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

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Abstract

Objectives: We examine how local food prices influence children's body mass index (BMI), overweight, food insecurity, and food consumption, and whether receipt of public food assistance moderates these associations.

Methods: We linked data from the Early Childhood Longitudinal Study-Birth Cohort (ECLS-B), a nationally representative study of children from birth to age 5, to local food price data from the ACCRA Cost-of-Living Index (COLI) (approx. 11,700 observations). Using OLS, linear probability, and fixed effects (FE) models, we exploit the variability in food price data over time and among children who move residences.

Results: Results indicate that higher-priced fruits and vegetables are associated with higher standardized measures of children's BMI. This relationship is driven by fresh (vs. frozen or canned) fruits and vegetables. In the FE models, higher-priced soft drinks are associated with a lower likelihood of being overweight, and surprisingly, higher fast food prices are associated with a greater likelihood of being overweight. Food prices are largely unassociated with children's food consumption. There is limited evidence that food stamp receipt mitigates the effect of food prices on adult-level food insecurity.

Conclusions: Policies that reduce the costs of fresh fruits and vegetables may be effective in promoting healthy weight among young children.

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

Both under- and over-nutrition are important public health problems facing young children in the United States. In 2011, approximately 20.6% of households with children in the U.S. were food insecure (1), defined as "having limited or uncertain availability of food, or limited or uncertain ability to acquire acceptable foods in socially acceptable ways"[1] (2). More than 26% of two- to five-year-old children were considered overweight (defined as having a body mass index [BMI] above the 85th percentile by age and gender) in 2009-2010, up from 21% in 1999-2000 (3). Being either food insecure and overweight during early childhood have negative effects on children's short- and long-term health, social, and economic outcomes (4-9).

A lack of affordable, healthy foods is one of the neighborhood factors presumed to underlie both food insecurity and obesity among children (10, 11). While general food prices (i.e., price per calorie) trended downward in recent decades, particularly the prices of snacks and sugar-sweetened beverages, the real prices of restaurant meals and fruits and vegetables increased (12), with fruit and vegetable prices increasing by 17% between 1997 and 2003 alone (13). Experimental work has found that children decrease their consumption of certain foods when the price is increased (14). Living in areas with higher-priced fast foods and soda is associated with lower body weight and BMI, while higher fruit and vegetable prices demonstrate the opposite association (15-23). These relationships appear to be larger among low-income children as compared to their higher-income counterparts (15-17), presumably because their families have less disposable income with which to adapt to a higher-price environment. With a

[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.

tight budget constraint, a family may purchase more poorer-quality, energy-dense foods (24-26), which cost less per calorie than more nutritious foods (27, 28), although not by weight or average portion size {Carlson, 2012 #1383}.

To help families purchase food, the U.S. spent $78.8 billion in fiscal year 2009 on domestic food assistance programs, much of which helps families with children through the Supplemental Nutrition Assistance Program (SNAP; formerly known as the Food Stamp Program) (29). SNAP serves nearly one-half of all children at some point in their lives (30). Research suggests that food assistance receipt increases total household food expenditures and reduces food insecurity (31-34). Evidence also exists that food assistance and subsidized meals may help combat obesity among low-income children through the provision of healthy foods (35-38); however, one study found that SNAP, which has few nutritional restrictions, may contribute to child obesity in cities with high food prices {Kimbro, 2010 #275}. In these studies, addressing selection into food assistance programs is difficult (39, 40).

Despite the importance of adequate nutrition during early childhood, to date, little research has examined how food prices relate to weight and food insecurity outcomes during early childhood (41), and, with few exceptions (16, 35), most studies have estimated cross-sectional associations between food prices and child outcomes. Further, previous research has not isolated fresh fruits and vegetables, whose prices vary more than frozen or canned options. Moreover, despite findings that sugar-sweetened beverages account for nearly 15% of children's daily caloric intake (42) and soft drinks can have negative impacts on children's health (43), little research has investigated associations between soft drink prices and children's weight, with the exception finding higher priced soft drinks associated with lower BMIs among school-age children (23).

We address these gaps in the literature by first estimating how local food prices (overall fruits and vegetables, frozen and canned fruits and vegetables, fast food, and soda) influence the weight outcomes, food insecurity, and food consumption of children from infancy to five years of age, and second, by examining how participation in food assistance programs changes the relationship between food prices and the weight outcomes, food insecurity, and food consumption of children from infancy to five years of age. We hypothesize that: 1) high-priced fruits and vegetables and low-priced fast food and soft drinks may contribute to a greater likelihood of being overweight, higher BMI, and less healthy food consumption, 2) high prices for fruits and vegetables, fast food, and soda may contribute to a greater likelihood of being food insecure, and 3) the prices of fresh fruits and vegetables will be more highly related to children's outcomes than frozen or canned fruits and vegetables. We expect that food assistance receipt serves as a buffer between local fruit and vegetable and soft drink prices and food insecurity; however, food assistance receipt may exacerbate the anticipated relationship between food prices and child weight outcomes.

Methods

Data

We use child-level data from the Early Childhood Longitudinal Study-Birth Cohort (ECLS-B) linked with city-level data from ACCRA Cost of Living Index (COLI). The ECLS-B, collected by the National Center for Education Statistics (NCES), is a longitudinal dataset of approximately 10,700 children and was designed to be nationally representative of children born in the United States in 2001.[2] The ECLS-B follows children from birth through kindergarten with data collection occurring when the children are 9 months of age (2001-02) including

[2] The reported sample sizes are rounded to the nearest 50, per NCES regulations regarding disclosure of restricted-use data. Asian and American-Indian children, twins, and low and very low birthweight children were oversampled.

information from birth certificates, 2 years of age (2003-04), approximately 4 years of age (preschool: 2005-06), and at two waves of kindergarten entry (2006-08). This study uses the first 4 waves of data, excluding the second kindergarten entry wave (fall 2007).[3] At each wave, information about child and family characteristics and residential zip codes were collected through interviews with parents and child assessments.

The ACCRA COLI dataset, collected by the Council for Economic Research (C2ER; http://www.coli.org), is the main source of cost-of-living data in the U.S., including local food prices. The ACCRA food price data are collected quarterly from more than 300 Core Based Statistical Areas (CBSA).[4] CBSAs constitute relatively large geographic areas, and exclude certain areas of the country, particularly rural areas. For this study, data from 2001 through 2007 were merged with the ECLS-B. Approximately 5,700 children (54%) have food price data for at least one wave. This is comparable to previous research using these data (17). Despite these limitations, the ACCRA food price data correlate highly with food price data from the Bureau of Labor Statistics, the Consumer Expenditure Survey, and the U.S. Department of Agriculture (USDA) (12), but provide more detailed city-level prices than other sources, and have been used in more than 15 studies since 2002.

The unit of analysis of the study is the child in a given wave and we limit our sample to observations of children with nonmissing data on food price and control variables who reside in households with income below 300% of the Federal Poverty Level (FPL: $61,950 for a family of 4 in 2007) at any wave, as the outcomes of children living in lower-income families are more

[3] In the fall of 2006, information was collected from all participating children, approximately 75% of whom were in kindergarten or a higher grade. 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.
[4] CBSA codes replaced Metropolitan Statistical Area (MSA) codes in 2000.

affected by food prices than those in high-income families.[5] We allow the sample size to vary by the dependent variable, as the 3 main dependent variables – children's weight outcomes, food insecurity, and food consumption – were measured over different time periods, as explained below. Table 1 compares the characteristics of our analysis sample (11,700 observations) to those dropped from our sample due to missing data (missing ACCRA food prices or covariates) under 300% of FPL. Notably, there were relatively few differences of a large magnitude; however, our analysis sample averaged lower BMI z-scores and rates of overweight than those excluded, not surprising given the higher rates of child obesity in rural areas (44).

Insert Table 1 here.

Measures

BMI z-scores, overweight status, food insecurity, and food consumption served as the dependent variables. Anthropometric measures of children's weight and height were obtained twice at the 2-year, preschool, and the first kindergarten waves of data collection. If the two measures were more than 5% apart, a third measurement was taken. The two closest measurements were then averaged together. BMI was calculated using measures of children's weight and height. Using the Centers for Disease Control and Prevention (CDC) standards (45), standardized BMI z-scores were generated to allow for comparisons across age and gender. The binary outcome of overweight (having a BMI 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 2 years of age, we include children 24 months and older when examining weight outcomes.

[5] Because the ECLS-B provides income ranges, we assign each child the midpoint of the range indicated. We compare this midpoint and the household size to 3 times the corresponding Federal Poverty Level for the first year of each wave. If the child resides in a household with income below 300% of the FPL at any wave—even if they are missing information on income in other waves—they are included in our sample for all waves. No children are missing income information in every wave.

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 Core Food Security Module (CFSM) created by the USDA. Respondents were asked about their food purchases, consumption, and concerns. Their responses were used to generate a categorical measure of adult-level food security. We use adult food security, as opposed to the child or household levels, as parents' reports of their own food security are more accurate than their reports of their children's experiences {Nord, 2012 #1382}. We use two binary indicators of adult food insecurity: one that includes both low and very low food security (1 = *low or very low food security*), and another indicating an adult in the household has very low food security (1 = *very low food security*).[6,7]

At the preschool and kindergarten entry waves, parents were asked about their children's food consumption (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 previous research (48), 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 or beverage. 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 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

[6] Note that the ECLS-B Users Guide refers to these categories as food secure, food insecure without hunger, and food insecure with hunger. We use the above terms in accordance with the National Academies of Sciences recommendation (46).

[7] The adult-level variables are calculated according to the USDA recommendations (47).

healthier eating; higher scores on the Unhealthy Eating Index indicate greater consumption of less healthy foods. Table 2 displays the indices.

Insert Table 2 here.

Our independent variables include the average prices of the following items measured in the ACCRA data: (1) 6 fruits and vegetables (potatoes, bananas, lettuce, canned sweet peas, canned peaches, and frozen corn); (2) 3 fast foods (the average price of a McDonald's quarter-pounder with cheese; 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); and (3) soft drinks (a 2-liter bottle of Coca-Cola). For some analyses, we separated the fruits and vegetables into: (1) fresh fruits and vegetables (potatoes, bananas, and lettuce) and (2) frozen and canned fruits and vegetables (canned peaches, canned sweet peas, and frozen corn). Because food prices are not collected for every CBSA at each quarter, measures of average annual food price indices were calculated for each category. Each of our food price measures was divided by the annual ACCRA overall cost-of-living composite index and inflation-adjusted to 2008 dollars. We then standardized these ratios relative to entire ACCRA sample, generating z-scores ($M = 0$, $SD = 1$). Average annual food prices and the standardized ratios of the national ACCRA sample are provided in Table 3. As shown, there is considerable price variability.

Insert Table 3 here.

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 outcomes. Covariates include child gender, race/ethnicity (*non-Hispanic white*, *non-Hispanic black*, *Hispanic, other*), whether the child was a multiple birth, age

in months, and birthweight (in kg). We use binary reports of respondent-reported maternal and paternal education at wave 1 (*neither parent graduated high school, at least one parent has a high school degree, and at least one parent graduated from college*), and their pre-pregnancy weight (in kg). At each wave, mother-reported family income and the number of children and adults living in the household were used to code the household's FPL. Also at each wave, mothers reported whether anyone in their household owned a car and their employment status and weekly work hours (*mother worked 35 or more hours per week*, *mother worked fewer than 35 hours per week, mother was not employed*). The child's geographic region (*Northeast, Midwest, West, South*), urbanicity (*urban* or *rural/suburban*), and wave of data collection were also controlled. At each wave of data, respondents reported their participation in the Food Stamp Program since the last interview (or in wave 1, since the child's birth).

Empirical Strategy

A series of Ordinary Least Squares (OLS) and linear probability models (LPM) 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, food consumption, and food insecurity, 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 fruit and vegetable, fast food, and soda 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 are clustered at the CBSA level. Although a rich set of explanatory variables is included, it

[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.

is likely that the food price estimates generated from Equation 1 are biased. To further limit potential omitted variable bias, within-child fixed effects (FE) models are also estimated, exploiting the variation in prices over time for each child and among the children in the sample (13%) who moved among different CBSAs between the 9 month and kindergarten entry waves. To test how participation in public food assistance programs changes the relationship between food prices and children's health outcomes, Equation 1 was re-estimated adding a food stamp receipt dummy variable and variables interacting food stamp receipt and food prices indices. Measures of effect size (*d*) for continuous dependent variables are presented (Coefficient/SD of the dependent variable: 1.34 for BMI z-score, 18.81 for healthy food consumption, and 14.87 for unhealthy food consumption).

Results

The analysis sample's descriptive statistics, pooled across waves, are displayed in Table 4. On average, children's BMIs were about one-half of a standard deviation above CDC recommendations. About 30% of children were overweight, and about 12% of children lived in households in which the adult respondent reported low or very low food security. Overweight children faced higher average annual fruit and vegetable, fast food, and soft drink prices than their peers who were not overweight, but the standardized price ratios did not differ. Households with food insecure adults averaged lower fruit and vegetable prices than those with food secure adults.

Insert Table 4 here.

Regression Results

Table 5 displays the primary model results. Consistent with hypotheses, standardized fruit and vegetable price ratios are associated with higher child BMI z-scores, indicating that a 1-

unit increase (or an increase in of 1 SD) in the standardized ratio of average annual fruit and vegetable prices, or a $0.24 increase, is associated with an increase of 0.088 in a child's BMI z-score ($d = 0.065$). By comparison, the magnitude of this association is about two-thirds that of the association between living below the poverty line and BMI. Fast food and soft drink prices are unrelated to children's BMI z-scores, healthy or unhealthy food consumption, or rates of overweight or food insecurity. Analyses that include each category of food prices in separate models (available upon request) show similar patterns.

Insert Table 5 here.

Results from the within-child fixed effects models, shown in Table 6, indicate that a $0.24 increase in the price of fruits and vegetables are associated with a 0.107 increase in children's BMI z-scores. In addition, a $0.17 increase in the price of soft drinks is associated with a 2.5% decrease in the likelihood a child is overweight. Surprisingly, however, a $0.40 increase in the price of fast foods is associated with a 5.9% increase in the likelihood a child is overweight.

Insert Table 6 here.

Table 7 displays OLS, LPM and FE models that separated the prices of fresh from frozen and canned fruits and vegetables. Results suggest that the prices of fresh fruits and vegetables, rather than canned or frozen, are driving the association between fruits and vegetables and children's BMI z-scores. A $0.38 increase in the price of fresh fruits and vegetables is also associated with a 2.5% increase in likelihood of child overweight in the LPM results.

Insert Table 7 here.

Models testing the moderating effects of food stamp receipt are shown in Table 8. There are few significant interactions between food stamp receipt and food prices. Surprisingly, food

stamp receipt significantly moderates the association between fast food prices and children's overweight, such that among food stamp recipients, a $0.40 increase in fast food prices is associated with a 3.7% increase in the likelihood of being overweight. Food stamp receipt also moderates the association between fruit and vegetable prices and adult food insecurity, such that among food stamp recipients, a $0.38 increase in fresh fruit and vegetable prices is associated with a 3.6% decrease in the likelihood of being food insecure.

Insert Table 8 here.

Sensitivity Analyses

A series of sensitivity tests were conducted (results available upon request). First, state-level sales tax rates and whether food is exempt from sales tax, gathered from the Bridging the Gap program[9], were added as controls, as the ACCRA prices do not include taxes. State-level taxes are unrelated to children's outcomes, and do not change the associations between food prices and outcomes. Second, we added controls for parent-reported measures of the time children spent engaged in physical activity and watching TV to models predicting children's BMI and overweight; these controls did not change the pattern of results. Third, we ran separate models predicting the individual food items in the Healthy and Unhealthy Eating Habits indices, finding no associations between food prices and consumption of the individual items. Finally, because food prices may have a lagged effect on children's weight outcomes, we tested associations between our food price measures at the previous wave and child BMI and overweight. Findings reveal no evidence of lagged effects.

Discussion

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

[9] More information about Bridging the Gap can be found at: http://www.bridgingthegapresearch.org/.

outcomes, food insecurity, and food consumption 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 outcomes. In general, results suggest that higher-priced fresh fruits and vegetables are associated with higher BMI and rates of overweight among young children. Surprisingly, food prices seem largely unrelated to food security and parents' reports of children's food consumption. However, there is limited evidence that food stamp receipt mitigates associations between food prices and food insecurity.

Consistent with previous research (15, 18, 49), 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. Building on previous research, we find that these associations are driven by changes in the prices of fresh fruits and vegetables, rather than frozen or canned. The magnitude of this association is considerable, when taking into account that small changes in price are associated with small but significant changes in children's weight outcomes. A $0.38 increase in the average annual price of fresh fruits and vegetables is linked with a one-tenth of a standard deviation increase in children's BMI z-scores. While these changes reflect relatively small increases in children's BMI measures, the corresponding price changes are relatively small, as well, and the range of food 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.

Also consistent with hypotheses, higher soft drink prices were associated with a decrease

in the likelihood of being overweight in the FE models. By contrast, surprisingly, higher fast food prices were associated with an increase in the likelihood of being overweight in the FE models, and among food stamp recipients in the linear probability models. The FE models are more limited in their sample size, and the inclusion of a more selective subsample may underlie the differences between the OLS and LPM models and the FE models. Alternatively, this may be a result of endogeniety; that is, fast food outlets may respond to increased demand or preferences for fast food with higher prices. Indeed, previous research indicates that fast food locales have substantial independent control over their prices (50). Further, 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 (20, 49), longitudinal analyses using fixed effects models find lower or non-significant associations (18, 20, 21, 51). 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 (15). 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 are relatively recent (2001-08), and may reflect a shift in this general pattern. More research is needed.

Also surprisingly, the mechanism through which food prices are expected to affect children's weight, 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, and only at two waves (preschool and kindergarten entry) is a major limitation. 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. Future research could 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, food prices were largely unrelated to adult-level food insecurity, with one exception: food stamp receipt appears to buffer the association between fresh fruit and vegetable prices and adult food insecurity. Although the premise that low-income families are unable to afford food underlies our public food assistance system, there has been very little research examining local food prices and food insecurity. 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 adult level (as opposed to scores or security at the child or household level) may mask associations.

As with all research, this study has several limitations. First, our analyses cannot reveal causal associations between food prices and child and family outcomes. It is likely that families select into cities or neighborhoods that match their food and cost of living preferences. While our FE models limit bias from unobserved, stable characteristics, it cannot address bias from time-varying characteristics or from reverse causality. Second, our measures of food security and food stamp receipt are parent-reported and are asked about the previous 12 months or since the previous interview, which could span a period of two years or more and not align with our

annual measures of food prices. Finally, our food price measures are assessed at relatively large geographic areas, focus on urban areas, and are limited in the food items assessed. Further, our measures represent annual averages of prices, masking seasonal variability.

Despite these limitations, this study identifies significant associations between food prices and child and family outcomes, shedding light on promising policy initiatives. Results suggest that policies that subsidize the cost fresh fruits and vegetables may be effective in improving the health and weight outcomes of young children. Further, there is some evidence that food stamps buffer the negative effects of high fruit and vegetable prices on recipients' food insecurity, but not children's weight outcomes. It is possible that the higher price of fruits and vegetables relative to other foods discourages households from purchasing them. SNAP (formerly known as the Food Stamp Program) is currently implementing new initiatives including financial incentives that reduce the costs of fruits and vegetables for recipients, which may better address children's weight outcomes. For example, in New York City, SNAP participants who shop at participating farmers markets receive an extra $2 for fruits and vegetables for every $5 of benefits used. The Healthy Incentives Pilot (HIP) in Hampden, Massachusetts is examining whether a financial incentive (an additional 30 cents for every dollar spent on targeted fruits and vegetables) increases fruit and vegetable consumption among SNAP recipients. More research on the interactions between food prices and public food assistance, particularly the effects of these new initiatives, is needed.

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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	0.464*	0.533
Child is overweight	30.8%**	33.6%
Number of times child ate healthy food in past 7 days	45.408	45.347
Number of times child ate unhealthy food in past 7 days	32.588	32.730
Adult has low or very low food security	12.3%**	10.9%
Adult has very low food security	3.5%	3.2%
Covariates		
Family lives in an urban area	78.6%***	59.3%
Family owns at least one car	88.8%***	86.6%
Child was a multiple birth	15.5%	14.4%
Child age (months)	34.497***	35.260
Child is male	50.9%	49.8%
Child is White, non-Hispanic	37.4%	36.1%
Child is Black, non-Hispanic	19.8%	19.1%
Child is Hispanic	24.1%	24.1%
Child is Other Race, non-Hispanic	18.6%*	20.6%
Household is below the federal poverty line (FPL)	31.1%**	33.3%
Household is between 100% and 185% of the FPL	29.5%	30.3%
Household is between 185% and 300% of the FPL	24.8%***	22.1%
Number of children in the household	2.536†	2.492
Number of adults in the household	2.138*	2.174
Mother is not employed	46.6%	46.9%
Mother is employed fewer than 35 hrs/wk	18.0%	17.5%
Mother is employed 35 or more hrs/wk	35.4%	35.6%
Child's birthweight (kg)	2.893	2.890
Mother's pre-pregnancy weight (kg)	66.976	66.667
Parent has no high school degree[2]	16.2%	17.0%
Parent has a high school degree, but no bachelor's degree[2]	62.7%	64.2%
Parent has at least a bachelor's degree[2]	21.2%**	18.8%
Family lives in the Northeast	5.9%***	18.6%
Family lives in the Midwest	20.7%***	25.1%
Family lives in the South	42.4%***	33.1%
Family lives in the West	31.0%***	23.2%
Family receives food stamps	30.1%	30.5%

Number of observations	11,700	13,850

[1] The number of observations varies by dependent variable.
[2] Determined as of Wave 1.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$

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 100% fruit juice (for example, Kool-Aid, Sunny Delight, Hi-C, Fruitopia, or	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 soda or fruit drinks during past 7

Fruitworks)?"	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. Food Price Means and Standard Deviations.

	Average Annual Prices		**Average Annual Prices Relative to Overall Cost-of-Living Index**	
	Mean (in $)	**SD (in $)**	**Mean**	**SD**
Fruits and vegetables	1.68	0.239	0.017	0.002
Fast foods	5.69	0.399	0.058	0.006
Soft drinks	1.40	0.169	0.014	0.002
Fresh fruits and vegetables	1.96	0.379	0.020	0.004
Frozen or canned fruits and vegetables	1.41	0.193	0.014	0.001

Table 4. Analysis Sample Descriptive Statistics.

Variable	Valid Overweight Indicator	Not Overweight	Overweight	Valid Food Security Status Indicator	Adult is Food Secure	Adult Has Low or Very Low Food Security	Valid Eating Food Consumption
Dependent variables[1]							
BMI z score	0.464	-0.146	1.834***	0.465	0.460	0.499	0.529
Child is overweight	30.8%	0%	100%	30.8%	30.6%	33.0%	32.8%
# Times child ate healthy food in past 7 days	45.507	45.345	45.853	45.417	45.264	46.519	45.685
# Times child ate unhealthy food in past 7 days	32.693	32.318	33.497*	32.576	32.487	33.219	32.766
Adult has low or very low food security	12.0%	11.6%	12.8%	12.3%	0.0%	100%***	12.2%
Adult has very low food security	3.6%	3.5%	3.9%	3.5%	0.0%	28.7%***	3.7%
Independent variables							
Fruit and vegetable average annual price ($)	1.678	1.672	1.691*	1.725	1.728	1.707**	1.667
Standardized relative fruit and vegetable average annual price index	-0.215	-0.210	-0.227	0.015	0.018	-0.006	-0.273
Fast food average annual price ($)	5.662	5.646	5.698***	5.715	5.714	5.716	5.640
Standardized relative fast food average annual price index	-0.278	-0.266	-0.305	-0.194	-0.205	-0.111**	-0.314
Soft drink average annual price ($)	1.381	1.376	1.390**	1.388	1.389	1.388	1.385

Standardized relative soft drink average annual price index	-0.200	-0.194	-0.213	-0.259	-0.267	-0.199*	-0.243
Fresh fruit and vegetable average annual price ($)	1.924	1.919	1.936	1.999	2.004	1.966***	1.909
Standardized relative fresh fruit and vegetable average annual price index	-0.200	-0.194	-0.213	0.008	0.015	-0.039	-0.243
Non-fresh fruit and vegetable average annual price ($)	1.432	1.426	1.447**	1.452	1.452	1.449	1.426
Standardized relative non-fresh fruit and vegetable average annual price index	-0.119	-0.119	-0.120	0.021	0.013	0.080*	-0.178
Covariates							
Family lives in an urban area	0.783	0.781	0.787	0.786	0.785	0.796	0.782
Family owns a car	0.897	0.901	0.887	0.888	0.903	0.780***	0.900
Child is a multiple birth	15.5%	16.2%	13.9%	15.5%	15.4%	16.6%	16.3%
Child age (months)	49.594	49.197	50.484**	34.487	34.619	33.543	58.284
Child is Male	50.8%	49.5%	50.5%**	50.9%	50.7%	52.0%	50.8%
Child is White, non-Hispanic	36.6%	38.7%	31.9%***	37.5%	38.6%	29.1%***	36.4%
Child is Black, non-Hispanic	20.1%	19.8%	20.8%	19.8%	19.5%	22.0%	20.1%
Child is Hispanic	24.3%	22.9%	27.5%**	24.1%	23.1%	31.3%***	25.0%
Child is Other Race, non-Hispanic	19.0%	18.6%	19.8%	18.6%	18.7%	17.7%	18.5%
Household is below the federal poverty line	30.4%	28.4%	35.0%***	31.1%	27.2%	58.8%***	30.5%
Household is between 100% and 185% of the federal poverty line (FPL)	28.0%	27.8%	28.5%	29.5%	29.1%	32.5%*	28.1%
Household is between 185% and 300% of the FPL	41.5%	43.8%	36.5%***	39.4%	43.7%	8.7%***	41.5%

Number of children in the household	2.620	2.660	2.530**	2.536	2.521	2.646**	2.662
Number of adults in the household	2.103	2.090	2.133	2.138	2.158	1.995***	2.070
Mother is not working	41.8%	43.1%	39.0%**	46.6%	45.5%	54.3%***	40.6%
Mother is employed part time (fewer than 35 hrs/wk)	18.0%	18.3%	17.2%	18.1%	18.4%	15.7%*	18.2%
Mother is employed full time (35 hrs/wk or more)	40.2%	38.6%	43.8%***	35.3%	36.1%	30.0%***	41.2%
Child's birthweight (kg)	2.897	2.800	3.115***	2.893	2.892	2.904	2.883
Mother's pre-pregnancy weight (kg)	66.920	65.356	70.429***	66.980	66.641	69.400***	67.058
Parent has no high school degree	15.8%	15.0%	17.5%	16.1%	14.7%	26.5%***	15.7%
Parent has a high school degree, but no bachelor's degree[2]	62.9%	61.0%	67.2%***	62.7%	62.3%	65.7%*	62.5%
Parent has at least a bachelor's degree[2]	21.3%	24.0%	15.3%***	21.2%	23.1%	7.8%***	21.8%
Family lives in the Northeast	6.5%	6.0%	7.7%*	5.9%	6.0%	5.4%	7.2%
Family lives in the Midwest	19.7%	20.1%	18.8%	20.6%	20.3%	23.1%	18.7%
Family lives in the West	31.6%	30.7%	33.6%*	31.0%	30.9%	32.3%	30.6%
Family lives in the South	42.2%	43.2%	39.9%	42.4%	42.8%	39.2%*	43.6%
Family receives food stamps	32.2%	30.7%	35.4%**	30.1%	26.5%	55.9%***	33.2%
Number of observations	6,450	4,450	2,000	11,700	10,250	1,450	4,950

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.
$^{\dagger}p < .10$. $*p < .05$. $**p < .01$. $***p < .001$ 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 5. Predicting child BMI z-score, overweight, food security, and eating habits from food prices.

	Weight		**Food Security**		**Food Consumption**	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	BMI z score	**Overweight**	**Adult has low or very low food security**	**Adult has very low food security**	**# Times child ate healthy food in past 7 days**	**# Times child ate unhealthy food in past 7 days**
Standardized relative fruit and vegetable average annual price index	0.088**	0.014	-0.005	0.003	-0.359	0.744
	(0.030)	(0.011)	(0.007)	(0.003)	(0.561)	(0.392)
Standardized relative fast food average annual price index	-0.007	0.001	0.011	0.004	-0.517	0.655
	(0.036)	(0.012)	(0.007)	(0.003)	(0.494)	(0.388)
Standardized relative soft drink average annual price index	-0.006	-0.004	0.004	0.001	0.405	-0.367
	(0.032)	(0.012)	(0.008)	(0.004)	(0.456)	(0.321)
Family lives in urban area	0.026	0.004	0.010	0.009	-0.663	-0.661
	(0.052)	(0.018)	(0.009)	(0.006)	(0.909)	(0.712)
Family owns a car	0.021	0.003	-0.043*	-0.013	-2.182*	-0.568
	(0.088)	(0.033)	(0.017)	(0.009)	(1.076)	(0.951)
Multiple birth	0.154*	0.048*	0.019	0.011	2.046*	-0.366
	(0.064)	(0.022)	(0.019)	(0.010)	(1.018)	(1.027)
Child age (months)	-0.000	0.003	0.001	0.000	-0.058	0.00599
	(0.006)	(0.002)	(0.001)	(0.001)	(0.100)	(0.0613)
Male	0.085	0.022	0.005	-0.002	-1.263*	0.909
	(0.044)	(0.013)	(0.008)	(0.004)	(0.493)	(0.494)
Black, non-Hispanic	-0.040	0.019	-0.033**	-0.021**	1.044	0.287
	(0.074)	(0.027)	(0.012)	(0.008)	(0.954)	(0.878)
Hispanic	0.107	0.048*	0.018	-0.004	1.810	-0.0833
	(0.064)	(0.023)	(0.014)	(0.008)	(1.039)	(0.637)

Other Race, non-Hispanic	0.017 (0.076)	0.033 (0.026)	0.007 (0.011)	-0.001 (0.007)	-1.441 (1.076)	-1.018 (0.664)
White, non-Hispanic (omitted)						
Household is below the federal poverty line (FPL)	0.135* (0.053)	0.072*** (0.018)	0.187*** (0.012)	0.069*** (0.007)	3.961*** (0.891)	0.320 (0.781)
Household is between 100% and 185% of the FPL	0.069 (0.048)	0.028 (0.019)	0.101*** (0.008)	0.036*** (0.004)	1.892** (0.683)	0.307 (0.511)
Household is between 185% and 300% of the FPL (omitted)						
Number of children in the household	-0.077*** (0.015)	-0.030*** (0.005)	-0.007* (0.003)	-0.003 (0.002)	0.139 (0.241)	-0.333 (0.189)
Number of adults in the household	0.047* (0.018)	0.015 (0.008)	-0.021*** (0.005)	-0.009** (0.003)	0.188 (0.459)	0.770** (0.286)
Mother is not employed	-0.088 (0.051)	-0.042* (0.017)	0.003 (0.007)	-0.001 (0.004)	-0.747 (0.678)	-1.927*** (0.574)
Mother is employed part time	-0.063 (0.055)	-0.029 (0.018)	-0.006 (0.010)	-0.006 (0.005)	-1.431 (0.816)	-0.727 (0.730)
Mother is employed full time (omitted)						
Child's birthweight (kg)	0.335*** (0.027)	0.080*** (0.008)	0.004 (0.004)	0.004 (0.002)	0.689* (0.332)	0.548 (0.314)
Mother's pre-pregnancy weight (kg)	0.010*** (0.002)	0.004*** (0.000)	0.001*** (0.000)	0.000** (0.000)	-0.044 (0.023)	0.0132 (0.0155)
Parent has no high school degree[1]	0.269** (0.089)	0.089* (0.034)	0.039** (0.014)	0.001 (0.008)	1.906 (1.113)	3.946*** (1.066)

Parent has a high school degree, but no bachelor's degree[1]	0.206*** (0.057)	0.066** (0.020)	0.021** (0.007)	0.005 (0.004)	1.165 (0.782)	2.459*** (0.628)
Parent has at least a bachelor's degree (omitted)[1]						
Family lives in the Northeast	0.245*** (0.068)	0.073** (0.028)	0.016 (0.018)	-0.010 (0.007)	3.077 (1.659)	-3.090** (1.053)
Family lives in the Midwest	-0.021 (0.106)	0.021 (0.021)	0.028** (0.011)	0.014* (0.006)	1.212 (1.099)	0.170 (0.756)
Family lives in the West	0.102 (0.064)	0.026 (0.024)	0.018 (0.014)	0.003 (0.008)	0.526 (1.267)	0.237 (0.885)
Family lives in the South (omitted)						
Wave 1			0.051 (0.063)	0.012 (0.040)		
Wave 2	-0.206 (0.263)	0.080 (0.082)	0.012 (0.048)	0.002 (0.031)		
Wave 3	0.023 (0.090)	0.041 (0.027)	0.028 (0.016)	0.010 (0.010)	1.390 (1.256)	1.131 (0.841)
Wave 4 (omitted)						
Constant	-1.357** (0.445)	-0.435** (0.145)	-0.020 (0.079)	-0.013 (0.051)	47.662*** (6.961)	28.21*** (4.706)
Number of observations	6,450	6,450	11,700	11,700	4,950	4,950
R-squared	0.092	0.068	0.084	0.032	0.031	0.025

Note: Robust standard errors in parentheses. $^{\dagger}p < .10$. $*p < .05$. $**p < .01$. $***p < .001$.

[1] Determined as of Wave 1.

Table 6. Predicting child BMI z-score, overweight, food security, and eating habits from food prices: Within-child fixed effects models.

	Weight		**Food Security**		**Food Consumption**	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	BMI z score	**Overweight**	**Adult has low or very low food security**	**Adult has very low food security**	**# Times child ate healthy food in past 7 days**	**# Times child ate unhealthy food in past 7 days**
Standardized relative fruit and vegetable average annual price index	0.107**	0.010	0.001	0.007	-0.426	-0.473
	(0.041)	(0.014)	(0.006)	(0.004)	(0.999)	(0.803)
Standardized relative fast food average annual price index	0.027	0.059**	-0.003	-0.008	-1.668	0.864
	(0.049)	(0.017)	(0.008)	(0.005)	(1.202)	(0.966)
Standardized relative soft drink average annual price index	0.018	-0.025*	0.002	0.004	1.360	-0.011
	(0.036)	(0.012)	(0.006)	(0.004)	(0.860)	(0.693)
Constant	0.646	0.194	-0.316***	0.102	60.109***	28.250*
	(0.561)	(0.194)	(0.095)	(0.057)	(15.343)	(4.703)
Number of observations	6450	6450	11,700	11,700	4950	4950
R-squared	0.022	0.016	0.020	0.010	0.015	0.011

Note: Robust standard errors in parentheses. Child, maternal and household characteristics are controlled (not shown).
$^{\dagger}p < .10$. $*p < .05$. $**p < .01$. $***p < .001$.

Table 7. Predicting child BMI z-score, overweight, food security, and eating habits from food prices: Separating fresh and frozen or canned fruits and vegetables using ordinary least squares, linear probability, and within-child fixed effects models.

	Weight		**Food Security**		**Food Consumption**	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	BMI z score	**Overweight**	**Adult has low or very low food security**	**Adult has very low food security**	**# Times child ate healthy food in past 7 days**	**# Times child ate unhealthy food in past 7 days**
OLS and LPM models:						
Standardized relative fresh fruit and vegetable average annual price index	0.123**	0.025*	-0.007	0.002	0.217	0.730
	(0.038)	(0.013)	(0.006)	(0.003)	(0.675)	(0.502)
Standardized relative frozen or canned fruit and vegetable average annual price index	-0.017	-0.009	0.003	0.002	-0.667	0.173
	(0.028)	(0.010)	(0.007)	(0.004)	(0.483)	(0.295)
Standardized relative fast food average annual price index	0.002	0.003	0.010	0.004	-0.401	0.673
	(0.036)	(0.011)	(0.007)	(0.003)	(0.476)	(0.396)
Standardized relative soft drink average annual price index	-0.002	-0.002	0.003	0.001	0.429	-0.363
	(0.029)	(0.011)	(0.008)	(0.004)	(0.449)	(0.321)
Constant	-1.341**	-0.430**	-0.022	-0.013	47.782***	28.23***
	(0.447)	(0.146)	(0.079)	(0.051)	(6.938)	(4.703)
Number of observations	6450	6450	11,700	11,700	4950	4950
R-squared	0.093	0.068	0.084	0.032	0.031	0.025
Within-child fixed effects models:						
Standardized relative fresh fruit and vegetable average annual price index	0.157**	-.003	-0.004	0.005	0.649	-0.249
	(0.047)	(0.016)	(0.007)	(0.004)	(1.172)	(0.942)
Standardized relative frozen or	-0.031	0.016	0.009	0.003	-1.114	-0.320

canned fruit and vegetable average annual price index	(0.036)	(0.012)	(0.006)	(0.004)	(0.824)	(0.664)
Standardized relative fast food average annual price index	0.028 (0.049)	0.059** (0.017)	-0.004 (0.008)	-0.008 (0.005)	-1.421 (0.824)	0.887 (0.970)
Standardized relative soft drink average annual price index	0.026 (0.036)	-0.026* (0.012)	0.001 (0.006)	0.004 (0.004)	1.454 (0.863)	0.004 (0.696)
Constant	0.678 (0.561)	0.188 (0.194)	0.309** (0.096)	0.101 (0.057)	63.214*** (15.527)	28.750* (12.480)
R-squared	0.024	0.016	0.020	0.010	0.016	0.011

Note: Robust standard errors in parentheses. Child, maternal and household characteristics are controlled (not shown).
$^{\dagger}p < .10$. $*p < .05$. $**p < .01$. $***p < .001$.

Table 8. Predicting child BMI z-score, overweight, food security, and eating habits from food prices: Testing the moderating effects of food stamp receipt.

	Weight		**Food Security**		**Food Consumption**	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	BMI z score	**Overweight**	**Adult has low or very low food security**	**Adult has very low food security**	**# Times child ate healthy food in past 7 days**	**# Times child ate unhealthy food in past 7 days**
Standardized relative fruit and vegetable average annual price index	0.086**	0.009	0.004	0.004	-0.047	0.730
	(0.029)	(0.010)	(0.006)	(0.003)	(0.546)	(0.411)
Standardized relative fast food average annual price index	-0.028	-0.013	0.003	-0.000	-0.461	0.855
	(0.035)	(0.013)	(0.007)	(0.002)	(0.597)	(0.444)
Standardized relative soft drink average annual price index	0.022	0.008	0.002	0.000	0.470	-0.751*
	(0.030)	(0.013)	(0.007)	(0.003)	(0.518)	(0.322)
Family receives food stamps	0.045	0.007	0.072***	0.041***	0.244	0.0188
	(0.045)	(0.021)	(0.013)	(0.008)	(0.958)	(0.631)
Standardized relative fruit and vegetable average annual price index X Food stamp receipt	0.004	0.014	-0.028*	-0.003	-0.860	0.0505
	(0.051)	(0.016)	(0.011)	(0.008)	(0.702)	(0.655)
Standardized relative fast food average annual price index X Food stamp receipt	0.050	0.038*	0.018	0.011	-0.224	-0.463
	(0.059)	(0.018)	(0.012)	(0.008)	(0.777)	(0.851)
Standardized relative soft drink average annual price index X Food stamp receipt	-0.084	-0.032	0.001	-0.001	-0.323	1.098
	(0.050)	(0.019)	(0.010)	(0.008)	(0.909)	(0.743)
Number of observations	6,450	6,450	11,700	11,700	4,950	4,950
R-squared	0.093	0.069	0.091	0.039	0.032	0.026

Note: Robust standard errors in parentheses. Child, maternal and household characteristics are controlled (not shown).
$^{\dagger}p < .10$. $*p < .05$. $**p < .01$. $***p < .001$.