Food Assistance and Children's Eating Patterns, Food Insecurity, and Overweight: The Influence of Local Food Prices

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Abstract

This study examines how local food prices influence children's Body Mass Index (BMI), overweight, food insecurity, and food consumption, and whether receipt of public food assistance changes these associations. We link data from the Early Childhood Longitudinal Study-Birth Cohort (ECLS-B), a nationally representative study of children from birth to age five, to local food price data from the ACCRA Cost-of-Living Index (COLI) (~10,450 observations). Using Ordinary Least Squares (OLS) regression and within-child fixed effects models that control for a range of explanatory variables, we exploit the variability in food price data over time and among children who move residences. Results indicate that higher-priced fruits and vegetables are associated with higher standardized measures of children's BMI. Surprisingly, higher-priced fast food is associated with a higher risk of being overweight. Associations between food prices and children's weight outcomes are stronger among children in households receiving public food assistance, but food assistance receipt does not appear to significantly mitigate nor exacerbate the associations between food prices and child outcomes. There was no evidence that food prices are associated with children's food consumption or household-level food insecurity. Implications for policy are discussed.

Food Assistance and Children's Eating Patterns, Food Insecurity, and Overweight: The Influence of Local Food Prices

Introduction

Both under- and over-nutrition are important public health problems facing young children in the United States. In 2009, approximately 23% of households with children aged six and younger in the U.S. were food insecure (Nord, Coleman-Jensen, Andrews, & Carlson, 2010), defined as "having limited or uncertain availability of food, or limited or uncertain ability to acquire acceptable foods in socially acceptable ways"[1] (Skalicky et al., 2006). More than 12% of two- to five-year-old children were considered obese (defined as above the 95th percentile by age and gender) in 2009-2010, up from 5% in 1971-1974 (Ogden, Carroll, Kit, & Flegal, 2012).

Both food insecurity and obesity during early childhood are associated with poor short- and long-term developmental outcomes. Food insecurity is associated with long-term health problems (Alaimo, Olson, Fongillo, & Briefel, 2001), poorer mother-child attachment security and cognitive development (Zaslow et al., 2009), and greater behavioral problems (Slack & Yoo, 2005). Likewise, being overweight in early childhood is associated with a greater likelihood of being an obese adult, poorer physical health (Sturm, 2002), and social-emotional and academic problems (Bradley et al., 2008; Crosnoe & Muller, 2004).

In addition to an increasingly sedentary lifestyle, a lack of affordable, healthy foods contributes to the growing epidemic of childhood obesity (IOM, 2005). While the real price of food has declined in recent decades, the real price of fruits and vegetables increased by 17% between 1997 and 2003 (Cawley, 2010). Poorer-quality, energy-dense foods cost less than more

[1] Food insecurity measures both the quality and quantity of food based on an 18-item scale developed by the USDA. The scale captures experiences at the household level (in the last 12 months), such as running out of food, perceptions that food in a household is of inadequate quality or quantity, and reduced food intake by adults or children, all because of financial constraints (Bickel, Nord, Price, Hamilton, & Cook, 2000).

nutritious foods, and there is evidence that this price gap is widening (Monsivais & Drewnowski, 2007; Monsivais, Mclain, & Drewnowski, 2010). As a result, families facing tight budgets are more likely to purchase lower-quality foods than healthier foods (Drewnoski, 2004; Drewnoski, Darmon, & Briend, 2004). Research suggests that higher prices of fast food are associated with lower body weight and body mass index (BMI; a measure of weight-for-height), while higher fruit and vegetable prices have the opposite effect (Powell & Bao, 2009a; Powell & Chaloupka, 2010; Sturm & Datar, 2005, 2008). In addition, experimental work has found that children decrease their consumption of certain foods when the price is increased (Epstein et al., 2006). Associations between local food prices and child BMI appear to be larger among low-income children as compared to their higher-income counterparts (Powell & Bao, 2009a; Powell & Chaloupka, 2010; Sturm & Datar, 2005), presumably because their families have less disposable income with which to adapt to a higher-price environment. Evidence exists that food assistance and subsidized meals may help combat obesity among low-income children through the provision of healthy foods (Hofferth & Curtin, 2005; Jones, Jahns, Laraia, & Haughton, 2003; Kimbro & Rigby, 2010; Schmeiser, 2012); however, one study found that the Supplemental Nutrition Assistance Program (SNAP; formerly known as the Food Stamp Program), which has few nutritional restrictions, may contribute to child obesity in cities with high food prices (Kimbro & Rigby, 2010).

A lack of access to affordable, nutritious foods is also presumed to underlie food insecurity (Rose, 2010). To help families purchase healthy foods, the U.S. spent $78.8 billion in fiscal year 2009 on domestic food assistance programs, much of which goes to families with children (Oliveira, 2010). In 2008, 81% of low-income households with food-insecure children received food assistance from one of the three largest programs: SNAP, the Special

Supplemental Nutrition Program for Women, Infants, and Children (WIC), or the National School Lunch Program. SNAP serves nearly one-half of all children at some point in their lives (Rank & Hirschl, 2009), and in 2009, WIC served more than 9 million women and their young children (USDA, 2011). WIC provides healthy foods to pregnant and postpartum women and their children to support healthy development, whereas the National School Lunch and Breakfast Programs provide subsidized or free lunch or breakfast to eligible children in kindergarten through 12th grade (Nord, Andrews, & Carlson, 2009). Research suggests that food assistance receipt increases total household food expenditures and reduces food insecurity (Bartfeld & Ahn, 2011; Fox, Hamilton, & Lin, 2004; Rose, Habicht, & Devaney, 1998; Yen, Andrews, Chen, & Eastwood, 2008), although selection into food assistance programs is problematic (Dunifon & Kowaleski-Jones, 2003; Wilde, 2007). Few studies examine the influence of food prices on food insecurity.

Although the effects of local food prices on children's outcomes have received greater research attention in recent years, several areas remain unexplored. Despite the importance of adequate nutrition during early childhood, the majority of these studies have focused on adolescent or school-aged children (Powell & Chaloupka, 2010; Sturm & Datar, 2005), while less is known about how local food prices affect child outcomes at younger ages. Second, with few exceptions (Kimbro & Rigby, 2010; Powell & Chaloupka, 2010), most studies have estimated cross-sectional associations between food prices and child outcomes, which may be biased by differences across individual children and their families that influence both the propensity to live in high-cost areas and children's outcomes. Third, to date, no study has looked at the influences of local food prices on obesity, food insecurity, and eating habits, and how the prices of different categories of food (e.g., fruits and vegetables vs. fast food) may differentially

influence these three outcomes.[2] Fourth, the processes through which higher food prices may affect children's weight or food insecurity – presumably through changes in food consumption – have not been identified. Finally, previous research regarding how food assistance receipt differentially affects child outcomes across communities with high or low food prices (Kimbro & Rigby, 2010) focused on a predominantly disadvantaged sample limited to 20 cities and only examined obesity; whether food assistance moderates relations between food prices, child obesity, and food insecurity remains unclear.

We address these gaps in the literature using two comprehensive datasets, namely the Early Childhood Longitudinal Study-Birth Cohort (ECLS-B) containing child-level information on child health and family dynamics, and the Council for Community and Economic Research's (C2ER) ACCRA Cost-of-Living Index (COLI) data, which contains city-level information on local food prices. Specifically, the two primary research objectives and hypotheses of this study are:

1) Estimate how local food prices influence the food insecurity, weight outcomes, and eating patterns of children from infancy to five years of age. We hypothesize that high-priced fruits and vegetables and low-priced fast food may contribute to higher likelihood of being overweight, higher BMI, and less healthy eating habits; high prices for both fruits and vegetables and fast food may contribute to a greater likelihood of being food insecure.
2) Understand how participation in food assistance programs changes the relationship between food prices and food insecurity, weight outcomes, and eating patterns of children from infancy to five years of age. We expect that food assistance receipt serves as a buffer between local food prices and children's food insecurity; however, food assistance receipt

[2] Note this study does not examine the relationship between food insecurity and obesity.

may exacerbate the anticipated relationship between food prices and child weight outcomes and poor eating habits.

Methods

Data

Early Childhood Longitudinal Study-Birth Cohort (ECLS-B). The ECLS-B is a longitudinal dataset collected by the National Center for Education Statistics (NCES). The baseline sample of approximately 10,700 children was designed to be nationally representative of children born in the United States in 2001 with an over-sample of Asian and American-Indian children, twins, and low and very low birthweight children.[3] The ECLS-B follows children from birth through kindergarten with data collection occurring when the children are 9 months of age (2001-02), 2 years of age (2003-04), approximately 4 years of age (2005-06, also known as the preschool wave), and at two waves of kindergarten entry (2006-08). The 9-month data collection also includes information from infants' birth certificates. Two waves of data were collected at kindergarten entry. In the fall of 2006, information was collected from all participating children, approximately 75% of whom were in kindergarten or higher. In the fall of 2007, data were collected from the remaining 25% of participants who had not yet entered kindergarten, as well as from those who were repeating kindergarten in the 2007-08 school year. At each wave, information about child and family characteristics were collected through interviews with parents and child assessments. The ECLS-B contains residential zip codes for children at all waves of data collection, allowing the dataset to be merged with contextual food price data.

ACCRA Cost of Living Index (COLI). The ACCRA COLI dataset collected by the Council for Economic Research (C2ER; http://www.coli.org) is the main source of cost-of-living

[3] The reported sample sizes are rounded to the nearest 50, per NCES regulations regarding disclosure of restricted-use data.

data in the United States, including local food prices. The ACCRA COLI food price data, collected from more than 300 metropolitan areas, have been reported quarterly since 1968. For this study, data from 2001 through 2008, corresponding with the years of ECLS-B data collection, were merged with the ECLS-B. The ACCRA data are measured at the Core Based Statistical Area (CBSA)[4] level, rather than by zip code or neighborhood. Since our food price data are collected at the CBSA-level, which constitutes a large area geographically, and important neighborhood-level differences in prices may not be detected.

To merge the ECLS-B and ACCRA data, children's residential zip codes from the ECLS-B were matched with their corresponding CBSA codes, and then merged with the ACCRA data. ACCRA data are not collected in certain areas of the country, particularly rural areas; as a result, we will not have corresponding food price data for some children in the ECLS-B. Approximately 5,650 children (53%) have food price data for at least one wave. This is comparable to previous research using these data (e.g., Sturm & Datar [2005] included 33% of the Early Childhood Longitudinal Study-Kindergarten Cohort sample). Despite these limitations, the ACCRA data remain the best source for comprehensive regional food prices and have been used in more than ten studies since 2004 (Powell & Chaloupka, 2010).

Analysis Sample

The analysis sample consists of children who reside in households with income below 300% of the Federal Poverty Level (FPL: $20,000 for a family of 4 in 2006) with ACCRA data. Because we hypothesized that the health outcomes of children in lower-income families will be more affected by food prices as compared to those in high-income families, we limited our sample to observations of children living in families under 300% of the FPL. A child observation

[4] CBSA codes replaced Metropolitan Statistical Area (MSA) codes in 2000.

is included for each wave the household has an income below 300% of the FPL; that is, an individual child may be included in the sample at one wave and excluded in another, depending on whether his or her family's income is below 300% FPL. We define our analysis sample broadly because many food-insecure households with children are well above the poverty line (Nord et al., 2010), and the rates of obesity and eating patterns of children across the income spectrum may be affected by local food prices. We only include an observation if the child in that wave has ACCRA data and valid information for all of the independent variables. We allow the sample size to vary by the dependent variable, as the three main dependent variables – children's weight outcomes, food insecurity, and food consumption – were measured over different time periods, as explained below.

Given the large number of observations excluded to missing ACCRA data, Table 1 compares the characteristics of our analysis sample to those under 300% of FPL dropped from our sample due to missing data (missing ACCRA food prices, other covariates, or dependent variables). Our analysis sample averaged lower BMI z-scores and rates of overweight than those dropped, not surprising given the higher rates of child obesity in rural areas (Liu et al., 2007). Analysis sample households were more likely to be in the South and West, given the ACCRA sampling. The analysis sample had higher rates of household food insecurity, parents who had graduated college, and were less likely to be American Indian, Asian or Multiracial (i.e., other race) or below the poverty line. Households were more likely to have incomes between 185 and 300% of FPL than excluded observations. It is important to note that the analysis sample does not differ from excluded observations along the following dimensions: child gender, child race/ethnicity, food consumption, household composition, maternal employment, or child's birth or mother's pre-pregnancy weight.

Insert Table 1 here.

Measures

Child overweight and body mass index (BMI). This study relies on anthropometric measures of child weight and height from the 2-year, 4-year, and both kindergarten waves of data collection. Each physical measurement was obtained twice to minimize measurement error. If the two measures were more than 5% apart a third measurement was taken. The two closest measurements were then averaged together. Body mass index (BMI) was calculated using measures of children's weight and height. Using the Centers for Disease Control and Prevention (CDC) standards (Kuczmarski et al., 2002), BMI z-scores with a mean of zero and standard deviation of one were generated to allow for comparisons across age and gender. The binary outcome of overweight[5] (at or above the 85th percentile for age and gender) is used (1 = *overweight or obese*). Because there is no agreed upon definition of BMI for children under two years of age, when examining weight outcomes, we study children 24 months and older.

Child eating habits. Beginning at preschool, parents were asked about their children's eating habits (i.e., frequency in the past 7 days) using a subset of the Food Consumption Questionnaire (FCQ), developed for the Youth Risk Behavior Surveillance Survey administered by the CDC. Parents reported the frequency that their children consumed specific foods in the past 7 days, including specific vegetables, fruit, milk, sweetened beverages (e.g., soda), and fast food. Following Sturm and Datar (2011), qualitative response categories were translated into continuous measures representing the number of times in the previous 7 days that the child ate or drank a certain food. Midpoints were used for responses spanning several times (e.g., "1-3 times during the past 7 days" was coded as "2 times per week"). Responses were used to generate 2

[5] The CDC previously recommended the terms "at risk for overweight" for a BMI at or above the 85th percentile for and "overweight" for above the 95th percentile, but, in 2010, modified its recommended terminology to child overweight and obese: see http://www.cdc.gov/nchs/data/nhsr/nhsr025.pdf.

continuous eating habits indices representing the total number of times per week that the child ate healthy or unhealthy foods. Higher scores on the Healthy Eating Index indicate healthier eating; higher scores on the Unhealthy Eating Habits indicate poorer eating. Table 2 describes the eating habits indices. For this variable, the preschool (4-year) and kindergarten waves of data are analyzed.

Insert Table 2 here.

Food insecurity. At all waves of data collection, participating households were asked about their experiences of food insecurity over the past 12 months using the 18-question standard Core Food Security Module (CFSM) created by the U.S. Department of Agriculture (USDA). Questions ask respondents about their experiences over the past 12 months regarding their food purchases, consumption, and concerns (e.g., whether they were worried their food would run out before they had money to buy more, whether they cut the size of or skip their own or their children's meals because there wasn't enough money to buy food). From these questions, a raw score, a scale score, and a categorical measure of food security at the following three levels were generated: household food security, adult food security, and children's food security. The raw scores are the number of questions answered affirmatively (i.e., yes; often or sometimes; almost every month; or some months but not every month). In this study, we use two binary indicators of household food insecurity: one which includes both low and very low food security (1 = *very low or low food security*), and another indicating the household has very low food security (1 = *very low food security*).[6,7]

[6] Note that the ECLS-B Users Guide refers to these categories as food secure, food insecure without hunger, and food insecure with hunger (Nord et al., 2006). We use the above terms in accordance with the National Academies of Sciences recommendation (Wunderlich & Norwood, 2006).

[7] The household-level variables are calculated according to Bickel et al. (2000).

Local average annual food prices. The ACCRA COLI data contain CBSA-level information on food prices for a total of 63 grocery items. In this study, we focus on 6 fruit and vegetable items purchased for home consumption and 3 fast foods consumed away from home: (1) fruits and vegetables (potatoes, bananas, lettuce, sweet peas, peaches, and frozen corn) and (2) fast foods (the average price of a McDonald's quarter-pounder with cheese [collected for at least 5 different restaurants if there were more than 5 in the area, or at all McDonald's in the area if there were less than 5]; the average price of an 11"-12" thin-crust regular cheese pizza at Pizza Hut and/or Pizza In; and the average price of a fried chicken drumstick and thigh at Kentucky Fried Chicken and/or Church's Fried Chicken). A total of 3 food price indices were calculated. We averaged together the items' prices for each of the two groups to create average indices for (1) fruits and vegetables and (2) fast foods. In addition, we created a third index of weighted fruit and vegetable food prices based on the item's share in the U.S. Department of Agriculture's (USDA) Thrifty Food Plan consumer basket for fruits and vegetables corresponding with the age of the child (e.g., for the 2-year wave, the weighted fruit and vegetable price index was based on the USDA's recommended intake of potatoes, bananas, lettuce, sweet peas, peaches, and corn for 2-year-olds) (USDA, 2007); however, the analyses presented here use the unweighted average, as results using the weighted average did not vary from those using the unweighted average (results not shown; available from authors upon request). Because areas are covered at different times in the ACCRA COLI data collection (that is, food prices within a CBSA may be assessed between 1 to 4 quarters each year), measures of annual averaged food prices indices were calculated. All average prices are inflation-adjusted to 2008 dollars.

Receipt of public food assistance. At each wave of data, parents were asked about participation in the Food Stamp and WIC programs over the past year, and after kindergarten

entry, about their children's school lunch and breakfast participation. Responses were used to create an overall dummy variable at each wave representing that the household had received any food assistance (1 = *received food stamps, WIC, school lunch, and/or school breakfast*, 0 = *did not receive any public food assistance*).

Covariates. We take advantage of the rich measures of child, maternal, and household characteristics in the ECLS-B data to control for potential confounding factors that may be associated with both local food prices and children's weight outcomes. Fixed (i.e., time-invariant) characteristics included child gender (1 = *male*), race/ethnicity, coded as a multicategorical variable (non-Hispanic *white*, non-Hispanic *black*, *Hispanic*, *other*), whether the child had a twin (1 = *twin*), age in months, and birthweight (in kg), which were taken from information on children's birth certificates. Mothers reported their and their child's father's education at wave 1 (9 months), which was coded as a multicategorical variable (*neither parent graduated high school, at least one parent has a high school degree but no bachelor's degree, and at least one parent graduated from college*). At 9 months, mothers reported their pre-pregnancy weight (in kg). At each wave, mothers reported their family income, which was used to generate a family's income-to-needs ratio based on the FPL and then coded into a series of dummy variables (*family income below 100% FPL, family income between 100-185% FPL, and family income between 185-300% FPL*). Also at each wave, mothers reported the number of children and adults living in the household and their employment status and weekly work hours, which were recoded into three dummy variables (*not employed, employed fewer than 35 hours per week, employed 35 or more hours per week*). The child's geographic region was controlled (*Northeast, Midwest, West, South*). The overall cost of living (COLI) index, which captured prices of a basket of goods such as housing and clothing, was controlled for to capture

differences in prices across CBSAs. Finally, indicator variables for the wave of data collection are included to control for fixed factors related to the time period of data collection.

Empirical Strategy

A series of Ordinary Least Squares (OLS) and linear probability models were used to predict children's health outcomes from measures of local food prices. First, to address the first aim of estimating how local food prices influence children's BMI, overweight, eating habits, and food insecurity, OLS regression models were estimated as described in Equation 1.

$$Y_{it} = \beta_0 + \beta_1 FP_{it} + \beta_2 CMH_{it} + \varepsilon_{it} \quad (1)$$

In Equation 1, Y_{it} represents children's BMI, overweight, eating habits, and food insecurity for child *i* at time *t*; FP_{it} represents the independent variables of interest, fruit and vegetable and fast food price indices, and CMH_{it} is a vector of child, maternal, and household characteristics. For the binary dependent variables of overweight and food insecurity, linear probability models (LPM)[8] were estimated. Standard errors were clustered at the CBSA level. Because fruit and vegetable and fast food price indices may be highly correlated, we also estimate models entering each index separately. Because food prices may have a lagged effect on children's weight outcomes, we test associations between food prices at the previous wave and child BMI and overweight.

To test the second objective of this study, how participation in public food assistance programs changes the relationship between food prices and children's health outcomes, Equations 1 is re-estimated using a subsample of children whose households reported receiving at least one public age-appropriate food assistance program at that wave (food stamps, WIC, school lunch, and/or school breakfast), and then again using a subsample of children whose

[8] Analogous logistic regression models were also conducted as sensitivity analyses. Because results were not substantially different from the linear probability models, they are not reported but are available upon request.

households had not received food assistance at that wave to compare coefficients across the subsamples.

Results

Descriptive Results

The analysis sample's descriptive statistics, pooled across years, are displayed in Table 3. The number of observations varies by dependent variable, as BMI z-scores are valid for children older than 24 months (thus, not at wave 1 and half of the children at wave 2) and children's eating habits were not assessed at waves 1 and 2. On average, children's BMIs were about one-half of a standard deviation above the CDC's recommendations for their age and gender. About one-third of children were overweight (at or above the 85^{th} percentile), and about 18% of children lived in households that had low or very low food security. Children living in food secure households were more likely to live in areas with higher average fruit and vegetable prices, and overweight children were more likely to live in areas with higher average fast food prices. As expected, there were several significant differences in covariates between overweight and not overweight children, and between children in food secure households and those in food insecure households, particularly in child race/ethnicity, family poverty, maternal employment, and parent education.

Insert Table 3 here.

Regression Results

Table 4 displays the OLS results predicting child BMI, overweight, eating habits, and household-level food insecurity from average annual food prices, controlling for the overall COLI in the CBSA and a range of child, maternal, and household characteristics. Consistent with hypotheses, fruit and vegetable prices are positively associated with higher child BMI z-scores.

An increase of $1 in the average annual price of fruits and vegetables is associated with an increase in children's BMI z-scores of 0.41, or two-fifths of a standard deviation increase. The overall COLI is negatively related to children's BMI z-scores, such that those living in generally low-cost areas had higher BMI z-scores, on average, than those in higher-cost areas. Surprisingly, higher average fast food prices are associated with a 6.8 percentage point increase in the likelihood of being overweight. As expected, household composition, family poverty status, maternal employment and pre-pregnancy weight, and child birthweight are related to children's weight outcomes.

In contrast with expectations, food prices are unrelated to either measure of household-level food insecurity. Consistent with previous research, non-Hispanic Black children and those living in households below 100 or 185% of FPL with fewer adults and lower parental education were more likely to experience household food insecurity. Fruit and vegetable and fast food prices are also not related to mothers' reports of children's food consumption. Likewise, sensitivity tests predicting children's consumption of individual food items (fruits, vegetables, and fast foods) from local fruit and vegetable and fast food prices did not reveal any significant associations (results not shown; available from authors upon request). Interestingly, living in higher-cost areas (i.e., high overall COLI) is associated with greater consumption of healthy foods, whereas living in lower-cost areas (i.e., low overall COLI) is associated with lower consumption of unhealthy foods. Boys tended to eat fewer healthy foods and more unhealthy foods than girls. Households living below the poverty line reported a higher consumption of healthy foods among their children. These families may more often eat less expensive, home-cooked meals, which tend to be healthier than those eaten out. Households with more adults averaged greater consumption of unhealthy foods, whereas those with non-employed mothers

averaged lower consumption of these foods. Child birthweight and parent education are associated with both healthy and unhealthy food consumption, such that higher birthweight children and those whose parents had lower education ate more of both healthy and unhealthy foods.

Analyses that included fruit and vegetable and fast food prices in separate models, as displayed in Table 5, show similar patterns and magnitudes of results suggesting that the fruit and vegetable and fast food prices are not highly correlated.

Insert Table 4 here.

Insert Table 5 here.

Because food prices may have a lagged effect on children's weight outcomes, we test associations between food prices at the previous wave and child BMI and overweight, controlling for concurrent measures of child, maternal, and household characteristics. As shown in Table 6, there is no evidence that food prices have a lagged effect on children's weight outcomes.

Insert Table 6 here.

Moderation Results

To test whether public food assistance receipt moderates associations between local food prices and children's BMI z-scores, overweight, food insecurity or eating habits, the OLS models described above are run on first the subsample reporting receipt of any public food assistance (food stamps, WIC, or school lunch/breakfast), and then on the subsample not receiving food assistance. Results, shown in Table 7, indicate that among those children living in households that receive food assistance, a $1 increase in local average fruit and vegetable prices is associated with an increase of 0.52 (more than half a standard deviation) in children's BMI z-scores; this

association is positive but small and non-significant among families not receiving food assistance. Likewise, local average fast food prices are associated with an 8.5 percentage point increase in the likelihood of being overweight among children in food assistance-receiving families only. However, in models including interactions between food prices and public food assistance receipt (run separately for fruit and vegetable and fast food prices), interactions were not statistically significant, indicating that food assistance receipt does not exacerbate nor mitigate the associations between food prices and child weight outcomes, food consumption, or household food insecurity (results not shown; available from authors upon request).

Insert Table 7 here.

Sensitivity Analyses

While a rich set of explanatory variables is included, it is likely that the food price estimates generated from Equation 1 are biased. To limit potential omitted variable bias, within-child fixed effects (FE) models, described in Equation 2, were also estimated as sensitivity analyses.

$$Y_{it} - Y_{i.} = \beta_{0it} - \beta_{0i.} + \beta_1(FP_{it} - FP_{i.}) + \beta_2(CMH_{it} - CMH_{i.}) + \beta_3(YEAR_{it} - YEAR_{i.}) + \varepsilon_{it} - \varepsilon_{i.} \quad (2)$$

FE models use within-child comparisons to examine how a child's health at a specific time point deviates from that same child's average health measured across all time points, as predicted by food prices at a single time point, from which is subtracted the average food prices across all time points. Each variable in the equation is averaged over all data collection points for each child (e.g., $FP_{i.}$, the average local food price across assessments across all data collection points), and this average value is then subtracted from the value at a particular time point for that specific child. As a result, all fixed (time-invariant) effects drop out of the model. Therefore,

only time-varying child, maternal, and household characteristics (e.g., child age) and the year of data collection are included in the model. We exploit the variation in prices over time for each child and the relatively large number of children in the ECLS-B who move to areas that vary in local food prices. As required by FE models, there is substantial variation in the predictors and outcomes. More than half (53%) of the sample moved to a different CBSA at least once from the 9 month to kindergarten entry waves. Inflation-adjusted average annual fruit and vegetable prices changed by $0.03 to $0.09 each year (range: -0.09 to +0.03); inflation-adjusted average annual fast food prices changed by $0.05 to $0.07 each year (range: -0.07 to +0.05). Children's BMI z-scores increased an average of 0.003 and 0.183 between each wave. As they grew older, children decreased the number of times per week they ate healthy food items (-2.15 to -2.70 between each wave) and the number of times they ate unhealthy food items remained similar across waves.

Results (not shown; available from authors upon request) show patterns similar to the OLS models. A $1 increase in the average price of fruits and vegetables predicts a 0.46 increase in a child's BMI z-score, whereas a $1 increase in the price of fast food predicts a 15 percentage point increase in a child's likelihood of being overweight. As with the OLS models, there is no evidence of a lagged effect of food prices on children's weight outcomes. However, changes in local food prices are related to changes in the likelihood of experiencing very low food security (but not low or very low food security). A $1 increase in the average price of fruits and vegetables predicts a 4 percentage point increase in the likelihood that a household experiences very low food security. Changes in local food prices are not associated with changes in children's food consumption.

Discussion and Next Steps

The goal of this study was to estimate how local food prices influence the food insecurity,

obesity, and eating patterns of children from infancy to five years of age, and to understand how participation in food assistance programs changes the relationship between food prices and children's weight outcomes, food insecurity, and eating patterns. In general, results suggest that higher-priced foods are associated with higher BMI and rates of overweight among young children, but, surprisingly, food prices seem largely unrelated to household food security and parents' reports of children's eating habits.

Consistent with previous research using cross-sectional data or data on older populations (Powell & Bao, 2009a; Powell, Han, & Chaloupka, 2010; Sturm & Datar, 2008), children living in areas with higher-priced fruits and vegetables averaged higher measures of standardized BMI scores, compared to their peers in areas with lower-priced fruits and vegetables. The magnitude of this association is considerable; an increase of $1 in the average annual price of fruits and vegetables is linked with an increase in children's BMI z-scores of two-fifths of a standard deviation. Likewise, within child FE models, which control for stable characteristics and provide more conservative estimates, indicate that a $1 increase in the average annual price of fruits and vegetables is linked with a half of a standard deviation increase in a child's BMI z-scores. However, given that inflation-adjusted fruit and vegetable prices averaged $1.68 (*SD* = 0.23; range $1.08-$2.71), an increase of $1, or more than four standard deviations, would represent a substantial increase in price. While this increase may be unlikely to occur within an area, the range of prices across CBSAs suggests that residential moves may expose children to areas with substantial variation in prices. Unfortunately, our sample of children who moved to different CBSAs, with both their pre- and post-move residence having full food price data, was limited (fewer than 300 children); however, future research should exploit residential moves as a means for testing the relationship between food prices and child weight outcomes.

In contrast with our expectations, higher fast food prices were associated with an increase in the likelihood of being overweight in both the OLS and FE models. This may be the result of endogeniety; that is, fast food outlets may respond to increased demand or preferences for fast food with higher prices. Indeed, while the literature on the relationship between fruit and vegetable prices and child BMI is relatively consistent, the research on fast food prices and child weight outcomes is more mixed. While some studies have found a negative association between fast food prices and BMI or obesity among adolescents or adults (Han & Powell, 2011; Powell et al., 2010), longitudinal analyses using fixed effects models find lower or non-significant associations (Han & Powell, 2011; Powell, 2009; Powell & Bao, 2009b; Sturm & Datar, 2008). In general, the literature suggests that the weight outcomes of adolescents and adults may be sensitive to the prices of both healthy and fast foods, whereas the weight outcomes of young children may be sensitive to healthy foods only (e.g., Powell & Bao, 2009). This may be because children increase their fast food consumption as they age, and also begin to use their own money to purchase foods when they are older. The weight outcomes of children across the age spectrum may be affected by fruit and vegetable prices in that their parents make purchasing decisions on foods consumed at home at least partially based on price. However, compared to previous research, the data used in the current study were collected relatively recently (2001-08), and may reflect a shift in this general age pattern. More research on this finding is needed.

Importantly, the relationships between food prices and children's weight outcomes are strong and present among the subsample receiving public food assistance. That is, among children in households who receive SNAP, WIC, or school lunch or breakfast, there is a positive relationship between fruit and vegetable prices and children's BMI, and between fast food prices and children's likelihood of being overweight. Food prices are unassociated with weight

outcomes among children in households under 300% of FPL not receiving food assistance. It may be that receipt of food assistance is an indicator of nutritional need; whereas non-receiving households have access to other support systems or family members that help provide food, those who turn to public assistance do not, and these families may be more sensitive to prices. Indeed, previous research indicates that low-income adolescents' weight outcomes are more sensitive to the prices of fruits and vegetables and fast foods than their higher-income counterparts (Powell & Bao, 2009a; Powell & Chaloupka, 2009; Sturm & Datar, 2005). In addition, it is possible that the Food Stamp Program (currently SNAP), the largest public food assistance program in the U.S., is not adequately indexed to the local cost of living, and families have to purchase less expensive, nutritionally low-quality foods in areas with high food prices. However, it is important to note that, among our subsample of those with family incomes below 300% of FPL, the associations between food prices and child weight outcomes, eating habits, and household food insecurity did not statistically differ between households receiving food assistance and those who did not. Additional research and specification of public food assistance is required.

Surprisingly, the mechanism through which food prices are expected to affect children's BMI and overweight status, their food consumption, was unassociated with food prices. This was true for the composite measures of eating habits (healthy and unhealthy foods) and the individual measures of fruit, vegetable, and fast food consumption. The use of parents' reports of children's food consumption across the previous 7 days is a major limitation to these analyses. Parents, particularly those who are employed, may not be aware of what their children are eating, and the recall of foods eaten over the last week is subject to memory loss. Further, children's food consumption questions were administered at preschool and kindergarten entry only. Future

research should incorporate more refined measures of children's food consumption, such as daily diaries, and test whether nutrition is a mediating factor between fruit and vegetable prices and children's BMI and overweight.

Also in contrast with expectations, local food prices were largely unrelated to household-level food insecurity, with one exception; in the FE models, an increase in local average fruit and vegetable prices is associated with a small increase in the likelihood that the household experiences very low food security. Although low-income families' inability to afford food is the premise underlying our public food assistance system, there has been very little research examining local food prices and food insecurity, particularly among young children. It may be that the variability in food prices across time and CBSAs is too limited to reveal associations between food prices and food insecurity. Alternatively, our specifications of categorical food security at the household level (as opposed to scores or security at the child and adult level) may mask associations. Further, CBSAs may represent too large of a geographic area for capturing local food prices, and thus, our CBSA-level food price data are not adequate for capturing associations between local food prices and household food insecurity.

These preliminary results provide several avenues for further research. First, models estimating associations between food prices and food insecurity using different specifications of food security (child-, adult-, and household-level scores and categorical measures, including marginal food security) will be tested. Secondly, as with the BMI and overweight outcomes, it may be that food prices are significantly related to food insecurity and food consumption among children in families receiving public food assistance only; the moderating effect of food assistance on food security and children's eating habits will be tested. Finally, different specifications for food assistance, separating food stamps, WIC, and school lunch/breakfast

receipt, will be tested. Whereas WIC and the National School Lunch and Breakfast Programs provide foods or packages, SNAP provides vouchers with which recipients purchase food. Because of this flexibility and limited budget, they may be purchasing less healthy foods in areas where fruits and vegetables are expensive, operating differently than WIC or school lunch/breakfast receipt. Finally, we will estimate models with different specifications of the food price variables including each food price index relative to the overall food price variable.

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Table 1. Descriptive Statistics of Analysis Sample Compared to Excluded Observations under 300% of the Federal Poverty Line

Variable	Analysis Sample	Excluded Observations
Dependent variables[1]		
BMI z score **	0.489	0.568
Child is overweight*	31.9%	34.3%
Number of times child ate healthy food in past 7 days	45.692	45.578
Number of times child ate unhealthy food in past 7 days	32.753	33.308
Household has low or very low food security*	17.7%	16.4%
Household has very low food security	3.9%	3.5%
Covariates		
Multiple birth	15.9%	14.3%
Child age (months)***	35.457	37.038
Male	51.1%	50.5%
White, non-Hispanic	34.6%	34.3%
Black, non-Hispanic	21.5%	20.6%
Hispanic	26.0%	24.9%
Other Race, non-Hispanic**	17.9%	20.2%
Household is below the federal poverty line (FPL) ***	35.9%	38.9%
Household is between 100% and 185% of the FPL	34.2%	34.6%
Household is between 185% and 300% of the FPL***	29.9%	26.5%
Number of children in the household	2.606	2.573
Number of adults in the household	2.133	2.166
Mother is not working	48.8%	49.0%
Mother is employed part time	17.9%	16.8%
Mother is employed full time	33.4%	34.2%
Child's birthweight (kg)	2.885	2.877
Mother's pre-pregnancy weight (kg)	67.515	66.937
Parent has no high school degree[2]	18.3%	19.5%
Parent has a high school degree, but no bachelor's degree[2]	64.7%	65.8%
Parent has at least a bachelor's degree[2] **	17.1%	14.7%
Family lives in the Northeast***	5.7%	17.3%
Family lives in the Midwest***	20.6%	25.0%
Family lives in the South***	42.3%	35.3%
Family lives in the West***	31.4%	22.3%
Wave 1***	31.3%	28.0%

Wave 2	25.4%	25.7%
Wave 3***	22.0%	23.6%
Wave 4*	16.8%	17.6%
Wave 5	4.6%	5.1%
Number of observations	10,450	13,800

[1] The number of observations varies by dependent variable.

[2] Determined as of Wave 1.

***$p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table 2. Food Consumption Questionnaire (FCQ) Subset Questions Used to Generate Eating Habits Indices.

Healthy Eating Habits	
Question	***Response and Score***
"During the past 7 days, how many times did your child drink milk?"	4 or more times a day = 28 times per week 3 times a day = 21 Twice a day = 14 Once a day = 7 4 to 6 times during the past 7 days = 5 1 to 3 times during the past 7 days = 2 Child did not drink milk during past 7 days = 0
"During the past 7 days, how many times did your child drink 100% fruit juices such as orange juice, apple juice, or grape juice? Do not count punch, Sunny Delight, Kool-Aid, sports drinks, or other fruit-flavored drinks."	4 or more times a day = 28 times per week 3 times a day = 21 Twice a day = 14 Once a day = 7 4 to 6 times during the past 7 days = 5 1 to 3 times during the past 7 days = 2 Child did not drink 100% fruit juice during past 7 days = 0
"During the past 7 days, how many times did your child eat fresh fruit, such as apples, bananas, oranges, berries or other fruit such as applesauce, canned peaches, canned fruit cocktail, frozen berries, or dried fruit? Do not count fruit juice."	4 or more times a day = 28 times per week 3 times a day = 21 Twice a day = 14 Once a day = 7 4 to 6 times during the past 7 days = 5 1 to 3 times during the past 7 days = 2 Child did not eat fruit during past 7 days = 0
"During the past 7 days, how many times did your child eat vegetables other than french fries and other fried potatoes? Include vegetables like those served as a stir fry, soup, or stew, in your response."	4 or more times a day = 28 times per week 3 times a day = 21 Twice a day = 14 Once a day = 7 4 to 6 times during the past 7 days = 5 1 to 3 times during the past 7 days = 2 Child did not eat vegetables during past 7 days = 0
Possible range of scores on Healthy Eating Habits Index	***0 – 112 times per week***
Unhealthy Eating habits	
"During the past 7 days, how many times did your child drink soda pop (for example, Coke, Pepsi, or Mountain Dew), sports drinks (for example, Gatorade), or fruit drinks that are not	4 or more times a day = 28 times per week 3 times a day = 21 Twice a day = 14 Once a day = 7 4 to 6 times during the past 7 days = 5

100% fruit juice (for example, Kool-Aid, Sunny Delight, Hi-C, Fruitopia, or Fruitworks)?"	1 to 3 times during the past 7 days = 2 Child did not drink soda or fruit drinks during past 7 days = 0
"During the past 7 days, how many times did your child eat a meal or snack from a fast food restaurant with no wait service such as McDonald's, Pizza Hut, Burger King, Kentucky Fried Chicken, Taco Bell, Wendy's and so on? Consider both eating out, carry out, and delivery of meals in your response."	4 or more times a day = 28 times per week 3 times a day = 21 Twice a day = 14 Once a day = 7 4 to 6 times during the past 7 days = 5 1 to 3 times during the past 7 days = 2 Child did not eat from a fast food restaurant during past 7 days = 0
"During the past 7 days, how many times did your child eat candy (including Fruit Roll-Ups and similar items), ice cream, cookies, cakes, brownies, or other sweets?"	4 or more times a day = 28 times per week 3 times a day = 21 Twice a day = 14 Once a day = 7 4 to 6 times during the past 7 days = 5 1 to 3 times during the past 7 days = 2 Child did not eat any sweets during past 7 days = 0
"During the past 7 days, how many times did your child eat potato chips, corn chips such as Fritos or Doritos, Cheetos, pretzels, popcorn, crackers or other salty snack foods?"	4 or more times a day = 28 times per week 3 times a day = 21 Twice a day = 14 Once a day = 7 4 to 6 times during the past 7 days = 5 1 to 3 times during the past 7 days = 2 Child did not eat any salty snacks during past 7 days = 0
Possible range of scores on Unhealthy Eating Habits Index	***0 – 112 times per week***

Table 3. Analysis Sample Descriptive Statistics.

Variable	Valid Overweight Indicator	Not Overweight	Overweight	Valid Food Security Status Indicator	Household is Food Secure	Household Has Low or Very Low Food Security	Valid Eating Habits Values
Dependent variables[1]							
BMI z score	0.488	-0.143	1.836***	0.489	0.486	0.501	0.529
Child is overweight	31.9%	0%	100%	31.9%	31.7%	33.1%	32.8%
# Times child ate healthy food in past 7 days	45.773	45.742	45.837	45.692	45.660	45.828	45.685
# Times child ate unhealthy food in past 7 days	32.839	32.375	33.788**	32.753	32.619	33.321	32.766
Household has low or very low food security	18.2%	17.9%	18.9%	17.7%	0.0%	100%***	19.1%
Household has very low food security	4.2%	4.0%	4.8%	3.9%	0.0%	21.8%***	4.4%
Independent variables							
Fruit and vegetable average price ($)	1.679	1.674	1.689	1.727	1.731	1.710**	1.669
Fast food average price ($)	5.655	5.636	5.696***	5.712	5.711	5.716	5.634
Lagged fruit and vegetable average price ($)	1.703	1.702	1.705	1.721	1.724	1.704*	1.673
Lagged fast food average price ($)	5.690	5.678	5.716*	5.704	5.703	5.706	5.660
Covariates							
General Cost of Living Index	101.511	101.168	102.243*	101.544	101.629	101.148	101.519
Multiple birth	15.9%	16.3%	15.0%	15.9%	15.7%	16.8%	16.6%

Child age (months)	51.222	50.859	51.997*	35.457	35.277	36.290	59.893
Male	51.1%	49.7%	54.2%*	51.1%	50.7%	52.6%	51.1%
White, non-Hispanic	32.9%	34.7%	29.0%***	34.6%	36.1%	27.8%***	32.3%
Black, non-Hispanic	22.3%	22.0%	23.0%	21.5%	21.2%	22.9%	22.7%
Hispanic	26.8%	25.8%	28.9%	26.0%	24.6%	32.2%***	27.6%
Other Race, non-Hispanic	18.0%	17.5%	19.0%	17.9%	18.1%	17.1%	17.3%
Household is below the federal poverty line	36.8%	35.1%	40.4%***	35.9%	30.8%	59.9%***	37.4%
Household is between 100% and 185% of the federal poverty line (FPL)	33.9%	34.0%	33.8%	34.2%	34.5%	32.4%	34.6%
Household is between 185% and 300% of the FPL	29.3%	31.0%	25.8%***	29.9%	34.7%	7.7%***	28.0%
Number of children in the household	2.703	2.756	2.591***	2.606	2.582	2.717**	2.749
Number of adults in the household	2.095	2.083	2.119	2.133	2.160	2.006***	2.062
Mother is not working	44.1%	45.3%	41.6%*	0.488	0.477	0.537***	0.431
Mother is employed part time	17.8%	18.7%	16.1%*	0.179	0.183	0.159*	0.181
Mother is employed full time	38.1%	36.1%	42.3%***	0.334	0.340	0.304**	0.388
Child's birthweight (kg)	2.882	2.780	3.101***	2.885	2.882	2.902	2.874
Mother's pre-pregnancy weight (kg)	67.626	65.760	71.607***	67.515	67.097	69.454***	67.936
Parent has no high school degree**	0.186	0.181	0.195	0.183	0.161	0.282***	0.187
Parent has a high school degree, but no bachelor's degree[2]	65.3%	63.8%	68.6%**	64.7%	64.6%	64.9%	65.1%
Parent has at least a bachelor's degree[2]	16.1%	18.1%	11.9%***	17.1%	19.2%	0.070***	16.2%

Family lives in the Northeast	6.3%	5.9%	7.1%	5.7%	5.8%	5.0%	6.8%
Family lives in the Midwest	19.9%	20.2%	19.3%	20.6%	20.2%	22.3%	19.4%
Family lives in the South	41.9%	42.7%	40.2%	42.3%	42.9%	0.393*	43.0%
Family lives in the West	31.9%	31.2%	33.4%	31.4%	31.0%	33.4%	30.8%
Wave 1	0.0%	0.0%	0.0%	31.3%	30.9%	32.7%	0.0%
Wave 2	24.9%	25.9%	22.8%**	25.4%	26.4%	0.205***	0.0%
Wave 3	37.9%	37.4%	39.1%	22.0%	21.3%	0.252***	50.6%
Wave 4	29.1%	28.7%	30.1%	16.8%	16.7%	17.2%	38.7%
Wave 5	8.1%	8.1%	8.0%	4.6%	4.7%	4.4%	10.7%
Number of observations	5,950	4,050	1,900	10,450	8,600	1,850	4,500

Note: Observations have valid ACCRA data and have income below 300% of the federal poverty line.

[1] Number of observations varies by dependent variable.

[2] Determined as of Wave 1.

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$ indicate statistically significant difference between observations considered overweight and not overweight, or as having low (or very low) food security or being food secure.

Table 4. Predicting child BMI z-score, overweight, food security, and eating habits from food prices.

	Weight		**Food Security**		**Eating Habits**	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	BMI z score	**Overweight**	**Household has low or very low food security**	**Household has very low food security**	**# Times child ate healthy food in past 7 days**	**# Times child ate unhealthy food in past 7 days**
Fruit and vegetable average price ($)	0.414*	0.057	-0.0350	0.018	-1.785	4.008
	(0.164)	(0.048)	(0.0358)	(0.015)	(2.298)	(2.122)
Fast food average price ($)	0.099	0.068**	0.0104	-0.003	1.231	-0.214
	(0.081)	(0.023)	(0.0169)	(0.009)	(0.959)	(0.956)
Overall cost of living index	-0.005	-0.001	-0.000363	-0.000	0.081*	-0.0999**
	(0.003)	(0.001)	(0.000918)	(0.000)	(0.038)	(0.0383)
Multiple birth	0.170*	0.067**	0.0198	0.011	1.341	-0.825
	(0.081)	(0.023)	(0.0212)	(0.012)	(1.055)	(1.212)
Child age (months)	0.002	0.003	0.000246	0.001	-0.006	-0.0204
	(0.006)	(0.002)	(0.00153)	(0.001)	(0.100)	(0.0756)
Male	0.081	0.024	0.0104	-0.000	-1.287*	1.073*
	(0.044)	(0.014)	(0.0102)	(0.004)	(0.582)	(0.527)
Black, non-Hispanic	-0.042	0.022	-0.0291	-0.016*	1.275	0.901
	(0.080)	(0.027)	(0.0162)	(0.008)	(0.968)	(0.938)
Hispanic	0.105	0.042	0.0265	0.002	2.119	-0.336
	(0.068)	(0.024)	(0.0177)	(0.008)	(1.208)	(0.738)
Other Race, non-Hispanic	-0.006	0.030	0.00906	0.003	-0.981	-0.524
	(0.080)	(0.026)	(0.0159)	(0.008)	(1.164)	(0.756)

White, non-Hispanic (omitted)						
Household is below the federal poverty line (FPL)	0.122* (0.053)	0.063*** (0.018)	0.230*** (0.0144)	0.070*** (0.006)	3.678*** (0.846)	0.827 (0.704)
Household is between 100% and 185% of the FPL	0.063 (0.052)	0.026 (0.019)	0.113*** (0.00929)	0.030*** (0.004)	1.159 (0.701)	0.648 (0.556)
Household is between 185% and 300% of the FPL (omitted)						
Number of children in the household	-0.077*** (0.015)	-0.035*** (0.005)	-0.00505 (0.00424)	0.001 (0.002)	0.079 (0.257)	-0.372 (0.205)
Number of adults in the household	0.037 (0.020)	0.015* (0.007)	-0.0286*** (0.00531)	-0.010*** (0.003)	-0.296 (0.495)	0.714* (0.292)
Mother is not working	-0.087 (0.059)	-0.039* (0.019)	-0.000430 (0.00849)	0.002 (0.005)	-0.228 (0.700)	-1.777** (0.589)
Mother is employed part time	-0.106 (0.063)	-0.057** (0.020)	-0.00873 (0.0127)	-0.000 (0.006)	-1.127 (0.917)	-0.859 (0.724)
Mother is employed full time (omitted)						
Child's birthweight (kg)	0.352*** (0.028)	0.084*** (0.008)	0.00455 (0.00486)	0.005* (0.002)	0.686* (0.305)	0.794* (0.344)
Mother's pre-pregnancy weight (kg)	0.012*** (0.002)	0.004*** (0.000)	0.00108** (0.000347)	0.000 (0.000)	-0.060* (0.024)	0.0139 (0.0182)
Parent has no high school degree[1]	0.158 (0.086)	0.071* (0.033)	0.0755*** (0.0180)	-0.002 (0.009)	2.419* (1.146)	4.062*** (1.209)
Parent has a high school degree, but no bachelor's degree[1]	0.140*	0.056**	0.0332**	0.003	1.783*	2.658***

	(0.060)	(0.021)	(0.0110)	(0.005)	(0.841)	(0.723)
Parent has at least a bachelor's degree (omitted)[1]						
Family lives in the Northeast	0.194**	0.049	0.0103	-0.012	2.660	-3.465**
	(0.068)	(0.037)	(0.0263)	(0.007)	(1.610)	(1.283)
Family lives in the Midwest	0.011	0.016	0.0327*	0.012	1.283	-0.0234
	(0.099)	(0.021)	(0.0142)	(0.007)	(0.996)	(0.906)
Family lives in the West	0.067	0.008	0.0276	-0.001	0.019	0.558
	(0.063)	(0.022)	(0.0183)	(0.009)	(1.183)	(1.094)
Family lives in the South (omitted)						
Wave 1			0.0291	0.029		
			(0.0842)	(0.046)		
Wave 2	-0.086	0.089	-0.0161	0.015		
	(0.250)	(0.090)	(0.0651)	(0.036)		
Wave 3	0.056	0.042	0.0232	0.019	1.651	0.920
	(0.082)	(0.029)	(0.0222)	(0.012)	(1.316)	(1.074)
Wave 4 (omitted)						
Wave 5	-0.102	-0.048	-0.0101	-0.007	-2.493	1.256
	(0.115)	(0.027)	(0.0264)	(0.012)	(1.445)	(0.925)
Constant	-2.329***	-0.809***	0.00312	-0.025	31.948***	31.89***
	(0.590)	(0.178)	(0.132)	(0.065)	(7.916)	(7.968)
Number of observations	5,950	5,950	10,450	10,450	4,500	4,500
R-squared	0.096	0.075	0.087	0.028	0.033	0.030

Note: Robust standard errors in parentheses.

[1] Determined as of Wave 1.

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table 5. Predicting child BMI z-score and overweight from fruit and vegetable and fast food prices in separate models.

	Fruit and vegetable average price ($) only		**Fast food average price ($) only**	
	Model 1	Model 2	Model 3	Model 4
	BMI z score	**Overweight**	**BMI z score**	**Overweight**
Fruit and vegetable average price ($)	0.436* (0.169)	0.072 (0.050)		
Fast food average price ($)			0.117 (0.087)	0.070** (0.024)
Overall cost of living index	-0.003 (0.002)	-0.000 (0.001)	0.000 (0.002)	-0.000 (0.001)
Multiple birth	0.169* (0.082)	0.066** (0.023)	0.169* (0.081)	0.067** (0.023)
Child age (months)	0.001 (0.006)	0.003 (0.002)	0.003 (0.006)	0.003 (0.002)
Male	0.080 (0.044)	0.023 (0.014)	0.080 (0.044)	0.024 (0.014)
Black, non-Hispanic	-0.052 (0.080)	0.016 (0.026)	-0.021 (0.080)	0.025 (0.027)
Hispanic	0.094 (0.068)	0.034 (0.023)	0.086 (0.067)	0.040 (0.024)
Other Race, non-Hispanic	-0.004 (0.079)	0.031 (0.026)	-0.013 (0.080)	0.029 (0.026)
White, non-Hispanic (omitted)				
Household is below the federal poverty line (FPL)	0.125* (0.054)	0.065*** (0.018)	0.120* (0.053)	0.062*** (0.018)
Household is between 100% and 185% of the FPL	0.065 (0.052)	0.027 (0.019)	0.060 (0.051)	0.025 (0.019)
Household is between 185% and 300% of the FPL (omitted)				
Number of children in the household	-0.077*** (0.015)	-0.035*** (0.006)	-0.079*** (0.015)	-0.035*** (0.006)
Number of adults in the household	0.036 (0.020)	0.014 (0.007)	0.036 (0.021)	0.015* (0.007)

Mother is not working	-0.088 (0.059)	-0.040* (0.019)	-0.089 (0.060)	-0.040* (0.019)
Mother is employed part time	-0.107 (0.063)	-0.058** (0.020)	-0.103 (0.064)	-0.057** (0.020)
Mother is employed full time (omitted)				
Child's birthweight (kg)	0.353*** (0.028)	0.085*** (0.008)	0.348*** (0.028)	0.083*** (0.008)
Mother's prepregnancy weight (kg)	0.012*** (0.002)	0.004*** (0.000)	0.012*** (0.002)	0.004*** (0.000)
Parent has no highschool degree[1]	0.162 (0.087)	0.074* (0.033)	0.160 (0.086)	0.071* (0.033)
Parent has a highschool degree, but no bachelors degree[1]	0.144* (0.060)	0.058** (0.021)	0.143* (0.060)	0.056** (0.021)
Parent has at least a bachelors degree (omitted)[1]				
Household lives in the northeast	0.190** (0.071)	0.046 (0.039)	0.200** (0.062)	0.050 (0.037)
Household lives in the midwest	0.012 (0.101)	0.017 (0.022)	-0.038 (0.102)	0.010 (0.022)
Household lives in the west	0.072 (0.064)	0.011 (0.022)	0.017 (0.060)	0.001 (0.022)
Household lives in the south (omitted)				
Wave 1				
Wave 2	-0.098 (0.255)	0.081 (0.091)	-0.057 (0.252)	0.093 (0.090)
Wave 3	0.055 (0.083)	0.041 (0.030)	0.034 (0.080)	0.039 (0.029)
Wave 4 (omitted)			-0.095	-0.047
Wave 5	-0.090 (0.115)	-0.040 (0.028)	(0.112)	(0.027)
Constant	-1.932*** (0.534)	-0.538** (0.173)	-2.196*** (0.604)	-0.791*** (0.182)
Observations	5,950	5,950	5,950	5,950
R-squared	0.096	0.073	0.094	0.075

Note: Robust standard errors in parentheses.

[1] Determined as of Wave 1.

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table 6. Predicting child BMI z-score and overweight from lagged food prices.

	Model 1	Model 2
	BMI z score	**Overweight**
Lagged fruit and vegetable average price ($)	0.227 (0.156)	-0.011 (0.045)
Lagged fast food average price ($)	0.143 (0.083)	0.049 (0.027)
Overall cost of living index	-0.002 (0.002)	-0.000 (0.001)
Multiple birth	0.184* (0.092)	0.074** (0.027)
Child age (months)	0.003 (0.007)	0.004 (0.002)
Male	0.075 (0.045)	0.019 (0.015)
Black, non-Hispanic	-0.010 (0.090)	0.033 (0.031)
Hispanic	0.127 (0.073)	0.042 (0.026)
Other Race, non-Hispanic	-0.011 (0.091)	0.033 (0.029)
White, non-Hispanic (omitted)		
Household is below the federal poverty line	0.095 (0.057)	0.054** (0.018)
Household is between 100% and 185% of the federal poverty line	0.053 (0.055)	0.022 (0.020)
Household is between 185% and 300% of the federal poverty line (omitted)		
Number of children in the household	-0.072*** (0.016)	-0.033*** (0.006)
Number of adults in the household	0.051* (0.023)	0.019* (0.008)
Mother is not working	-0.087 (0.062)	-0.038* (0.019)
Mother is employed part time	-0.070 (0.065)	-0.042* (0.019)
Mother is employed full time (omitted)		

Child's birthweight (kg)	0.337*** (0.032)	0.079*** (0.009)
Mother's pre-pregnancy weight (kg)	0.012*** (0.002)	0.004*** (0.001)
Parent has no high school degree[1]	0.158 (0.090)	0.071* (0.035)
Parent has a high school degree, but no bachelor's degree[1]	0.155* (0.061)	0.063** (0.022)
Parent has at least a bachelor's degree (omitted)[1]		
Family lives in the Northeast	0.201** (0.071)	0.067 (0.046)
Family lives in the Midwest	-0.009 (0.107)	0.013 (0.025)
Family lives in the West	0.035 (0.061)	0.002 (0.023)
Family lives in the South (omitted)		
Wave 1		
Wave 2	-0.106 (0.288)	0.121 (0.102)
Wave 3	0.030 (0.094)	0.057 (0.035)
Wave 4 (omitted)		
Wave 5	-0.096 (0.128)	-0.039 (0.029)
Constant	-2.540*** (0.749)	-0.750*** (0.213)
Number of observations	5,200	5,200
R-squared	0.090	0.069

Note: Robust standard errors in parentheses.

[1] Determined as of Wave 1.

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table 7. Predicting child outcomes among subsamples of children in households receiving public food assistance (food stamps, WIC, and/or free or reduced-price lunch and those in households not receiving any public food assistance.

	Weight		**Food Security Status**		**Eating Habits**	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	BMI z score	**Overweight**	**Household has low or very low food security**	**Household has very low food security**	**# Times child ate healthy food in past 7 days**	**# Times child ate unhealthy food in past 7 days**
Receives SNAP, WIC, or free/reduced school lunch						
Fruit and vegetable average price ($)	0.522*	0.100	-0.0528	0.021	-0.983	4.522
	(0.214)	(0.058)	(0.0443)	(0.021)	(2.914)	(2.645)
Fast food average price ($)	0.145	0.085**	0.0188	-0.003	0.472	0.528
	(0.101)	(0.030)	(0.0221)	(0.014)	(1.156)	(0.961)
Number of observations	3700	3700	6900	6900	2800	2800
R-squared	0.099	0.070	0.062	0.022	0.029	0.037
Does not receive SNAP, WIC, or free/reduced school lunch						
Fruit and vegetable average price ($)	0.175	-0.023	5.28e-05	0.013	-2.244	3.418
	(0.167)	(0.070)	(0.0344)	(0.018)	(3.477)	(2.577)
Fast food average price ($)	-0.020	0.029	-0.0192	-0.008	2.581	-1.037
	(0.085)	(0.034)	(0.0139)	(0.006)	(1.727)	(1.468)
Number of observations	2250	2250	3600	3600	1750	1750
R-squared	0.117	0.087	0.064	0.026	0.045	0.042

Note: Robust standard errors in parentheses.

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$