Food Insecurity, Childhood Obesity, and the Role of Assistance Programs

By

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ABSTRACT

Childhood obesity has become a major health issue in the United States and is disproportionately prevalent among low-income children. A relationship may exist between food insecurity—uncertain access to adequate food--and childhood obesity, but empirical findings have been inconclusive. This study uses National Health and Nutrition Examination Survey (NHANES) data from 2003-2012 (n = 7,430) to reassess the relationship between food insecurity and weight status among low-income (PIR ≤ 1.85) children and adolescents using objective body measures, multiple measures of food insecurity, the most recent available data, and analytic methods to differentiate between overweight and obesity. In addition, this study explores the impact of the three largest food assistance programs (WIC, SNAP, and the National School Lunch Program (NSLP)) on the relationship between food insecurity and child weight status. Results suggest that both household and child-referenced food insecurity are significantly and persistently associated with obesity, but not overweight, among low-income children. Household participation in WIC, SNAP, and the NSLP does not mediate the relationship between child food insecurity and weight status, but results suggest that NSLP participation may be associated with increased risk for obesity among low-income children. Although this study was unable to account for selection factors in assistance program participation, results suggest the need to adjust assistance measures to better meet the needs of low-income food-insecure families in order to improve the health of children both during childhood and over the life course.

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INTRODUCTION

Childhood obesity has become a major social and health problem in the United States. Approximately one-third of children and adolescents are overweight or obese, with the highest rates found among Hispanics and non-Hispanic blacks (Ogden et al. 2014) and low-socioeconomic status (SES) groups (Singh, Siahpush, and Kogan 2010; Singh et al. 2008). Childhood obesity is associated with numerous comorbidities, such as diabetes and elevated blood pressure, and is considered a key predictor of adult obesity (Deckelbaum and Williams 2001). Although obesity is generally caused by an overabundance of energy intake, a seemingly paradoxical relationship may exist between obesity and food insecurity, which refers to a limited or uncertain ability to acquire adequate food. Food insecurity is experienced by approximately 19% of US households with children, and like obesity, it is concentrated among low-income and minority families (Coleman-Jensen, McFall, and Nord 2013). This possible convergence of over- and under-nutrition may create a double burden of negative health outcomes among the poor and racial/ethnic minorities. Despite the public health importance of this issue, however, the research on this relationship has been inconclusive. Due in part to inconsistencies in measurements and controls, studies have found mixed evidence of a relationship between food insecurity and childhood obesity, with substantial variation in findings by age, race/ethnicity, and sex.

This study explores the relationship between household and child-referenced food insecurity and weight status among low-income children using the National Health and Nutrition Examination Survey (NHANES) data from 2003-2012 (n = 7,430). This research has several advantages over prior studies, including objective rather than self-reported body measures, multiple measures of food insecurity, more recent data, and differentiation between overweight and obesity. In addition, few studies on food insecurity and child weight status have accounted

for the effect of participation in food assistance programs. I assess the relationship between household participation in the three largest food assistance programs in the U.S. (WIC, SNAP, and the National School Lunch Program (NSLP)), food insecurity, and child weight status to better understand the impact of these programs in addressing food insecurity and obesity among low-income children.

BACKGROUND

Overweight and obesity among children is one of the most pressing public health issues in the United States. In addition to the numerous health risks associated with obesity during childhood, it is associated with negative health outcomes throughout the life course. Evidence indicates that being overweight during childhood is associated with increased risk for severe obesity during adulthood (Ferraro, Thorpe Jr., and Wilkinson 2003), as well as adult morbidities (such as diabetes, hypertension, stroke, and heart disease) and premature mortality (Reilly and Kelly 2011). Additionally, obese children are subject to stigma which can influence self-esteem, depression, body dissatisfaction, social capital, and other outcomes (Puhl and Latner 2007), and may lead to negative social and behavioral consequences throughout the life course. More broadly, childhood socioeconomic conditions are associated with a wide range of adult health outcomes (Braveman and Barclay 2009); the link between childhood obesity—disproportionately prevalent among low-SES children—and adult health is only one example of the important connection between childhood disadvantage and health over the life course. Thus, addressing childhood disadvantage is a key area for policy intervention in order to improve overall population health, and understanding the mechanisms underlying inequalities in childhood obesity may help to target specific areas for intervention.

While the term "obese" strictly refers to excess adiposity and "overweight" refers to weight in excess of a weight standard, children's weight status is commonly classified using sex- and age-specific body mass index (BMI) percentiles (Ogden and Flegal 2010). BMI is used to express height-adjusted weight, and children at or below the 5th percentile of BMI-for-age are considered underweight, while overweight and obese cutoffs are at the 85th and 95th percentiles, respectively. While BMI does not directly measure excess adiposity, children at or above the 95th percentile for BMI are likely to have the high adiposity termed "obese" and children between the 85th and 95th percentiles for BMI are at greater risk for high adiposity, although the relationship between BMI and adiposity may vary by race (Flegal et al. 2010). Thus, it may be important to differentiate between BMI measures for overweight and obesity, as obesity is more likely to be associated with the high levels of adiposity thought to influence health and social outcomes. For example, among adults, obesity is associated with excess mortality, but overweight has a slight protective effect for mortality (Flegal et al. 2005).

Food Insecurity

Food insecurity is defined as the limited or uncertain ability to acquire adequate food through socially acceptable means for an active, healthy life (USDA 2014). Food insecurity typically encompasses two different levels of severity, termed "low" and "very low" food security. Low food security involves difficulties or uncertainties in food acquisition and possibly reduced dietary quality, but little to no reductions in food intake, while very low food security involves reductions in food intake and disruptions in eating patterns. Thus, the current conceptualization of food insecurity may or may not involve hunger or actualized reductions in food consumption. Food insecurity is most commonly assessed using the USDA's Food Security Survey Module (FSSM), an 18-item scale developed for use in the Current Population Study,

which is now included in several other national surveys (Nord et al. 2010). Of the 18 questions, 10 assess household-level food security (e.g., "we worried whether our food would run out before we got money to buy more") and 8 questions, asked of households with one or more children under age 18, are child-referenced (e.g., "did any of the children ever skip meals because there wasn't enough money for food?"). Food insecurity is then categorized based upon the number of affirmative responses (Nord et al. 2010).

Although the USDA FSSM has been validated and widely adopted to measure food security in the United States, it has several limitations (National Research Council 2006). Importantly, it is a subjective measure, and statements such as "we worried whether…" are inherently subject to individual interpretation. Additionally, it does not necessarily measure *nutritional* security and, as a household-level measure, it does not fully account for the allocation of food within the household or measure the individual experience of hunger (Pinstrup-Andersen 2009). The FSSM questions are typically asked in reference to the past 12 months, and thus do not provide detailed information on the duration of food insecurity. Finally, not all studies have consistently used guidelines to categorize food security based upon FSSM responses; for example, Kuku, Garasky, and Gundersen (2012) used a continuous measure of the number of total affirmative responses, and others have suggested that the classification of households with "marginal" food security (1-2 affirmative responses) as food secure may be problematic (Cook et al. 2013).

Food insecurity is, broadly, a consequence of a lack of resources, and the FSSM questions explicitly specify that the uncertainty or lack of food is due to financial constraints. Food insecurity is concentrated among low-income households, and among these low-income households, food insecurity rates are highest in households headed by single women, non-

Hispanic blacks, and Hispanics, and households with children are also more likely to be food-insecure (Coleman-Jensen et al. 2015). However, although food insecurity is inversely related to income, many poor households are not food insecure, and some higher-income households (i.e., those with a poverty-to-income ratio (PIR) greater than 2) are food insecure (Gundersen, Kreider, and Pepper 2011). Income over multiple years and liquid assets may be better predictors of food insecurity than current income, and this could explain some of the variation in the relationship between current income and food insecurity (Gundersen et al. 2011). The prevalence of food insecurity is sensitive to economic conditions; although rates were relatively steady between 2001 and 2007, there was a 35% increase in food insecurity in 2008 (from 12.2% to 16.4%), and an even greater relative increase in very low food insecurity, likely due to the economic recession (Gundersen et al. 2011). In 2014, an estimated 14% of all U.S. households were food insecure, and among households with children, 19.2% were food insecure (Coleman-Jensen et al. 2015). However, among households with children, only 9.4% reported that children were food insecure (Coleman-Jensen et al. 2015), showing that children are sometimes protected from the direct experience of household food insecurity.

Overall, food insecurity is strongly tied to SES and is one mechanism through which SES may impact health. Food insecurity is associated with numerous negative health and behavioral outcomes among children, including poorer reported health, higher hospitalization rates, higher rates of anxiety and depression, and lower academic achievement (see Nord and Parker 2010).

Food Insecurity and Weight Status

While research has generally found a consistent relationship between food insecurity and obesity for adult women, findings have been less conclusive for adult men and for children (Larson and Story 2011). One explanation for this trend is the gendered expectation that mothers

are responsible for the wellbeing of their children, and thus are more likely to risk their health when resources are scarce (Martin and Lippert 2012). Children, then, may be protected in some circumstances from the health consequences of household food insecurity.

The potential relationship between food insecurity and childhood obesity has been the focus of a growing body of literature. Investigation of this topic began after a 1995 case study of a low-income, food-insecure, obese girl (Dietz 1995). The family's first welfare check of the month was spent on rent, leaving no money for food until the second check arrived. The girl was fed high-fat foods to alleviate her hunger during these periods. Since this initial report, numerous academic articles have been published on the topics of food insecurity and childhood obesity, including four reviews of related literature (Dinour et al 2007, Eisenmann et al. 2011, Larson and Story 2011, Franklin et al. 2012).

Research has suggested several reasons for a potential linkage between food insecurity and childhood obesity. In 2014, food-secure households spent 24% more on food than comparable food-insecure households (Coleman-Jensen et al. 2015). As suggested by Dietz's (1995) case study, these food-insecure households may therefore be more likely to rely on low-cost, energy-dense foods, which may increase children's overall energy consumption. Evidence suggests that food insecurity is associated with reduced dietary quality, particularly among adults, and food insecurity may be associated with reduced fruit consumption among children (Hanson and Connor 2014). Because food insecurity tends to be recurrent but not chronic (Coleman-Jensen et al. 2015), it is possible that recurrent or cyclical food insecurity (for example, through the "food stamp cycle") contributes to patterns of overeating in periods of relative abundance as compensation for deprivation during periods of scarcity. This may lead to both immediate and long-term negative impacts on children's dietary quality, as children's eating

patterns and preferences become internalized over time. The impact of food insecurity on diet may therefore be one way in which the social environment becomes embodied as part of the habitus, a system of dispositions structured by social circumstances (Maton 2014). Because the habitus is to some extent durable over the life course, this may be one mechanism through which childhood obesity is associated with obesity and negative health outcomes during adulthood.

Food insecurity at the household level may affect child weight status through an interaction with parental stress (Lohman et al. 2009). The family stress perspective suggests that poverty creates economic stress within families, which is linked to maternal depression and parental food behaviors such as food acquisition and management strategies (McCurdy, Gorman, and Metallinos-Katsaras 2010). Thus stressors create disruptions in parental behaviors and mental health, leading to less competent parenting behaviors that may then affect children's risk of overweight and obesity. These parental disruptions may also cause suboptimal food management strategies, which contributes to food insecurity, and both food insecurity and less-competent parenting behaviors may affect children's risk of overweight and obesity. This view suggests that food insecurity may operate similarly to other forms of socioeconomic disadvantage, in that it leads to behavioral changes and tradeoffs among needs, and thus the coexistence of obesity and food insecurity may not be as paradoxical as previously imagined (Frongillo and Bernal 2014). Evidence for these theories is inconclusive, however, as some research has suggested that stress may have a protective effect on child weight status in food-insecure households as compared to food-secure households (Gundersen et al. 2008).

Empirical findings on the relationship between food insecurity and childhood obesity have been mixed. Research has found evidence for positive (e.g., Casey et al. 2006; Jyoti, Frongillo, and Jones 2005), negative (e.g., Alaimo, Olson, and Frongillo 2001), and no

associations (e.g., Gundersen, Garasky, and Lohman 2009; Bhargava, Jolliffe, and Howard 2008) between food insecurity and weight status among children. In a review of articles published between 2000 and 2010, Larson and Story (2011) found that the majority of studies showed no evidence of a direct relationship between food insecurity and childhood obesity, although a smaller number of studies reported either positive or negative results for some groups of children. They noted that early studies were limited by small sample sizes and inconsistent measurements, but measures and analytical tools have improved over time. For example, most research now uses the USDA FSSM to measure food insecurity, and studies increasingly utilize objective body measures rather than self- or parent-reported weight. More recent studies tend to support the conclusion that a direct causal relationship does not exist, but results are still not consistent or conclusive, and the role of mediating factors such as parental stress requires further exploration (Franklin et al. 2012). Current inconsistencies in results may also be attributable in part to differences in the populations studied, as researchers often examine different age groups and income categories. Additionally, studies differ on the analytic categories used for weight status; some combine overweight and obese into a single category, while others include overweight children in the normal weight category, and the decision to include or exclude underweight children varies. Finally, studies differ on the use of household, child-referenced, or personal food insecurity measures.

Recent work has further complicated these mixed results. Kuku, Garasky, and Gundersen (2012) criticized past studies for reliance on binary measures of food insecurity and instead performed a nonparametric analyses using a continuous measure of food insecurity, finding that the risk of obesity varies with the level of food insecurity, with substantial variation by gender, race/ethnicity, and poverty status. The relationships they found were complex and nonlinear,

suggesting that previous research may not have fully accounted for the complexity of the relationship between food insecurity and childhood obesity. Despite the innovative nature of this research, however, the USDA FSSM does not translate intuitively to a continuous measure of food insecurity, as the individual questions do not assess conditions of equal severity.

Other recent studies have found positive associations using parametric methods. Using NHANES data from 1999-2006, Holben and Christopher (2015) found that household food insecurity is associated with overweight and obesity among adolescents ages 12-18. Additionally, Kaur, Lamb, and Ogden (2015), using NHANES data from 2001-2010, found that personal food insecurity was associated with obesity for children aged 6-11, but not for children aged 2-5, and that child-referenced household food insecurity was not associated with obesity for either of these age groups. They suggested that household-level measures may not adequately capture food insecurity among children, as children may be protected from the effects of food insecurity within the family.

The Impact of Assistance Programs

Approximately half of food-insecure households participate in one or more of the three largest federal food and nutrition assistance programs in the U.S.: the Supplemental Nutrition Assistance Program (SNAP, formerly the Food Stamp Program), the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), and the National School Lunch Program (NSLP) (USDA 2014). SNAP and WIC provide food vouchers for qualifying low-income households, while the NSLP provides free or reduced-cost school lunches for qualifying low-income children. While these programs provide transfers of nutritional resources to participants and should directly decrease food insecurity, the overall effect of these voucher programs on health may be "theoretically ambiguous," as a family's previous food expenditures

that are replaced by program vouchers may be reallocated to either health-promoting expenditures (e.g., "healthy" food, bicycles, etc.) or health-depreciating expenditures (e.g., a television) (Gundersen 2015). However, food-insecure families may not have these resources to reallocate if they did not have enough money to buy food before participation, and programs may provide more resources to purchase better foods or reduce the stress associated with insufficient resources.

Empirical research has shown mixed results for the impact of SNAP, WIC, and the NSLP on obesity and other health outcomes, in part due to the problem of self-selection biases and reporting error. Although the goal of SNAP is to reduce food insecurity, food insecurity rates among SNAP recipients are nearly double the rates among eligible non-participants (Nord et al. 2010), and SNAP participation is systematically under-reported (Gundersen, Kreider, and Pepper 2011). Kreider et al. (2012) used statistical methods to account for selection and classification problems and concluded that, in contrast to many studies suggesting relationships between SNAP and poor health outcomes, SNAP participation may have positive effects on child health. However, other longitudinal studies have suggested that long-term receipt of SNAP benefits may be associated with higher BMIs among certain groups (Gibson 2004). Others suggest that the impact of food assistance on weight may vary by other characteristics such as local food prices (Kimbro and Rigby 2010).

Results of research on the link between WIC and NSLP participation and child obesity have also been mixed. WIC may reduce child health risks by attenuating the impact of stressors (including food insecurity) on health (Black et al. 2012), but others have found no relationship between assistance and weight (e.g., Ver Ploeg et al. 2008). Similarly, the NSLP may reduce obesity (Gundersen, Kreider, and Pepper 2012) or increase it, even after controlling for selection

biases (Millimet, Tchernis, and Husain 2010). Other research suggests that low-income girls who participate in the NSLP are at risk for greater weight gain over time than non-participants, but that this relationship does not exist for boys (Hernandez, Francis, and Doyle 2011).

A handful of studies have attempted to assess the role of food assistance programs in the relationship between food insecurity and childhood obesity. Some evidence suggests that the impact of assistance program participation on obesity for children in low-income families varies by food-insecurity status (i.e., that assistance increases the risk of obesity for food-secure youth but does not increase the risk of obesity for food-insecure youth) (Larson and Story 2011). Research has been inconclusive due to the inability to account for selection bias in program participation and due to many families' participation in multiple programs. For example, Jones et al. (2003) found that food-insecure girls participating in WIC, SNAP, and NSLP were less likely to be overweight than nonparticipating food-insecure girls, but no effect was found for boys or for girls participating in fewer than all of the programs. Recent research has suggested that self-selection bias may explain some, but not all, of the associations, and supports the conclusion that outcomes for assistance programs vary by food security status (Kohn et al. 2013).

Research Questions

Due to the inconclusive findings in previous research, this study will reassess the relationship between food insecurity, child weight status, and assistance program participation by answering the following research questions: (1) Is there a relationship between household or child-referenced food insecurity and risk of overweight or obesity among low-income children? (2) If such a relationship exists, does it vary by age, race/ethnicity, or sex? (3) Does household participation in one or more of the three largest food assistance programs (WIC, SNAP, and the NSLP) mediate or modify the relationship between food insecurity and child weight status?

METHODS

Data

In order to obtain a sufficient sample size, this study combined five waves (10 years) of data from the 2003-2012 National Health and Nutrition Examination Survey (NHANES). NHANES is a publicly available, cross-sectional dataset that is representative of the U.S. civilian noninstitutionalized population. NHANES collects demographic and health information through in-home interviews and examinations in a mobile examination center using a complex multistage probability sample. Data is collected from approximately 5,000 participants in 15 U.S. counties each year and is released in 2-year cycles. NHANES oversamples several key population groups, including Hispanics, non-Hispanic blacks, low-income individuals, and Asians (beginning in 2011), and sample weights are provided to adjust for survey design. On average, NHANES samples 1.6 individuals per household, however measures are not provided to adjust for similarities between participants residing within a single household. More detailed descriptions of NHANES are available elsewhere (CDC 2011).

This study used components of the NHANES examination and questionnaire data. Weight status was measured using weight and height measurements taken during the examination by trained health technicians. Individual demographic and questionnaire data was gathered from interviews performed in-home or in the examination center. Household-level measures (income, assistance program participation, and food security) were gathered at the family level, where an adult family member responded to questions for the entire family.

Analyses were conducted for low-income (PIR $\leq$ 1.85) children between the ages of 2 and 17 at the time of screening (n = 9,302). This PIR cutoff was chosen because it corresponds generally with the income eligibility guidelines for the three assistance programs (1.3 for SNAP

benefits, 1.85 for WIC, 1.3 for free school lunches, and 1.85 for reduced-price school lunches), and because high-income households are unlikely to be food-insecure. Additionally, this analysis excluded children under age 2 because BMI categories are not defined for this group. 17 was used as the upper age bound for analyses because child food security questions were asked only of households with a child at or below age 17.

Pregnant adolescent girls (n = 24) and nursing children (n = 22) were excluded from the analysis. Further, underweight children (n = 556), defined as those with BMIs below the 5th percentile for sex and age, were also excluded due to the small sample size, resulting in a total sample of 8,700. Listwise deletion was used for missing data, resulting in the removal of 1,270 additional cases from the final analysis. The majority of missing data came from the PIR (1,082), child food insecurity (736), and weight status (412) variables, and other missing observations included household food insecurity (23) and assistance program participation (145 WIC, 18 SNAP, and 22 NSLP). Analysis of the missing data suggested that missing data patterns were not systematic. To test for biases introduced by listwise deletion of missing data, an additional regression model was run using pairwise deletion, with a dummy variable to control for observations with missing data that were removed from the final analysis (see Appendix). Overall, these results were comparable with the final model, indicating that the final analysis is robust despite the removal of missing data.

Measures

The dependent variable used in this study was weight status. Weight status was measured using BMI scores based upon height and weight, which were measured directly by trained health technicians in the examination component of NHANES. For children, overweight and obesity statuses are determined using CDC growth charts corresponding to the child's age and sex.

Overweight is defined as a BMI between the 85th and 95th percentile and obesity is defined as at or above the 95th percentile for age and sex. Weight status was coded categorically, with categories obtained using the user-written *zbmicat* command in Stata (Vidmar, Cole, and Pan 2013). Analyses were conducted for normal weight, overweight, and obese children, with normal weight serving as the reference category in multinomial logistic regression analyses.

Food insecurity, the primary independent variable in this analysis, was measured using the U.S. Food Security Survey Module (FSSM), an 18-item scale developed by the USDA (Nord et al. 2010). Of the 18 questions, 10 assess household food security and 8 questions are child-referenced. Both household and child-referenced food insecurity were measured at the household level; child-referenced questions refer to all children in the household, not necessarily the individual child respondent. Household and child food insecurity were coded as separate binary variables, where household food insecurity was classified as 3 or more affirmative responses to the 18 FSSM questions and child food insecurity was classified as 2 or more affirmative responses to child-referenced FSSM questions. These categories correspond to "low" or "very low" food security and are consistent with USDA guidelines (Nord et al. 2010).

Assistance program participation, the potential mediating or moderating variables in this analysis, were coded as individual binary variables for household-level participation in WIC, SNAP, or the National School Lunch Program (NSLP) within the last 12 months. WIC and SNAP participation were coded directly from interview questions assessing household-level participation at any time in the past 12 months. For the NSLP, participation was measured as receiving free or reduced-priced school lunches within the past 12 months. Children who were under 4 years old, did not attend school, did not report eating at least one school lunch per week

on average when school is in session, or who received full-price school lunches were coded as non-participants.

Covariates used in this study included sex, age, race/ethnicity, and survey wave. To control for income, this analysis used family poverty-to-income ratios (PIR) to restrict analyses to low-income children (PIR $\leq$ 1.85). Respondents were asked to indicate their household income from a range of income categories, and PIR was calculated using the midpoints of these categories and adjusted for household size and age composition using U.S. poverty guidelines. Sex was coded as male/female, with males as the reference category. Age in years was coded categorically as 2-5, 6-11, and 12-17, consistent with the age cutoffs used in many previous studies (e.g., Holben and Christopher 2015; Kaur et al. 2015). 12-17 was used as the reference group because it was the largest category. Race/ethnicity was coded as non-Hispanic white, non-Hispanic black, Hispanic, and other/multiple races, with non-Hispanic white as the reference category. NHANES began oversampling Asians in 2011-2012 and added a new non-Hispanic Asian category to the race variable, however to maintain consistency with prior survey years, this study included non-Hispanic Asians in the "other/multiple races" category; as a result, the "other" category includes many Asians. Survey wave was coded as a series of dummy variables based upon the survey wave in which data was collected, with the reference group corresponding to the first wave of data used in this study (2003-2004).

Analytic Strategy

Analyses were conducted in Stata 13 using sample weights provided by NHANES, and all analyses used the *survey* command in Stata to adjust for the complex multistage survey design. This study first examined the conditional distributions of weight status and household and child food insecurity across demographic variables and assistance program participation.

Chi-square, ANOVA, and t-tests were used to determine the significance of differences. The primary analysis then used multiple multinomial logistic regression models to assess the relationship between food insecurity and child weight status and the impact of assistance programs on this relationship. By using multinomial logistic regression, this study differentiates between overweight and obesity and provides separate estimates of the relative risks of overweight and obesity relative to normal weight. Because obesity is a more severe condition than overweight, I anticipated that if food insecurity is strongly associated with increased adiposity, the relative risks for obesity will be greater than for overweight. The regression models were run separately for household and child food insecurity due to multicollinearity between the two variables, as they were strongly correlated ($r_{\varphi} = 0.80$). All models controlled for survey wave in order to account for any changes that may have occurred over the wide range of years in which data was collected.

In order to assess the relationship between food insecurity and child weight status and the potential impact of assistance program participation, this study used five multinomial regression models. The first model included food insecurity and all demographic covariates, but did not control for any of the assistance programs. This created a base model to compare with further models that added assistance program variables, and allows for the comparison of results to other studies that did not control for program participation. Models 2-4 added each program individually to the base model, and Model 5 includes all three programs. This allowed for the assessment of both the individual and combined effects of assistance program participation on weight status, which is important because participation in multiple programs is common. By examining changes in the food insecurity coefficients across models we can estimate the potential mediating effects of program participation on the relationship between food insecurity

and child weight status. If the relationship between food insecurity and risk of child overweight or obesity works through participation in assistance programs, which may influence dietary resources and choices, the strength of the regression coefficients for food insecurity in Models 2-5 should decrease compared to Model 1. However, if food insecurity increases risk of overweight or obesity independent of assistance program participation, the addition of the assistance program variables would not change the strength of the food insecurity coefficients.

Finally, I examined potential interactions between food insecurity, demographic variables, and assistance program participation to assess whether the relationship between food insecurity and weight status varies by demographic groups and whether the relationship between food insecurity and child weight status differs by program participation status. If the relationship between food insecurity and risk of child overweight or obesity varies based upon assistance program participation, interaction terms between food insecurity and program participation should be significant.

RESULTS

Table 1 reports the distribution of weight status by food security, demographic, and assistance program variables. Chi-square tests indicate that the distribution of weight status categories differs by household and child food security, which provides initial evidence for a significant relationship between these variables. For household food insecurity, low-income food-insecure children are more likely to be overweight (20.64% vs. 18.91%) or obese (19.08% vs. 15.23%) relative to their low-income food-secure counterparts. These differences are slightly larger for child-referenced food insecurity, with 21.11% of food-insecure children classified as overweight compared to 18.95% of food-secure children, and 19.86% classified as obese versus 15.40% of food-secure children. The distribution of weight status also differs significantly by

WIC and NSLP participation. WIC participants are less likely to be overweight (18.50% vs. 19.83%) or obese (14.13% vs. 17.34%) than non-participants. In contrast, NSLP participants are more likely to be overweight (20.98% vs. 17.26%) and much more likely to be obese (20.29% vs. 10.89%) than non-participants. In addition, we can see that assistance program participation is common among children in low-income households; the majority (58.84%) of these children participated in the NSLP, many (46.00%) were in households that participated in SNAP within the last 12 months, and some (28.58%) were in households that participated in WIC in the past 12 months. Differences in participation rates across programs are likely to reflect differences in eligibility criteria and cost (in terms of time, knowledge, stigma, etc.), as the NSLP has the fewest requirements and WIC has the most. Finally, ANOVA tests indicate that among low-income children, mean PIR does not differ by weight status.

Table 2 shows the distribution of household and child food insecurity by weight status, demographic variables, and assistance program participation, and mean PIR by food security status. While most households reporting child food insecurity are also household food insecure, approximately 26.90% of food insecure households with children report no child food insecurity. This affirms that household food insecurity is not distributed evenly within many families, and children are often protected from the direct experience of food insecurity. Assistance program participation is higher among food-insecure households than food-secure households, but many food-insecure households do not receive assistance through WIC, SNAP, and the NSLP. While many households may not qualify for WIC due to eligibility restrictions, approximately 25% of low-income households with children that did not receive SNAP benefits in the past 12 months reported food insecurity. Finally, Table 2 shows that, among households at or below 185% of the

poverty line with children, those experiencing food insecurity had significantly lower incomes than those that did not experience food insecurity.

Tables 3 and 4 present multinomial logistic regression results for household and child food insecurity, respectively. Both household and child food insecurity are consistently associated with increased risk for obesity, but not overweight, across all models. The relative risk of obesity is greater for child food insecurity than for household food insecurity, but differences between the two measures are not statistically significant. Model 1 in Tables 3 and 4 shows that, among low-income children and adolescents, household food insecurity is associated with a 26% increase in the risk of obesity relative to normal weight, and child food insecurity is associated with a 32% increase in the risk of obesity relative to normal weight, after controlling for sex, race/ethnicity, and age.

Models 2-5 in Tables 3 and 4 control for assistance program participation (WIC, SNAP, and NSLP) individually (Models 2-4) and jointly (Model 5). Both household and child food insecurity are consistently significantly associated with increased risk of obesity across all models, with very little change in the relative risk ratios. This suggests that none of the three assistance programs substantially mediate the relationship between food insecurity and obesity. Additionally, after accounting for food insecurity and demographic factors, neither WIC nor SNAP is significantly associated with weight status. Model 4 shows that NSLP participation, however, is associated with a 36-37% increased risk of obesity, but no increased risk for overweight, and this relationship remains after controlling for participation in the other two programs in Model 5.

Additional analyses (not shown) tested for interactions between food insecurity (both household and child) and age, sex, and race, however the only significant interactions were with

age. In order to more clearly show these age group differences, Table 5 presents the full model (Model 5) disaggregated by age group. Results indicate that household food insecurity is associated with obesity only among children ages 6-11, and child food insecurity is associated with obesity among children ages 2-5 and 6-11. For adolescents ages 12-17, neither household nor child food insecurity is significantly associated with increased risk of obesity, however SNAP participation is associated with an increased risk of overweight for this age group. Additionally, NSLP participation is associated with increased risk of obesity among children ages 2-5 and 6-11, however the strong association between NSLP participation and risk of obesity among children ages 2-5 must be interpreted with caution as most children in this age group are ineligible and those who are eligible are likely to be at the upper end of this age range. As shown in Table 1, the prevalence of overweight and obesity is relatively low among young children, likely due to the fact that overweight and obesity are the result of cumulative overconsumption over time.

Table 6 presents the results of interaction analyses for the three assistance programs. All three interaction terms were added to the full model (Model 5) for the full sample. Although the main effect of WIC participation is not significant, there is a significant interaction between child food insecurity and WIC participation, showing that low-income children who are in a child food-insecure household that participates in WIC are at a 56% greater risk for obesity. Table 6 also shows that the relationship between NSLP participation and obesity does not vary by food security status. Overall, the insignificant interaction effects and the continued significance of food insecurity shown in Table 6 suggest that in general, the relationship between food insecurity and obesity among low-income children does not vary by assistance program participation.

DISCUSSION

This study finds evidence of a robust and consistent relationship between household and child food insecurity and obesity, but not overweight, among low-income children. This is supported by the conclusions of several recent studies which found various positive relationships between food insecurity and obesity among children (Kuku, Garasky, and Gundersen 2012; Holben and Taylor 2015; Kaur, Lamb, and Ogden 2015; Papas et al. 2015), but this study provides additional detail by examining differences between overweight and obesity and between household and child food insecurity measures. The insignificant relationships found for overweight suggest that the inclusion of overweight children in either the normal weight or obese category in many prior studies may impact the significance of findings. My results suggest that future research should carefully consider the analytic categories used for weight status, particularly because obesity is distinct from overweight and in general poses a more severe risk for negative health outcomes.

The aggregate estimates found in this study were somewhat weaker than those from Holben and Taylor's (2015) recent study, which found significant relationships between household food insecurity and both overweight (OR = 1.33 – 1.44) and obesity (OR = 1.24 – 1.38) using NHANES 1999-2006 data for children aged 12-18. Additionally, after disaggregating this analysis by age group, results suggested that the relationship between food insecurity and obesity may only hold for children ages 11 and younger. My estimates also differ from Kaur et al. (2015), who found that child food insecurity was not associated with obesity using a similar sample from NHANES 2001-2010 of children ages 2-11 from all income levels. These differences may be attributable to newer data or this study's restriction of analysis to low-income

children. Additionally, these two prior studies did not exclude underweight children, instead grouping them with normal-weight children, which may alter results.

This study contributes to the literature by examining the role of the three largest food assistance programs, WIC, SNAP, and the NSLP, in the relationship between food insecurity and childhood overweight and obesity. Results suggest that these programs do not have a substantial impact on the relationship between food insecurity and childhood overweight and obesity, although participation in the NSLP may increase the risk of obesity. These results stand in contrast to Kohn et al.'s (2013) findings that assistance program participation was associated with increased body size among low-income food-secure children, but not among low-income food-insecure children. Additional research is needed to clarify differences in findings across studies.

Although this study did not assess the mechanisms through which food insecurity may affect the risks of overweight and obesity among children, my finding that both household and child-referenced food insecurity increase the risk of obesity suggests that food insecurity may affect health at least in part through indirect mechanisms. Because many children are protected from the direct experience of household-level food insecurity, it is plausible that the health impact operates through other factors such as parental stress. The stress process model (Turner 2010) may be particularly relevant in this context, as low socioeconomic status may contribute to parental stress, which operates through numerous mechanisms to affect health, including mental health and depression. Parents' stress and poor mental health may affect both general and food-related parenting behaviors to influence both food insecurity and children's risk of obesity (McCurdy et al. 2010). This is supported by research suggesting that family stressors are related to overweight and obesity among children (Garasky et al. 2009).

Limitations

The primary limitation of the analysis of the role of assistance programs in this study is the inability to account for self-selection biases and the potentially systematic underreporting of assistance program participation. For example, research suggests that households self-select into SNAP at periods when they are more severely food insecure, while SNAP may moderately reduce the prevalence of very low food security among recent new recipients (Nord and Golla 2009). Barriers to participation, such as stigma and the time and knowledge necessary to sign up for and maintain benefits, further contribute to these selection effects, as the perceived benefits must outweigh these costs. Some research suggests that selection biases may not be as problematic for the NSLP (Millimet, Tchernis, and Husain 2010), but in general the results of this research in regard to assistance programs must be interpreted with caution, as those who report participation in assistance programs may have other unobserved characteristics that could impact the relationship between food insecurity and obesity among low-income children.

Other limitations of this study include the absence of additional covariates to control for the impact of physical activity, stress, parental education, and additional determinants of obesity such as genetic factors and birth weight, as well as the impact of other factors such as location and neighborhood characteristics. These measures are not available in NHANES or were not consistently available for all age groups and survey years included in this study. Future research should further investigate these and other covariates in order to better understand the mechanisms through which food insecurity may be associated with child weight status. Another limitation is the current lack of a personal measure of food insecurity, as the most recently released wave of NHANES (2011-2012) discontinued this measure. In addition, although initial analyses suggested that the exclusion of underweight children did not substantially affect the

models used in this research, the impact of this exclusion is somewhat theoretically ambiguous, as research is unclear on the relationship between food insecurity and risk of underweight.

Additional research, particularly research that utilizes longitudinal data and more advanced statistical techniques, is needed in order to better understand the causal relationships between food insecurity, child weight status, and assistance program participation. This is especially important due to evidence suggesting that food insecurity is a transient rather than persistent condition; for example, one longitudinal study found that, over a 5-year period, about half of the households that reported food insecurity at any point experienced it for only one year, and only 1% experienced it for the entire 5-year period (Wilde, Nord, and Zager 2010), and persistent food insecurity is likely to be associated with more negative health outcomes (Ryu and Bartfeld 2012). An Instrumental Variable approach or Structural Equation Modeling analyses may provide more detailed and conclusive estimates of the effects of assistance program participation on the relationship between food insecurity and child weight status.

Conclusions

The childhood obesity epidemic is currently one of the most pressing health issues due to the association between childhood obesity and negative health outcomes over the life course. Because obesity is in large part associated with potentially modifiable health behaviors rather than solely biological determinants, policies may play a particularly important role in addressing this epidemic. This study found that food assistance programs did not impact the relationship between food insecurity and obesity among low-income children, but NSLP participation was associated with increased risk of obesity among low-income children. Each of these programs must be continually reassessed to ensure that they provide the resources needed to combat the obesity epidemic, as these programs may provide the best ways to directly impact the food and

nutrition choices of the low-income families that are the most in need of health interventions. Policy interventions must be carefully implemented by considering potentially unintended consequences; for example, increasing restrictions on food vouchers may increase stigma and the transaction costs of participation if recipients must navigate increasingly numerous and complex restrictions (Gundersen 2015). Likewise, further restrictions on the NSLP may result in schools opting out of the program or in greater waste from discarded foods (Gundersen 2015). Careful expansion of benefit levels and reaching out to eligible but non-participating food-insecure households may help to address some of the outcomes of food insecurity.

The family stress perspective suggests that the relationship between food insecurity and child obesity may be caused in part by the parental stress associated with economic hardship. Food insecurity is ultimately a consequence of socioeconomic disadvantage, and this study suggests that despite efforts to address food insecurity and its associated health outcomes through food assistance programs, there is a persistent link between food insecurity and obesity among children. In a broader sense, this provides further evidence of the importance of SES as a "fundamental cause" of health disparities (Link and Phelan 1995). Fundamental cause theory would suggest that even if food insecurity were adequately addressed through food assistance programs, the broader link between SES and health disparities would persist despite changes in the intervening mechanisms. Overall, this suggests that health policy, to be truly effective in reducing disparities in health, must address not only food insecurity but the upstream causes of food insecurity, such as SES disparities.

Table 1. Conditional Distributions of Weight Status, % (n) (n = 7,430)

	Overall	Normal Weight	Overweight	Obese	Sig
Total	100.00 (7,430)	64.13 (4,716)	19.45 (1,471)	16.42 (1,243)	
Household Food Security					
Secure	68.95 (4,914)	65.86 (3,210)	18.91 (929)	15.23 (775)	**
Insecure	31.05 (2,516)	60.28 (1,506)	20.64 (542)	19.08 (468)	
Child Food Security					
Secure	77.04 (5,510)	65.65 (3,588)	18.95 (1,047)	15.40 (875)	***
Insecure	22.96 (1,920)	59.03 (1,128)	21.11 (424)	19.86 (368)	
Sex					
Male	49.97 (3,720)	66.26 (2,441)	18.03 (682)	15.71 (597)	**
Female	50.03 (3,710)	62.00 (2,275)	20.87 (789)	17.13 (646)	
Race / Ethnicity					
Non-Hispanic White	41.84 (1,562)	67.07 (1,069)	17.94 (269)	15.00 (224)	***
Non-Hispanic Black	20.31 (2,288)	63.25 (1,463)	18.58 (423)	18.17 (402)	
Hispanic	31.17 (3,155)	59.56 (1,891)	22.70 (713)	17.74 (551)	
Other / Multiple Races	6.69 (425)	69.68 (293)	16.40 (66)	13.92 (66)	
Age					
2-5	27.06 (2,172)	80.04 (1,706)	13.10 (293)	6.86 (173)	***
6-11	38.30 (2,699)	60.71 (1,589)	20.41 (565)	18.88 (545)	
12-17	34.64 (2,559)	55.47 (1,421)	23.35 (613)	21.18 (525)	
Assistance Program Participation					
No WIC[a]	71.42 (4,889)	62.83 (3,027)	19.83 (981)	17.34 (881)	**
WIC	28.58 (2,541)	67.37 (1,689)	18.50 (490)	14.13 (362)	
No SNAP[b]	54.00 (3,719)	65.00 (2,329)	19.40 (770)	15.61 (620)	
SNAP	46.00 (3,711)	63.11 (2,387)	19.51 (701)	17.38 (623)	
No NSLP[c]	41.16 (2,896)	71.85 (2,063)	17.26 (497)	10.89 (336)	***
NSLP	58.84 (4,534)	58.72 (2,653)	20.98 (974)	20.29 (907)	
Poverty Income Ratio, Mean (SD)	0.98 (0.01)	0.98 (0.01)	0.98 (0.02)	0.95 (0.02)	

Estimates adjusted for complex survey design.

Chi-square and ANOVA tests used to test significance of differences.

Data: NHANES 2003-2012, PIR ≤ 1.85, Ages 2-17

* p < .05; ** p < .01; *** p < .001

[a] Special Supplemental Nutrition Program for Women, Infants, and Children

[b] Supplemental Nutrition Assistance Program

[c] National School Lunch Program

Table 2. Conditional Distributions of Food Security Status, % (n) (n = 7,430)

	Household Food Secure	Household Food Insecure	Sig	Child Food Secure	Child Food Insecure	Sig
Overall	68.95 (4,914)	31.05 (2,516)		77.04 (5,510)	22.96 (1,920)	
Weight Status						
Normal Weight	70.81 (3,210)	29.19 (1,506)	**	78.87 (3,588)	21.13 (1,128)	***
Overweight	67.05 (929)	32.95 (542)		75.08 (1,047)	24.92 (424)	
Obese	63.94 (775)	36.06 (468)		72.24 (875)	27.76 (368)	
Household Food Security						
Secure	---	---		99.62 (4,894)	0.38 (20)	***
Insecure	---	---		26.90 (616)	73.10 (1,900)	
Child Food Security						
Secure	89.16 (4,894)	10.84 (616)	***	---	---	
Insecure	1.14 (20)	98.86 (1,900)		---	---	
Sex						
Male	68.30 (2,436)	31.70 (1,284)		75.86 (2,732)	24.14 (988)	
Female	69.60 (2,478)	30.40 (1,232)		78.22 (2,778)	21.78 (932)	
Race / Ethnicity						
Non-Hispanic White	73.64 (1,096)	26.36 (466)	***	80.40 (1,216)	19.60 (346)	***
Non-Hispanic Black	70.66 (1,597)	29.34 (691)		77.09 (1,731)	22.91 (557)	
Hispanic	59.96 (1,900)	40.04 (1,255)		71.64 (2,221)	28.36 (934)	
Other / Multiple Races	76.31 (321)	23.69 (104)		81.07 (342)	18.93 (83)	
Age						
2-5	73.36 (1,515)	26.64 (657)	**	81.90 (1,710)	18.10 (462)	***
6-11	68.49 (1,779)	31.51 (920)		76.42 (2,012)	23.58 (687)	
12-17	66.02 (1,620)	33.98 (939)		73.93 (1,788)	26.07 (771)	
Assistance Program Participation						
No WIC[a]	71.03 (3,315)	28.97 (1,574)	**	78.89 (3,689)	21.11 (1,200)	**
WIC	63.75 (1,599)	36.25 (942)		72.43 (1,821)	27.57 (720)	
No SNAP[b]	74.88 (2,632)	25.12 (1,087)	***	81.62 (2,874)	18.38 (845)	***
SNAP	61.99 (2,282)	38.01 (1,429)		71.67 (2,636)	28.33 (1,075)	
No NSLP[c]	74.84 (2,034)	25.16 (862)	***	81.25 (2,235)	18.75 (661)	***
NSLP	64.83 (2,880)	35.17 (1,654)		74.10 (3,275)	25.90 (1,259)	
Poverty Income Ratio, Mean (SD)	1.02 (0.02)	0.88 (0.01)	***	1.01 (0.01)	0.86 (0.02)	***

Estimates adjusted for complex survey design.

Chi-square and t-tests used to test significance of differences.

Data: NHANES 2003-2012, PIR ≤ 1.85, Ages 2-17

* p < .05; ** p < .01; *** p < .001

[a] Special Supplemental Nutrition Program for Women, Infants, and Children

[b] Supplemental Nutrition Assistance Program

[c] National School Lunch Program

Table 3. Multinomial Logistic Regression of Weight Status (Ref = Normal Weight) on Household Food Insecurity, Relative Risk Ratios (n = 7,430)

	Model 1		**Model 2**		**Model 3**		**Model 4**		**Model 5**	
	Overweight	Obese	Overweight	Obese	Overweight	Obese	Overweight	Obese	Overweight	Obese
Food Insecurity (Household)	1.09	1.26**	1.09	1.26**	1.08	1.23*	1.09	1.23*	1.08	1.22*
	(0.92 - 1.30)	(1.06 - 1.49)	(0.91 - 1.30)	(1.06 - 1.49)	(0.90 - 1.28)	(1.03 - 1.47)	(0.91 - 1.30)	(1.04 - 1.46)	(0.90 - 1.28)	(1.02 - 1.45)
Sex (Ref = Male)										
Female	1.24**	1.16	1.24**	1.16	1.23**	1.16	1.24**	1.17	1.23**	1.17
	(1.06 - 1.44)	(0.98 - 1.37)	(1.06 - 1.44)	(0.98 - 1.37)	(1.06 - 1.44)	(0.98 - 1.36)	(1.06 - 1.44)	(0.99 - 1.38)	(1.06 - 1.44)	(0.99 - 1.38)
Race / Ethnicity (Ref = Non-Hispanic White)										
Non-Hispanic Black	1.10	1.30*	1.10	1.30*	1.07	1.25*	1.10	1.23	1.07	1.20
	(0.91 - 1.34)	(1.04 - 1.61)	(0.91 - 1.33)	(1.04 - 1.61)	(0.89 - 1.30)	(1.02 - 1.53)	(0.90 - 1.34)	(0.99 - 1.53)	(0.88 - 1.30)	(0.98 - 1.48)
Hispanic	1.45***	1.34**	1.45***	1.34**	1.45***	1.34**	1.45***	1.27*	1.45***	1.28*
	(1.23 - 1.72)	(1.10 - 1.63)	(1.22 - 1.71)	(1.10 - 1.63)	(1.23 - 1.72)	(1.10 - 1.63)	(1.23 - 1.71)	(1.04 - 1.55)	(1.22 - 1.72)	(1.05 - 1.56)
Other / Multiple Races	0.90	0.93	0.90	0.93	0.90	0.93	0.90	0.91	0.90	0.91
	(0.61 - 1.32)	(0.65 - 1.34)	(0.61 - 1.31)	(0.65 - 1.34)	(0.61 - 1.31)	(0.65 - 1.34)	(0.61 - 1.32)	(0.63 - 1.31)	(0.61 - 1.31)	(0.63 - 1.31)
Age (Ref = 12-17)										
2-5	0.39***	0.23***	0.38***	0.23***	0.38***	0.22***	0.39***	0.26***	0.38***	0.26***
	(0.31 - 0.48)	(0.18 - 0.28)	(0.30 - 0.48)	(0.18 - 0.28)	(0.31 - 0.48)	(0.18 - 0.28)	(0.31 - 0.50)	(0.21 - 0.34)	(0.29 - 0.50)	(0.20 - 0.33)
6-11	0.80*	0.82*	0.79*	0.82*	0.79*	0.81*	0.79*	0.78*	0.79*	0.78*
	(0.65 - 0.98)	(0.68 - 0.99)	(0.65 - 0.98)	(0.68 - 0.99)	(0.65 - 0.98)	(0.68 - 0.98)	(0.65 - 0.97)	(0.65 - 0.95)	(0.65 - 0.97)	(0.65 - 0.95)
Assistance Program Participation										
WIC[a]			1.04	1.00					1.02	0.96
			(0.89 - 1.22)	(0.84 - 1.20)					(0.87 - 1.21)	(0.79 - 1.17)
SNAP[b]					1.09	1.15			1.09	1.11
					(0.93 - 1.28)	(0.90 - 1.48)			(0.92 - 1.28)	(0.86 - 1.45)
NSLP[c]							1.03	1.36**	1.01	1.34**
							(0.86 - 1.22)	(1.11 - 1.67)	(0.84 - 1.21)	(1.09 - 1.64)
Constant	0.34***	0.23***	0.34***	0.23***	0.33***	0.23***	0.33***	0.20***	0.33***	0.20***
	(0.25 - 0.46)	(0.18 - 0.31)	(0.25 - 0.45)	(0.18 - 0.31)	(0.24 - 0.45)	(0.17 - 0.31)	(0.24 - 0.46)	(0.14 - 0.28)	(0.24 - 0.45)	(0.14 - 0.27)

95% confidence intervals in parenthesis. Estimates adjusted for complex survey design and survey wave.

Data: NHANES 2003-2012, PIR ≤ 1.85, Ages 2-17

* p < .05; ** p < .01; *** p < .001

[a] Special Supplemental Nutrition Program for Women, Infants, and Children

[b] Supplemental Nutrition Assistance Program

[c] National School Lunch Program

Table 4. Multinomial Logistic Regression of Weight Status (Ref = Normal Weight) on Child Food Insecurity, Relative Risk Ratios (n = 7,430)

	Model 1		**Model 2**		**Model 3**		**Model 4**		**Model 5**	
	Overweight	Obese	Overweight	Obese	Overweight	Obese	Overweight	Obese	Overweight	Obese
Food Insecurity (Child)	1.14	1.32**	1.13	1.32**	1.12	1.30*	1.13	1.30**	1.12	1.29*
	(0.93 - 1.39)	(1.09 - 1.61)	(0.93 - 1.39)	(1.09 - 1.61)	(0.92 - 1.37)	(1.06 - 1.58)	(0.93 - 1.39)	(1.07 - 1.58)	(0.92 - 1.36)	(1.06 - 1.57)
Sex (Ref = Male)										
Female	1.24**	1.16	1.24**	1.16	1.24**	1.16	1.24**	1.18	1.24**	1.17
	(1.06 - 1.44)	(0.99 - 1.37)	(1.06 - 1.44)	(0.99 - 1.37)	(1.06 - 1.44)	(0.99 - 1.37)	(1.06 - 1.44)	(1.00 - 1.39)	(1.06 - 1.44)	(0.99 - 1.39)
Race / Ethnicity (Ref = Non-Hispanic White)										
Non-Hispanic Black	1.10	1.29*	1.10	1.29*	1.07	1.25*	1.10	1.22	1.07	1.20
	(0.91 - 1.34)	(1.04 - 1.61)	(0.91 - 1.33)	(1.04 - 1.60)	(0.89 - 1.30)	(1.01 - 1.53)	(0.90 - 1.33)	(0.98 - 1.53)	(0.88 - 1.30)	(0.97 - 1.47)
Hispanic	1.46***	1.35**	1.45***	1.35**	1.45***	1.35**	1.45***	1.28*	1.45***	1.29*
	(1.23 - 1.72)	(1.11 - 1.64)	(1.22 - 1.71)	(1.11 - 1.64)	(1.23 - 1.72)	(1.11 - 1.64)	(1.22 - 1.71)	(1.05 - 1.56)	(1.22 - 1.72)	(1.06 - 1.57)
Other / Multiple Races	0.90	0.93	0.90	0.93	0.90	0.93	0.90	0.90	0.90	0.90
	(0.61 - 1.32)	(0.64 - 1.34)	(0.61 - 1.31)	(0.64 - 1.34)	(0.61 - 1.31)	(0.64 - 1.34)	(0.61 - 1.32)	(0.62 - 1.30)	(0.61 - 1.31)	(0.63 - 1.31)
Age (Ref = 12-17)										
2-5	0.39***	0.23***	0.38***	0.23***	0.39***	0.22***	0.39***	0.27***	0.39***	0.26***
	(0.31 - 0.49)	(0.18 - 0.28)	(0.31 - 0.48)	(0.18 - 0.28)	(0.31 - 0.48)	(0.18 - 0.28)	(0.31 - 0.50)	(0.21 - 0.34)	(0.30 - 0.50)	(0.21 - 0.34)
6-11	0.80*	0.82*	0.80*	0.82*	0.79*	0.82*	0.80*	0.79*	0.79*	0.79*
	(0.65 - 0.98)	(0.68 - 0.99)	(0.65 - 0.98)	(0.68 - 0.99)	(0.65 - 0.98)	(0.68 - 0.98)	(0.65 - 0.97)	(0.65 - 0.95)	(0.65 - 0.97)	(0.65 - 0.95)
Assistance Program Participation										
WIC[a]			1.04	1.00					1.02	0.96
			(0.88 - 1.22)	(0.84 - 1.19)					(0.86 - 1.20)	(0.79 - 1.16)
SNAP[b]					1.09	1.15			1.09	1.11
					(0.93 - 1.27)	(0.90 - 1.47)			(0.92 - 1.27)	(0.86 - 1.44)
NSLP[c]							1.03	1.37**	1.01	1.35**
							(0.86 - 1.23)	(1.12 - 1.68)	(0.85 - 1.21)	(1.10 - 1.65)
Constant	0.33***	0.23***	0.33***	0.23***	0.33***	0.23***	0.33***	0.20***	0.33***	0.19***
	(0.24 - 0.45)	(0.17 - 0.31)	(0.24 - 0.45)	(0.17 - 0.31)	(0.24 - 0.45)	(0.17 - 0.31)	(0.24 - 0.45)	(0.14 - 0.27)	(0.23 - 0.45)	(0.14 - 0.27)

95% confidence intervals in parenthesis. Estimates adjusted for complex survey design and survey wave.

Data: NHANES 2003-2012, PIR ≤ 1.85, Ages 2-17

* p < .05; ** p < .01; *** p < .001

[a] Special Supplemental Nutrition Program for Women, Infants, and Children

[b] Supplemental Nutrition Assistance Program

[c] National School Lunch Program

Table 5. Disaggregated Analyses by Age Group. Multinomial Logistic Regression of Weight Status (Ref = Normal Weight) on Food Insecurity, Relative Risk Ratios

	Age 2-5 (n = 2,172)		**Age 6-11 (n = 2,699)**		**Age 12-17 (n = 2,559)**	
	Overweight	Obese	Overweight	Obese	Overweight	Obese
Food Insecurity (Household)	1.29	1.28	1.26	1.49**	0.83	0.94
	(0.95 - 1.76)	(0.89 - 1.84)	(0.95 - 1.67)	(1.18 - 1.87)	(0.63 - 1.10)	(0.72 - 1.23)
WIC[a]	1.06	1.06	1.04	0.92	0.99	0.97
	(0.80 - 1.42)	(0.73 - 1.53)	(0.79 - 1.37)	(0.70 - 1.20)	(0.75 - 1.31)	(0.67 - 1.41)
SNAP[b]	0.96	0.95	0.84	1.00	1.50**	1.33
	(0.69 - 1.33)	(0.61 - 1.46)	(0.65 - 1.09)	(0.72 - 1.37)	(1.17 - 1.91)	(0.92 - 1.94)
NSLP[c]	0.97	2.28***	1.21	1.49*	0.87	1.07
	(0.69 - 1.35)	(1.55 - 3.37)	(0.90 - 1.62)	(1.03 - 2.17)	(0.65 - 1.16)	(0.79 - 1.43)

	Age 2-5 (n = 2,172)		**Age 6-11 (n = 2,699)**		**Age 12-17 (n = 2,559)**	
	Overweight	Obese	Overweight	Obese	Overweight	Obese
Food Insecurity (Child)	1.37	1.63*	1.20	1.35*	0.93	1.12
	(0.92 - 2.03)	(1.13 - 2.37)	(0.90 - 1.61)	(1.07 - 1.71)	(0.69 - 1.25)	(0.83 - 1.50)
WIC	1.06	1.04	1.04	0.92	0.98	0.96
	(0.79 - 1.42)	(0.72 - 1.50)	(0.79 - 1.37)	(0.71 - 1.20)	(0.75 - 1.30)	(0.67 - 1.37)
SNAP	0.96	0.93	0.85	1.02	1.47**	1.31
	(0.69 - 1.34)	(0.61 - 1.43)	(0.65 - 1.10)	(0.74 - 1.39)	(1.16 - 1.87)	(0.89 - 1.91)
NSLP	0.97	2.31***	1.22	1.53*	0.86	1.06
	(0.70 - 1.36)	(1.56 - 3.42)	(0.91 - 1.64)	(1.06 - 2.21)	(0.64 - 1.15)	(0.79 - 1.42)

95% confidence intervals in parenthesis. Estimates adjusted for complex survey design, sex, race/ethnicity, and survey wave.

Data: NHANES 2003-2012, PIR ≤ 1.85, Ages 2-17

* p < .05; ** p < .01; *** p < .001

[a] Special Supplemental Nutrition Program for Women, Infants, and Children

[b] Supplemental Nutrition Assistance Program

[c] National School Lunch Program

Table 6. Interaction Analyses. Multinomial Logistic Regression of Weight Status (Ref = Normal Weight) on Child Food Insecurity, Relative Risk Ratios (n = 7,430)

	Household Food Insecurity		**Child Food Insecurity**	
	Overweight	Obese	Overweight	Obese
Food Insecurity	1.11	1.50*	1.27	1.62*
	(0.79 - 1.57)	(1.01 - 2.21)	(0.86 - 1.89)	(1.08 - 2.45)
Assistance Program Participation				
WIC[a]	1.04	0.86	1.06	0.82
	(0.83 - 1.31)	(0.68 - 1.09)	(0.86 - 1.30)	(0.66 - 1.03)
SNAP[b]	1.04	1.22	1.03	1.18
	(0.85 - 1.28)	(0.93 - 1.59)	(0.84 - 1.25)	(0.89 - 1.57)
NSLP[c]	1.05	1.43**	1.08	1.46**
	(0.84 - 1.31)	(1.12 - 1.81)	(0.88 - 1.33)	(1.16 - 1.84)
Interactions				
Food Insecurity x WIC	0.95	1.30	0.87	1.56*
	(0.66 - 1.38)	(0.87 - 1.94)	(0.62 - 1.24)	(1.01 - 2.39)
Food Insecurity x SNAP	1.12	0.79	1.19	0.80
	(0.81 - 1.55)	(0.56 - 1.11)	(0.85 - 1.67)	(0.54 - 1.20)
Food Insecurity x NSLP	0.89	0.81	0.75	0.71
	(0.64 - 1.22)	(0.55 - 1.17)	(0.55 - 1.04)	(0.47 - 1.07)

95% confidence intervals in parenthesis. Estimates adjusted for complex survey design, sex, race/ethnicity, age, and survey wave.

Data: NHANES 2003-2012, PIR ≤ 1.85, Ages 2-17

* p < .05; ** p < .01; *** p < .001

[a] Special Supplemental Nutrition Program for Women, Infants, and Children

[b] Supplemental Nutrition Assistance Program

[c] National School Lunch Program

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Appendix. Missing Data Analysis. Multinomial Logistic Regression of Weight Status (Ref = Normal Weight) on Child Food Insecurity, Relative Risk Ratios

	Model 1		Model 2		Model 3		Model 4		Model 5	
	Overweight	Obese	Overweight	Obese	Overweight	Obese	Overweight	Obese	Overweight	Obese
Food Insecurity (Child)	1.11	1.32**	1.13	1.32**	1.10	1.29*	1.12	1.29**	1.12	1.29*
	(0.91 - 1.36)	(1.08 - 1.61)	(0.92 - 1.38)	(1.08 - 1.61)	(0.91 - 1.34)	(1.06 - 1.58)	(0.92 - 1.37)	(1.07 - 1.57)	(0.92 - 1.36)	(1.06 - 1.57)
Missing	0.83	0.76	1.11	0.54	0.86	0.75	0.74	0.80		
	(0.50 - 1.38)	(0.44 - 1.30)	(0.38 - 3.25)	(0.17 - 1.74)	(0.50 - 1.47)	(0.43 - 1.33)	(0.40 - 1.40)	(0.45 - 1.42)		
Sex (Ref = Male)										
Female	1.24**	1.14	1.24**	1.17	1.24**	1.13	1.23**	1.15	1.24**	1.17
	(1.07 - 1.44)	(0.97 - 1.34)	(1.07 - 1.45)	(0.99 - 1.37)	(1.07 - 1.44)	(0.96 - 1.34)	(1.06 - 1.43)	(0.98 - 1.36)	(1.06 - 1.44)	(0.99 - 1.39)
Race / Ethnicity (Ref = Non-Hispanic White)										
Non-Hispanic Black	1.09	1.30*	1.10	1.30*	1.07	1.25*	1.09	1.23	1.07	1.20
	(0.90 - 1.33)	(1.04 - 1.61)	(0.91 - 1.33)	(1.04 - 1.61)	(0.88 - 1.30)	(1.02 - 1.53)	(0.89 - 1.33)	(0.99 - 1.53)	(0.88 - 1.30)	(0.97 - 1.47)
Hispanic	1.45***	1.34**	1.44***	1.35**	1.45***	1.34**	1.45***	1.27*	1.45***	1.29*
	(1.22 - 1.72)	(1.10 - 1.63)	(1.22 - 1.71)	(1.11 - 1.65)	(1.22 - 1.73)	(1.10 - 1.63)	(1.22 - 1.72)	(1.04 - 1.55)	(1.22 - 1.72)	(1.06 - 1.57)
Other / Multiple Races	0.88	0.91	0.89	0.93	0.88	0.91	0.88	0.89	0.90	0.90
	(0.60 - 1.29)	(0.63 - 1.30)	(0.61 - 1.30)	(0.64 - 1.33)	(0.60 - 1.28)	(0.63 - 1.30)	(0.60 - 1.30)	(0.62 - 1.27)	(0.61 - 1.31)	(0.63 - 1.31)
Age (Ref = 12-17)										
2-5	0.39***	0.23***	0.38***	0.23***	0.39***	0.22***	0.39***	0.27***	0.39***	0.26***
	(0.31 - 0.49)	(0.18 - 0.28)	(0.31 - 0.48)	(0.18 - 0.28)	(0.31 - 0.49)	(0.18 - 0.28)	(0.31 - 0.50)	(0.21 - 0.34)	(0.30 - 0.50)	(0.21 - 0.34)
6-11	0.80*	0.80*	0.79*	0.82*	0.80*	0.80*	0.80*	0.77**	0.79*	0.79*
	(0.65 - 0.98)	(0.67 - 0.96)	(0.65 - 0.97)	(0.68 - 0.99)	(0.65 - 0.98)	(0.67 - 0.96)	(0.65 - 0.98)	(0.64 - 0.92)	(0.65 - 0.97)	(0.65 - 0.95)
Assistance Program Participation										
WIC[a]			1.04	1.00					1.02	0.96
			(0.88 - 1.22)	(0.84 - 1.19)					(0.86 - 1.20)	(0.79 - 1.16)
SNAP[b]					1.07	1.15			1.09	1.11
					(0.92 - 1.24)	(0.90 - 1.48)			(0.92 - 1.27)	(0.86 - 1.44)
NSLP[c]							1.01	1.38**	1.01	1.35**
							(0.86 - 1.19)	(1.13 - 1.70)	(0.85 - 1.21)	(1.10 - 1.65)
Constant	0.34***	0.24***	0.33***	0.23***	0.34***	0.24***	0.34***	0.20***	0.33***	0.19***
	(0.25 - 0.46)	(0.18 - 0.32)	(0.24 - 0.45)	(0.17 - 0.31)	(0.25 - 0.46)	(0.17 - 0.32)	(0.25 - 0.47)	(0.15 - 0.28)	(0.23 - 0.45)	(0.14 - 0.27)
Observations	7,584	7,584	7,462	7,462	7,572	7,572	7,564	7,564	7,430	7,430

95% confidence intervals in parenthesis. Estimates adjusted for complex survey design and survey wave.

Data: NHANES 2003-2012, PIR ≤ 1.85, Ages 2-17

* p < .05; ** p < .01; *** p < .001

[a] Special Supplemental Nutrition Program for Women, Infants, and Children

[b] Supplemental Nutrition Assistance Program

[c] National School Lunch Program