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RESEARCH ARTICLE

Food Security and Weight Status in Children: Interactions With Food Assistance Programs

Binh T. Nguyen, PhD,[1] Christopher N. Ford, PhD,[2] Amy L. Yaroch, PhD,[3] Kerem Shuval, PhD,[2] Jeffrey Drope, PhD[2]

Introduction: It is unclear whether Supplemental Nutrition Assistance Program (SNAP) or National School Lunch Program (NSLP) participation modifies the relationship between food insecurity and obesity in children.

Methods: Data were included for 4,719 children aged 9–17 years who participated in the National Health and Nutrition Survey between 2003–2004 and 2011–2012. Linear regression was used to examine the relationship between household food security (full, marginal, low, and very low) and BMI percentile. Adjusted models were also stratified by SNAP and NSLP participation.

Results: There was no significant overall relationship between household food security and BMI percentile. In SNAP non-participants, there was no apparent overall relationship between BMI percentile and household food security. However, BMI percentile in children from households with low food security was significantly higher than that of children from fully food-secure households (risk difference [RD]=5.95, 95% CI=1.11, 10.80). Among SNAP participants, there was no significant relationship between household food security and BMI percentile. By NSLP participation category, there was a non-significant trend toward increasing BMI percentile with decreasing household food security in those reporting two or fewer (RD=1.75, 95% CI= −0.79, 4.29) and two to three (RD=1.07; 95% CI= −1.74, 3.89) lunches/week. There was no apparent relationship between household food security and BMI percentile in those reporting four or more lunches/week.

Conclusions: Although the overall relationship between household food security and weight status in school-aged children was not statistically significant, there was some evidence that the relationship may differ by SNAP or NSLP participation, suggesting the need for more research.

INTRODUCTION

One in six (16.9%) U.S. children aged 2–19 years suffers from obesity,[1] presumed to be the result of overconsumption of calories and insufficient physical activity.[2] Although the high prevalence of obesity would suggest a widespread abundance of calories in the diets of U.S. children, a significant number of children do not have sufficient access to nutritious foods. In 2014, nearly 9.4% of U.S. households with children reported having inadequate or inconsistent access to nutritious food on one or more occasions during the past year, and 422,000 households reported that children went hungry or without food as a result of severe food insecurity.[3] Though the coexistence of obesity and food insecurity might seem counterintuitive, some research suggests that food insecurity may increase the risk of obesity in children.[4,5]

Although prior studies have examined how food insecurity relates to weight status in children, the overall relationship remains unclear. Foremost, the interpretation

From the [1]Independent Research Consultant, Mountain View, California; [2]Economic and Health Policy Research, American Cancer Society, Atlanta, Georgia; and [3]The Gretchen Swanson Center for Nutrition, Omaha, Nebraska

Address correspondence to: Jeffrey Drope, PhD, American Cancer Society, 250 Williams Street NW, Suite D600, Atlanta GA 30303. E-mail: jeffrey.drope@cancer.org.

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of the extant literature is complicated by the conflation of child-specific food insecurity and household food insecurity. Nonetheless, findings from studies of the relationship between weight status in children and child-specific[6–12] and household food insecurity[5,7,8,10,13–18] have been equally inconsistent. One source of such inconsistencies may be participation in the Supplemental Nutrition Assistance program (SNAP) or the National School Lunch Program (NSLP), which, by improving access to nutritious foods,[19,20] could minimize the extent to which food insecurity adversely affects weight status in low-income children. In fact, at least two studies have found NSLP participation to be inversely related to weight status, particularly in children from the lowest income households.[21,22] The relationship between SNAP participation and weight status in children is less clear. Two studies found no evidence of a relationship between SNAP participation and weight status in children,[23,24] whereas another found that SNAP participation was associated with higher BMI only in children from households earning <130% of the Federal Poverty Level (FPL) living in cities where food prices were high.[22] Moreover, although studies examining the relationship between participation in SNAP and NSLP and weight status in school-aged children are scant, the authors are aware of no prior studies that have explored whether SNAP or NSLP participation modifies the relationship between food insecurity and weight status in school-aged children.

To address these gaps in the literature, this study used data on children and adolescents from the National Health and Nutrition Examination Study (NHANES). The overall relationship between household food security and weight status in children was examined, and participation in SNAP or NSLP was evaluated as a potential modifier of the relationship between food security and weight status in school-aged children. Lastly, all analyses were repeated using a child-specific measure of food security. By addressing these specific objectives, this study aimed to further the understanding of the complex relationship between food insecurity and weight status in children, and inform public health efforts to reduce both food insecurity and obesity among U.S. children.

METHODS

Data Sample

Five waves of NHANES data were used: 2003–2004, 2005–2006, 2007–2008, 2009–2010, and 2011–2012. NHANES comprises a multistage, cross-sectional, nationally representative survey conducted by the National Center for Health Statistics at the Centers for Disease Control and Prevention on an ongoing basis to monitor the health and nutrition status of the U.S. population.[25] Data were included for children with complete Day 1 dietary intake data and non-missing data for SNAP and NSLP participation who were aged 9–17 years, as children aged ≥9 years have been shown to report dietary intake with greater accuracy than younger children.[26–28] Additionally, the sample was restricted to children from households with an annual income ≤185% FPL to capture children who qualify for free or reduced-price lunches through NSLP, and in an effort to minimize bias due to residual confounding by household income level.[29] The current analysis did not require IRB approval.

Measures

The primary outcome, weight status, was represented using BMI percentile, computed from height and weight (kg/m^2) using Centers for Disease Control and Prevention growth charts.[30] Height and weight were measured in the mobile examination center by trained examiners following a standardized protocol. A description of these procedures has been previously published,[31] and more information can be found on the National Center for Health Statistics website (www.cdc.gov/nchs/nhanes/nhanes2011-2012/manuals11_12.htm). BMI percentile was modeled as a continuous outcome to capture subtle changes in weight status not otherwise reflected by a binary (e.g., normal weight versus obese) or ordinal measure (e.g., normal weight, overweight, or obese). This approach maximizes statistical power,[32] while allowing for the detection of subtle between-group differences in weight status.

As the primary exposure, food security was categorized as full, marginal, low, or very low based on responses to the NHANES Food Security Survey Module questionnaires, the details of which are available online.[25] NHANES characterizes household- and child-specific food security, but household food security status was chosen to represent food security status in all primary analyses. Households with full food security reported no food access problems or limitations; those with marginal food security reported concerns over food sufficiency or food shortage; households with low food security generally reported reduced quality, variety, or desirability of diet; and those with very low food security generally reported reduced food consumption and disrupted eating patterns.[24]

Food assistance program participation was characterized by participation in SNAP or NSLP. SNAP participation was determined by an affirmative response to the question *In the last 12 months, did [you, or any member of your household] receive food stamp benefits?* within the NHANES Food Security module.[25] NSLP participation was ascertained using responses to the following question in the NHANES Diet Behavior and Nutrition module: *During the school year, about how many times a week do you usually get a complete school lunch?* In all models, SNAP participation was modeled as a binary (yes/no) variable. NSLP participation was characterized by the number of weekly school lunches reported (continuous). To facilitate representation of model estimates, NSLP participation was categorized into three groups in stratified models: (1) zero to one lunch/week; (2) two to three lunches/week; and (3) four or more lunches/week. The three-category version of NSLP participation was modeled using disjoint indicator variables.

Statistical Analysis

Ordinary least squares regression was used to examine the relationship between food security status and BMI percentile. BMI percentile was modeled as a continuous variable to capture small differences in weight status between groups. Food security

status was modeled using disjoint indicator variables, with "full food security" serving as the reference category. SNAP participation, NSLP participation, age, race/ethnicity, and gender were evaluated as potential modifiers of the relationship between household food security status and BMI percentile. Interaction terms (food security status X potential modifier) were added to a model containing base terms for household food security status and the potential modifier of interest. A joint Wald test was used to test interaction relationships, whereby $p < 0.10$ was indicative of a statistically significant interaction.[33] Potential confounders of the relationship between food security status and BMI percentile were identified from the literature. Final adjusted models included gender,[21] age,[6] race/ethnicity,[34] and household income level.[22]

Appropriate survey weighting procedures were used in all analyses to account for the complex, multistage random sampling design of NHANES,[25] and to allow for representation of the U.S. population. Two-year mobile exam weights corresponding to each of five survey waves (2003–2004, 2005–2006, 2007–2008, 2009–2010, and 2011–2012) were combined and divided by five to represent 10-year weights. All analyses were conducted in Stata, version 14. The threshold for statistical significance was set at $\alpha=0.10$ for tests of interaction, and $\alpha=0.05$ for primary analyses.

RESULTS

Selected sample characteristics are presented in Table 1. The analytic sample comprised 4,719 children and adolescents, the plurality of whom were from fully food secure households (47.3%). Almost one in four (24.3%) children were from households with low food security, and 14.2% of children were from households with very low food security. Nearly one third (30.41%) of children participated in SNAP, and >80% reported consuming school lunch at least four times/week. The mean age of the sample was 12.9 (±3.5) years, and non-Hispanic white (42.0%) was the largest category, followed by Hispanic (29.8%) and non-Hispanic black (21.6%).

Risk differences (RDs) from crude and adjusted models of the relationship between household food security and BMI percentile are shown in Table 2. Overall, household food security status was not significantly related to BMI percentile in crude or adjusted models neither as a categorical or linear term variable.

A Wald test of the interaction of SNAP participation and household food security status was not statistically significant ($p=0.253$). The results of stratified analyses by SNAP participation are given in Table 3. Among non-participants of SNAP, there was no apparent relationship between BMI percentile and food security (RD=0.11, 95% CI= –1.11, 1.33). However, only children from households with low food security were significantly different from those from fully food-secure households (RD=5.95, 95% CI=1.11, 10.80). Among SNAP participants, there was no significant association between BMI percentiles and household food security (RD= –0.34; 95% CI= –1.99, 1.31).

Participation in NSLP was found to be a significant modifier of the relationship between food security status and BMI percentile (Wald test, $p<0.001$). Accordingly, the results of stratified models by category of reported weekly lunches are also presented in Table 3. In children reporting zero to one lunch/week (RD=1.75, 95% CI= –0.79, 4.29), and in children who reported two to three lunches/week (RD=1.07, 95% CI= –1.74, 3.89), there was not a significant trend relationship between BMI percentile and food security status. In children reporting four or more lunches/week, there was no apparent relationship between food security and BMI percentile.

In addition to testing for interaction of the relationship between household food security status and BMI percentile by SNAP and NSLP participation, age, race/ethnicity, and gender were evaluated as potential effect measure modifiers in separate models. Included in these models were base terms for SNAP and NSLP participation, as well as an interaction term for NSLP participation (school lunches/week) X household food security status. Neither age, race/ethnicity, or gender was found to be a significant modifier of the relationship between household food security status and BMI percentile.

DISCUSSION

Overall, household food security was not found to be significantly related to BMI percentile in children aged 9–17 years, which is consistent with findings from a number of previous studies. Although two prior studies have reported a positive relationship,[10,21] and one study an inverse relationship,[18] a majority of studies to date have found there to be no significant relationship between household food security and weight status in school-aged children.[7,8,13,15–17] Thus, the primary finding is consistent with the preponderance of evidence on the relationship between household food security and weight status in children. Nonetheless, this study may be the first to suggest that the relationship between food insecurity and weight status in school-aged children may differ according to participation status in SNAP or NSLP. In fact, consistent with speculation from the extant literature, household food insecurity (low or very low food security) was positively related to BMI in non-participants of SNAP, as well as in children reporting low participation in NSLP. Furthermore, in SNAP participants, and children with high NSLP participation, there was some evidence of a non-significant inverse relationship between household food security and BMI percentile. This observation would suggest that participation in food assistance programs (namely SNAP or NSLP) could weaken the relationship between food insecurity and weight status in school-aged children.

Table 1. Characteristics of Children Aged 9–17 Years From Low-Income (<185% of Federal Poverty Level) Households by Weight Status[a]

Variable	Full sample	Weight status[b]			
		Underweight	Normal weight	Overweight	Obese
Number of observations	4,719	93	2,484	819	1,169
Age, M ± SD	12.9 ± 3.5	12.7 ± 3.7	13.0 ± 3.5	12.9 ± 3.7	12.7 ± 3.4
Poverty-to-income ratio, M ± SD	1.0 ± 0.6	1.0 ± 0.7	1.0 ± 0.6	1.0 ± 0.7	1.0 ± 0.6
Household size, M ± SD	4.7 ± 2.0	4.9 ± 2.1	4.8 ± 2.0	4.6 ± 2.0	4.6 ± 2.0
Boy	49.7	50.5	50.6	46.6	50.1
SNAP participation	30.41	34.63	28.30	30.87	33.80
Household food security status					
Full food security	47.3	46.4	48.2	47.5	45.8
Marginal food security	14.2	8.5	13.6	15.2	15.0
Low food security	24.3	27.7	23.9	24.2	24.7
Very low food security	14.2	17.4	14.3	13.0	14.5
NSLP participation					
0–1 lunch/week	11.1	7.1	11.1	14.1	9.5
2–3 lunches/week	8.4	5.9	7.6	10.2	9.1
≥4 lunches/week	80.5	87.0	81.3	75.6	81.3
Race/ethnicity					
Non-Hispanic white	42.0	40.7	43.4	39.5	41.0
Non-Hispanic black	21.6	15.1	21.4	21.7	22.2
Hispanic	29.8	26.9	28.2	33.1	31.2
Other	6.6	17.3	7.0	5.7	5.5
Marital status of head of household					
Married	54.6	56.5	56.1	54.3	52.1
Widowed	25.9	29.3	25.5	23.0	27.8
Divorced/separated	3.7	2.9	3.5	4.0	4.1
Never married	15.9	11.3	14.9	18.7	16.0
Education level of head of household					
Less than high school	36.6	33.1	35.1	35.2	40.9
High school	29.1	32.8	29.5	27.7	28.3
Some college	26.3	27.5	26.0	28.8	25.3
College and above	8.1	6.6	9.3	8.2	5.5
WIC participation during the last year	18.1	20.2	17.4	19.1	18.4
Survey wave					
Wave 1 (2003–2004)	20.3	16.8	21.2	22.8	17.2
Wave 2 (2005–2006)	17.3	11.6	17.8	16.4	17.7
Wave 3 (2007–2008)	20.4	26.0	20.5	18.5	20.5
Wave 4 (2009–2010)	19.7	28.2	19.6	19.2	19.7
Wave 5 (2011–2012)	22.2	17.4	20.9	23.1	24.9

Note: Values are percentages unless otherwise noted.
[a]Data were from the National Health and Nutrition Examination Survey, Years 2003–2004, 2005–2006, 2007–2008, 2009–2010, and 2011–2012.
[b]Underweight was defined as a BMI that was less than the fifth percentile, normal weight included those with a BMI at or above the fifth percentile but less than the 85th percentile, overweight comprised children at or above the 85th BMI percentile but less than the 95th BMI percentile, and obese included children whose BMI was at or above the 95th percentile.
NSLP, National School Lunch Program; SNAP, Supplemental Nutrition Assistance Program; WIC, Special Supplemental Nutrition Program for Women, Infants and Children.

With participation in these programs, food insecurity is associated with decreased risk of elevated weight status. Notably, both SNAP and NSLP aim to improve access to healthy and nutritious food among children from low-income households.[19,20] However, eligibility for SNAP and NSLP are income dependent, which could thereby make participation more likely among children from lower-income households, who may also experience greater rates of low and very low household food security. Stratum-specific findings were consistent with this paradigm, wherein those with the greatest need (i.e., food insecurity) are able to take the greatest advantage of the program benefits. For SNAP participants,

Table 2. Differences in BMI Percentile by Household Food Security Status in Children From Low-Income Households[a,b,c,d]

Variable	Crude	Adjusted
Household food security status (categorical)		
Full food security	0.00 (ref)	0.00 (ref)
Marginal food security	1.80 (−1.32, 4.91)	1.16 (−1.96, 4.28)
Low food security	1.19 (−1.45, 3.83)	0.76 (−1.84, 3.35)
Very low food security	−0.65 (−4.19, 2.89)	−0.58 (−4.22, 3.05)
Household food security status (continuous)	0.06 (−0.90, 1.03)	0.00 (−0.98, 0.98)
p, trend	0.900	0.997

[a]Data were included for children ages 9–17 years from households earning ≤185% of the Federal Poverty Level who participated in the National Health and Nutrition Examination Survey between 2003 and 2012.
[b]All values excluding "*p*, trend" are given as mean difference from the reference category and 95% CIs (in parentheses).
[c]Adjusted models controlled for age; race/ethnicity; SNAP participation during the last 12 months (yes/no); number of weekly school lunches reported consumed by child; and household size.
[d]*p* for trend corresponds to the Wald test *p*-value when "household food security" was modeled as a continuous term.
SNAP, Supplemental Nutrition Assistance Program.

the amount of assistance for which a participant is eligible increases with decreasing income. Similarly, NSLP benefits increase with lower household income level: Although all children from households earning ≤185% FPL are eligible for free or reduced-price lunch, free lunch is provided only to children from households earning <130% FPL.

In addition to the primary analyses, age, race/ethnicity, and gender were examined as potential modifiers of the relationship between food security and weight status. Although it has been previously reported that the relationship between food security and weight status in children may differ by age,[6,8] the current study found that age was not a significant modifier of this relationship. This finding is consistent with that of two previous studies. Casey et al.[6] reported a significant and positive relationship between food insecurity and weight status in children aged 12–17 years, but there was no significant relationship observed in children aged 3–11 years. Similarly, Gunderson and colleagues[8] found that the relationship between food insecurity and overweight differed among children aged 3–10 years and those aged 11–17 years. Although the current study did not find a significant interaction effect by age, it is likely due to the age range of the sample, which did not include children aged <9 years.

Similarly, neither gender nor race/ethnicity was found to be a significant modifier of the relationship between food

Table 3. Differences in BMI Percentile by Household Food Security Status, SNAP Participation, and NSLP Participation[a,b,c,d]

	SNAP		NSLP Participation		
Variable	**Non-participant**	**Participant**	**0–1 lunch/week**	**2–3 lunches/week**	**≥4 lunches/week**
Household food security status (categorical)					
Full food security	0.00 (ref)	0.00 (ref)	0.00 (ref)	0.00 (ref)	0.00 (ref)
Marginal food security	1.46 (−2.43, 5.34)	−0.59 (−6.87, 5.69)	1.23 (−8.00, 10.46)	1.38 (−9.75, 12.52)	0.40 (−4.02, 4.82)
Low food security	**5.95 (1.11, 10.80)**	−2.94 (−8.41, 2.53)	6.77 (−0.70, 14.25)	1.35 (−6.66, 9.36)	0.84 (−2.75, 4.43)
Very low food security	−1.41 (−5.95, 3.12)	−3.19 (−22.61, 16.23)	5.20 (−3.61, 14.00)	4.54 (−5.54, 14.62)	−3.51 (−8.72, 1.71)
Household food security status (continuous)	0.11 (−1.11, 1.33)	−0.34 (−1.99, 1.31)	1.75 (−0.79, 4.29)	1.07 (−1.74, 3.89)	−0.67 (−1.82, 0.49)
p, trend	0.857	0.681	0.175	0.450	0.254

Note: Boldface indicates statistical significance ($p < 0.05$).
[a]Data were included for children aged 9–17 years from households earning ≤185% of the Federal Poverty Level who participated in the National Health and Nutrition Examination Survey between 2003 and 2012.
[b]All values excluding "*p*, trend" are given as mean difference from the reference category and 95% CIs (in parentheses).
[c]Models were adjusted for age, race/ethnicity, number of weekly school lunches reported consumed by child, and household size. When SNAP was modeled as the primary exposure, a continuous term for NSLP participation (lunches/week) was also included in the model. When NSLP participation was modeled as the primary exposure, a binary variable for SNAP participation (yes/no) was also included in the model.
[d]*p* for trend corresponds to the Wald test *p*-value when "household food security" was modeled as a continuous term.
NSLP, National School Lunch Program; SNAP, Supplemental Nutrition Assistance Program.

security and BMI percentile, despite previous reports to the contrary.[6,21] Findings from these studies have nonetheless been inconsistent. For example, Casey et al.[6] found a significant relationship between household food insecurity and overweight in girls but not in boys. Conversely, Jones and colleagues[21] found a significant relationship between food security and weight status in boys but not in girls. Likewise, some have found a significant relationship between food insecurity and weight status in white children but not among other racial/ethnic groups, whereas others have reported no differences in this relationship by race/ethnicity.[7] Of note, however, there may be differences in the prevalence of obesity in children by gender and race/ethnicity,[10,12,17] as well as gender and racial/ethnic differences in food security status.[7,15] Thus, gender and race/ethnicity are likely to be confounders of the relationship between household food security and BMI percentile, which was substantiated in model building as both variables met the criteria for inclusion in adjusted models.

Limitations

Although the current study offers an important contribution to the literature, there are limitations to this study that bear mentioning here. Foremost, NHANES comprises a nationally representative "snapshot" of the U.S. population at the time of the survey. Though these data are particularly useful for modeling trends in the health of the U.S. population over time, they are nonetheless limited by their cross-sectional nature. Moreover, most characteristics are measured at the same point in time, and individuals are not measured repeatedly over time; thus, the temporal sequencing of any exposure and outcome of interest cannot be determined. Therefore, the ability to draw causal inferences from such data is limited.[35] A further limitation is the use of self-report to ascertain both household food security status and food assistance program participation. Self-report may be prone to both intentional and unintentional misreporting,[36,37] which could lead to bias.

A final limitation of this study is the potential for sample bias. First, there may be differences between participants and non-participants of SNAP and NSLP that may also influence weight status. Children who participate in SNAP or the NSLP's free or reduced-price lunch program must meet income eligibility requirements, thereby making participants of the programs likely to differ from non-participants in important demographic characteristics such as race/ethnicity, head of household education level, and household income level. Differences in these and other between-group sample characteristics may have confounded the relationship between food security and weight status. However, to ensure adequate power to detect statistical significance, it was necessary to limit the number of covariates included in adjusted models. Accordingly, a minimally sufficient set of potential confounders was identified from the literature and included only age, gender, race/ethnicity, and annual household income. Nonetheless, the potential for residual confounding due to variables not included in the model remains a limitation of this study. Second, households who participate in SNAP tend to be more food insecure than non-participating households at the same income level. Moreover, the differences in food security between participants and non-participants may be greater than the effect of SNAP participation on food security, thereby making it difficult to determine how SNAP participation influences food security. Unfortunately, the most effective treatment of this issue requires longitudinal data that could permit the examination of changes in individuals' food security status over time. As appropriate data become available, future research will need to explore these potentially important issues.

CONCLUSIONS

There was no significant overall relationship between household food security and BMI percentile in school-aged children. However, although statistical significance was not achieved for trend relationships, the direction (inverse/positive) of the relationship differed according to participation level in SNAP or NSLP. In children with no or low participation in SNAP or NSLP, there was an inverse relationship between household food security and BMI percentile. Conversely, this relationship was positive in children participating in SNAP, or those with high participation in NSLP. This would suggest that participation in food assistance programs may attenuate the relationship between food insecurity and risk of obesity in school-aged children. However, future studies—ideally using time series data—are necessary to confirm these findings.

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SUPPLEMENTAL MATERIAL

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