family income, is positively associated with dysthymia and suicide symptoms in adolescents. J Nutr. 2002; 132(4): 719–725. [PubMed: 11925467]

71. Story M, Kaphingst KM, Robinson-O'Brien R, Glanz K. Creating healthy food and eating environments: policy and environmental approaches. Annu Rev Public Health. 2008; 29:253–272. [PubMed: 18031223]

72. Krueger PM, Reither EN. Mind the gap: race/ethnic and socioeconomic disparities in obesity. Curr Diab Rep. 2015; 15(11):95. [PubMed: 26377742]

73. Kurka JM, Adams MA, Todd M, Colburn T, Sallis JF, Cain KL, et al. Patterns of neighborhood environment attributes in relation to children's physical activity. Health Place. 2015; 34:164–170. [PubMed: 26057609]

74. Thompson, FE., Subar, AF. Nutrition in the Prevention and Treatment of Disease. In: Coulston, AM., Boushey, CJ., editors. Dietary Assessment Methodology. 2nd. Burlington, M.A.: Academic Press; 2008. p. 3-39.

Table 1

Characteristics of Lower-Income Adolescents (12–19 Years): NHANES 2003–2010

Characteristics	Higher-income nonparticipants (n=1,773)		Low-income nonparticipants (n=1,468)		SNAP participants (n=1,209)		*p*-value[a]
	n/mean	%/SE	n/mean	%/SE	n/mean	%/SE	
Adolescent characteristics							
Age	15.2	0.1	16.0	0.1	15.1	0.08	**<0.0001**
Female	825	48.0	729	51.4	603	50.3	0.24
Race/ethnicity							
Non-Hispanic white	468	60.3	321	48.2	208	38.2	**<0.0001**
Non-Hispanic black	529	14.3	357	14.6	561	31.9	
Hispanic	688	18.9	728	30.3	389	23.8	
Other or multi-racial	88	6.5	62	7.0	51	6.2	
Parental characteristics							
Birthplace							**<0.0001**
Born in the U.S.	1,221	80.0	793	66.7	894	76.9	
Born outside of the U.S.	507	17.5	621	30.1	279	19.8	
Educational attainment							**<0.0001**
<12 years	484	16.5	622	33.4	599	40.1	
High school diploma/ equivalent	450	27.7	354	25.7	335	33.5	
Any college	581	37.9	354	30.5	206	19.5	
College graduate	210	15.4	72	6.8	30	3.4	
Missing	48	2.6	66	3.6	39	3.4	
Marital status							**<0.0001**
Married/ living with partner	1,130	67.1	728	49.1	428	40.5	
Not partnered	568	28.2	609	40.2	677	51.5	
Missing	75	2.2	131	3.1	104	1.8	
Household characteristics							
Income as ratio to FPL (mean)	2.14	0.02	0.77	0.02	0.64	0.01	**<0.0001**

Characteristics	Higher-income nonparticipants (n=1,773)		Low-income nonparticipants (n=1,468)		SNAP participants (n=1,209)		*p*-value[a]
	n/mean	%/SE	n/mean	%/SE	n/mean	%/SE	
Income as ratio to FPL							-
0–50% FPL	-	-	379	26.9	445	33.2	
50.1–100% FPL	-	-	626	37.9	598	52.7	
100.1–130% FPL	-	-	463	35.2	166	14.1	
130.1–200% FPL	876	42.9	-	-	-	-	
200.1–300% FPL	897	57.1	-	-	-	-	
Household size	4.3	0.1	4.3	0.1	4.7	0.1	**0.001**
WIC participation							-
WIC participant	79	2.2	243	12.5	365	26.1	
Income-eligible nonparticipant	578	29.0	1057	75.2	816	71.2	
Higher-income nonparticipant	976	62.2	0	-	0	-	
Missing	140	6.6	168	12.3	28	2.7	
Food security							**<0.0001**
Food secure	1,261	76.0	741	51.3	588	51.3	
Marginally food secure	120	5.6	118	7.1	190	14.6	
Food insecure	212	8.8	287	16.5	376	29.4	
Missing	180	9.5	322	25.1	55	4.7	

Notes: Boldface indicates statistical significance (*p<0.05*).

[a]Differences between groups were tested using χ^2 tests for categorical variables and univariate regression for continuous variables.

SNAP, Supplemental Nutrition Assistance Program; FPL, federal poverty level; WIC, The Special Supplemental Nutrition Program for Women, Infants, and Children

Table 2

Associations Between SNAP Participation and Adolescent Diet Quality: NHANES 2003–2010[a]

Dietary components	Mean	Median	10th, 90th percentile	% Meeting guideline	Relative difference[b]	95% CI
Vegetables (servings/day)						
Higher-income non-participants	1.3	1.3	0.7, 2.2	0	Ref.	
Income-eligible nonparticipants	1.5	1.4	0.7, 2.4	0	1.07	0.90, 1.27
SNAP participants	1.3	1.2	0.6, 2.1	0	1.05	0.86, 1.28
Fruit (servings/day)						
Higher-income non-participants	0.8	0.5	0.1, 1.9	0.8	Ref.	
Income-eligible nonparticipants	1.0	0.7	0.1, 2.2	1.2	1.57	1.19, 2.08
SNAP participants	0.8	0.6	0.1, 2.0	1.0	1.40	0.99, 1.98
100% fruit juice (servings/day)						
Higher-income non-participants	0.3	0.2	0.0, 0.8	-	Ref.	
Income-eligible nonparticipants	0.5	0.3	0.1, 1.1	-	0.81	0.52, 1.26
SNAP participants	0.4	0.2	0.0, 0.9	-	0.58[c]	0.37, 0.91
Whole grains (servings/day)						
Higher-income non-participants	0.5	0.4	0.1, 1.0	0	Ref.	
Income-eligible nonparticipants	0.4	0.3	0.1, 0.9	0	0.96	0.72, 1.27
SNAP participants	0.4	0.3	0.1, 0.9	0	0.89	0.67, 1.19
Sugary beverages (servings/day)						
Higher-income non-participants	3.0	2.9	1.2, 5.0	2.2	Ref.	
Income-eligible nonparticipants	3.1	2.9	1.3, 5.2	2.3	0.98	0.81, 1.18
SNAP participants	3.0	2.8	1.4, 4.8	1.4	1.06	0.87, 1.29
Nuts, legumes, and soy (servings/day)						
Higher-income non-participants	0.8	0.6	0.1, 1.8	49.0	Ref.	
Income-eligible nonparticipants	0.8	0.5	0.1, 1.8	48.4	1.05	0.70, 1.58
SNAP participants	0.8	0.5	0.1, 1.8	45.4	0.96	0.61, 1.51
Red meat (servings/day)						
Higher-income non-participants	0.3	0.3	0.1, 0.6	92.5	Ref.	
Income-eligible nonparticipants	0.4	0.4	0.1, 0.6	90.7	0.90	0.66, 1.24

Dietary components	Mean	Median	10th, 90th percentile	% Meeting guideline	Relative difference[b]	95% CI
SNAP participants	0.4	0.3	0.1, 0.6	92.5	0.91	0.65, 1.29
Processed meat (servings/day)						
Higher-income non-participants	0.4	0.4	0.1, 0.8	39.9	Ref.	
Income-eligible nonparticipants	0.4	0.3	0.1, 0.8	44.5	1.10	0.81, 1.48
SNAP participants	0.4	0.4	0.1, 0.8	39.3	1.37[c]	0.97, 1.96
Long-chain fatty acids (g/day)						
Higher-income non-participants	0.04	0.04	0.02, 0.07	0	Ref.	
Income-eligible nonparticipants	0.05	0.04	0.02, 0.09	0	1.15	0.70, 1.90
SNAP participants	0.04	0.04	0.02, 0.07	0	0.91	0.57, 1.47
Polyunsaturated fat (% energy)						
Higher-income non-participants	7.1	7.0	5.4, 8.9	-	Ref.	
Income-eligible nonparticipants	7.3	7.2	5.6, 9.1	-	1.03	0.94, 1.14
SNAP participants	7.2	7.0	5.4, 9.0	-	0.99	0.89, 1.10
Sodium (mg/day)						
Higher-income non-participants	3445	3353	2294, 4721	9.7	Ref.	
Income-eligible nonparticipants	3457	3357	2297, 4739	9.6	0.98	0.93, 1.04
SNAP participants	3232	3139	2138, 4442	14.0	0.99	0.94, 1.04
Alternate Healthy Eating Index-2010 score						
Higher-income non-participants	34.2	33.9	26.8, 41.8	-	Ref.	
Income-eligible nonparticipants	35.0	34.8	27.5, 42.9	-	1.03	0.97, 1.09
SNAP participants	33.5	33.2	26.2, 41.1	-	0.97[c]	0.92, 1.04

Note: Boldface indicates statistical significance ($p<0.05$).

[a] Diet quality assessed using the Alternate Healthy Eating Index-2010

[b] Relative difference obtained from generalized linear models adjusted for adolescent's age, adolescent's gender, adolescent's race/ethnicity, parental birth place, parental educational attainment, parental marital status, household size, household income, household WIC participation, household food insecurity, and total energy intake.

[c] $p<0.05$ comparing SNAP participants to income-eligible nonparticipants

SNAP, Supplemental Nutrition Assistance Program, NHANES, National Health and Nutrition Examination Survey

Table 3

Associations Between SNAP Participation and Adolescent Anthropometric Measures of Adiposity: NHANES 2003–2010

Measures	Continuous measure			Clinical definition[a]		
	Mean ± SE	Multivariate-adjusted[b]		n (%)	Multivariate-adjusted[b]	
		β	95% CI		OR	95% CI
BMI-for-age Z score[c]						
Higher-income nonparticipants	0.59 ± 0.04	Ref.		359 (19.0)	Ref.	
Income-eligible nonparticipants	0.56 ± 0.05	0.11	−0.05, 0.28	295 (18.6)	1.15	0.83, 1.59
SNAP participants	0.74 ± 0.05	**0.21**	**0.01, 0.41**	303 (27.5)	**1.59**	**1.06, 2.39**
Waist circumference Z score[d]						
Higher-income nonparticipants	−0.05 ± 0.04	Ref.		486 (33.6)	Ref.	
Income-eligible nonparticipants	0.03 ± 0.05	0.09	−0.06, 0.25	447 (32.1)	1.21	0.87, 1.68
SNAP participants	0.08 ± 0.04	**0.21**	**0.03, 0.39**	364 (33.6)	1.48	0.96, 2.27
Waist-to-height ratio						
Higher-income nonparticipants	0.49 ± 0.003	Ref.		652 (37.1)	Ref.	
Income-eligible nonparticipants	0.50 ± 0.004	0.01	−0.01, 0.02	604 (39.7)	1.01	0.75, 1.38
SNAP participants	0.51 ± 0.004	**0.02**	**0.00, 0.03**	482 (43.6)	1.21	0.80, 1.82

Note: Boldface indicates statistical significance ($p<0.05$).

[a]Obesity was defined as BMI-for-age ≥95th percentile; elevated waist circumference was defined as a waist circumference ≥90th percentile specific to their age, sex and ethnicity; elevated waist-to-height ratio was defined as waist-to-height ratio >0.50.

[b]Model adjusted for adolescent's age, adolescent's gender, adolescent's race/ethnicity, parental birth place, parental educational attainment, parental marital status, household size, household income, household WIC participation, and household food insecurity.

[c]BMI-for-age z score derived from age- and sex-specific percentiles using the 2000 Centers for Disease Control and Prevention growth charts

[d]Waist circumference z score derived from analytic sample

SNAP, Supplemental Nutrition Assistance Program, NHANES, National Health and Nutrition Examination Survey

Table 4

Associations Between SNAP Participation and Adolescent Cardiometabolic Health: NHANES 2003–2010

Measures	Continuous measure				Clinical definition[b]			
	Mean ± SE		Multivariate-adjusted[c]		n (%)		Multivariate-adjusted[d]	
	Boys	Girls	β	95% CI	Boys	Girls	OR	95% CI
Systolic blood pressure (in mmHg)								
Higher-income nonparticipants	112.7 ± 0.5	107.2 ± 0.4	Ref.		60 (3.9)	10 (2.1)	Ref.	
Income-eligible nonparticipants	112.6 ± 0.7	107.0 ± 0.5	0.02	−0.13, 0.18	39 (4.8)	9 (0.8)	0.93	0.46, 1.87
SNAP participants	111.7 ± 0.6	107.2 ± 0.6	0.03	−0.14, 0.20	26 (7.3)	10 (1.1)	1.09	0.44, 2.71
Fasting triglycerides (in mg/dL)								
Higher-income nonparticipants	88.1 ± 3.6	87.7 ± 4.2	Ref.		41 (9.9)	28 (11.3)	Ref.	
Income-eligible nonparticipants	91.9 ± 4.3	87.3 ± 4.2	−0.02	−0.23, 0.20	31 (12.5)	22 (9.5)	1.09	0.40, 2.94
SNAP participants	92.5 ± 5.0	88.2 ± 4.6	0.10	−0.11, 0.31	23 (11.4)	19 (9.8)	1.37	0.49, 3.79
HDL cholesterol (in mg/dL)								
Higher-income nonparticipants	49.0 ± 0.5	54.3 ± 0.7	Ref.		198 (23.7)	194 (25.6)	Ref.	
Income-eligible nonparticipants	49.2 ± 0.7	54.4 ± 0.6	−0.03	−0.21, 0.15	166 (24.5)	175 (24.4)	1.02	0.70, 1.49
SNAP participants	49.5 ± 0.7	52.4 ± 0.7	−0.13	−0.32, 0.06	136 (28.8)	194 (31.5)	1.36[f]	0.86, 2.17
Fasting glucose (in mg/dL)								
Higher-income nonparticipants	96.4 ± 1.0	91.7 ± 0.6	Ref.		85 (24.3)	28 (10.6)	Ref.	
Income-eligible nonparticipants	96.1 ± 1.6	91.5 ± 0.7	0.12	−0.13, 0.36	66 (21.3)	33 (11.5)	0.96	0.48, 1.90
SNAP participants	96.7 ± 2.0	94.3 ± 2.1	**0.29**	**0.04, 0.53**	85 (21.4)	24 (13.0)	1.15	0.56, 2.35
Cardiometabolic risk (Z score)[e]								
Higher-income nonparticipants	0.7 ± 0.2	−0.5 ± 0.2	Ref.		28 (7.3)	16 (6.0)	Ref.	
Income-eligible nonparticipants	0.6 ± 0.2	−0.5 ± 0.2	0.20	−0.40, 0.80	19 (6.9)	16 (5.2)	1.16	0.51, 2.60
SNAP participants	0.5 ± 0.3	−0.2 ± 0.3	**0.75**[f]	**0.02, 1.49**	17 (7.9)	12 (4.8)	1.59	0.67, 3.77

Note: Boldface indicates statistical significance ($p<0.05$).

[a] Z scores derived from analytic sample

[b] International Diabetes Federation criteria used to define age-appropriate clinical cutpoints for cardiometabolic risk factors: Waist circumference ≥90th percentile or BMI-for-age ≥95th percentile and the presence of ≥2 risk factors: elevated triglycerides (≥150 mg/dL), low HDL-cholesterol (<40 mg/dL in boys, <50 mg/dL in girls), elevated blood pressure (≥130/ ≥85 mmHg), and elevated fasting glucose (≥100 mg/dL).

[c] Multivariate linear regression models were fit for continuous measures converted to Z scores and adjusted for adolescent's age, adolescent's gender, adolescent's race/ethnicity, parental birth place, parental educational attainment, parental marital status, household size, household income, household WIC participation, and household food insecurity.

[d] Multivariate logistic regression models adjusted for adolescent's age, adolescent's gender, adolescent's race/ethnicity, parental birth place, parental educational attainment, parental marital status, household size, household income, household WIC participation, and household food insecurity.

[e] As a continuous outcome, cardiometabolic risk was defined as the summation of the systolic blood pressure, fasting triglycerides, HDL cholesterol (inverse), and fasting glucose Z scores, with a higher score denoting higher cardiometabolic risk. As a dichotomous outcome, the metabolic syndrome was defined as waist circumference ≥90th percentile or BMI-for-age ≥95th percentile, and the presence of adverse levels of ≥2 risk factors.

[f] $p<0.05$ comparing SNAP participants to income-eligible nonparticipants.

SNAP, Supplemental Nutrition Assistance Program, NHANES, National Health and Nutrition Examination Survey; HDL, high-density lipoprotein; WIC, Special Supplemental Nutrition Program for Women, Infants and Children