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Regional price differences and food consumption frequency among elementary school children

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SUMMARY

Objective—Food prices may affect diet and weight gain among youth and lead to geographic disparities in obesity. This paper examines the association between regional prices and consumption frequency of fruit/vegetables and snack items among elementary school children in the USA.

Study design—Observational study using individual-level survey data of fifth-grade children (average age 11 years) and regional food prices based on store visits in 2004.

Methods—Dependent variables are self-reported consumption frequency in fifth grade; primary explanatory variables are metropolitan area food prices relative to cost of living. Multivariate regression analysis.

Results—Price variation across metropolitan areas exists, and lower real prices for vegetables and fruits predict significantly higher intake frequency. Higher dairy prices predict lower frequency of milk consumption, while higher meat prices predict increased milk consumption. Similar price effects were not found for fast food or soft drink consumption.

Discussion—The geographic variation in food prices across the USA is sufficiently large to affect dietary patterns among youth for fruit, vegetables and milk. This suggests that either the price variation is too small to affect children's consumption frequency of fast food or soft drinks, or that the consumption of these foods is less price sensitive.

Keywords

Obesity; Diet; Food prices; Children; Multilevel models; Geographic variation

Introduction

Childhood overweight has increased rapidly over the past two decades,[1] and it is widely thought that community food environments play a role. Numerous studies have provided evidence about geographic variations in food environments and their relationship to sociodemographics. Low-income, minority and rural neighbourhoods tend to have less

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access to supermarkets, and low-income urban neighbourhoods have more small stores.[2] Better access to supermarkets and other retail stores that provide access to healthful food products is associated with better diets for adults.[2–5]

Fewer studies can link the community food environment to youth diet and obesity. Two different systematic reviews of food environments and obesity published in 2009 found a total of five papers for youth and 11 papers for adults.[6,7] Four of the five youth studies considered prices, and all of them found a relationship between prices and obesity. Two of the five studies considered food outlet density but did not find a significant relationship. One additional study not included in the reviews reported that youth obesity rates are lower in areas with more chain supermarket stores.[8] However, none of those studies could investigate whether prices or outlet types affected diets in a way that could relate to obesity.

This study examined whether regional price differences for different types of food are associated with consumption patterns among fifth-grade students, and whether the effects differ by race/ethnicity, poverty status or for children at risk for becoming overweight. The data analysed are from the Early Childhood Longitudinal Study - Kindergarten Class (ECLS-K) merged with regional data on food prices from the Council for Community and Economic Research (C2ER), formerly the American Chambers of Commerce Researchers Association.

In previous price studies, higher fruit and vegetable prices have been associated with increased obesity rates among youth, including prospectively in a longitudinal study, even though those studies did not have information about diet.[9–11] Research on the link from prices to purchases to diet to obesity is largely split between two unrelated fields. On one side are economic price studies; most have used aggregate time series data to relate prices and purchases, and few studies consider price effects for particular subgroups.[12] On the other side are studies that relate dietary patterns to obesity. For youth, cross-sectional analyses from NHANES suggest that higher intakes of dairy, grains and total fruit and vegetables are associated with lower rates of central obesity.[13] For adults, higher fruit consumption is associated with lower body mass index (BMI), but there are many other confounding factors.[14] A potential physiological pathway is that fruit and vegetable consumption lowers the energy density of diets, and less energy dense diets are associated with lower total energy intake and reduced BMI.[15,16] Lower energy density diets can be more costly, which has been suggested as a reason for differential obesity rates across income groups among women and children.[17,18] The present study considered this latter possibility by testing whether diets of children in lower-income families are more sensitive to regional price differences.

Methods

The individual-level data come from the ECLS-K. The ECLS-K surveyed a nationally representative cohort of kindergarten children from over 1000 schools in the USA during the 1998–99 school year. The sample was selected using a multistage cluster sampling design, where schools were selected initially and then children within schools were selected. The ECLS-K is a panel dataset and followed the students over time. In fifth grade, a food frequency questionnaire was added to the survey for the first time, and the data from this wave were analysed in this study. The ECLS-K collected information on children’s anthropometric outcomes, as well as detailed data on parental background characteristics, sociodemographics and lifestyles.

The major advantage over other national surveys, where geographic information tends to be limited to the state level, is access to more detailed geographic identifiers, including the census tract and zip (postal) code for the child's school and residence.

To measure children's food consumption, in the spring of 2004, the ECLS-K assessors administered the food consumption questionnaire (FCQ, a questionnaire used to determine the types of food the children can buy at school and the food they have eaten in the past week) to fifth-grade children (average age 11 years). The FCQ for children consisted of 19 questions in two sets. The first set of questions was about foods available at school, and the second set of questions was about the frequency of consumption of specific foods in the past 7 days, including specific vegetables, fruit, milk, sweetened beverages (e.g. soft drinks) and fast food. They were asked to include food they ate at home, at school, at restaurants or anywhere else. Most questions came from two surveys by the Center for Disease Control/ Division of Adolescent and School Health Surveys: the Youth Risk Behavior Surveillance Survey and the School Health Programs and Policies Survey. Assessors read each question of the FCQ to the child, along with the response categories, and the child circled his or her answer. The child was asked to tell the assessor what he or she circled so the assessor could enter the answer into the computer. To combine questions, for example, to obtain a total number of vegetable servings (e.g. adding carrots and salad), qualitative response categories were translated into continuous measures using midpoints; for example, '1–3 times during the past 7 days' was coded as '2 per week'.

The source of food price data was the cost-of-living-index (COLI) data collected by C2ER. The COLI data have been published quarterly since 1968 and are the premier source of data on cost-of-living differentials in approximately 311 metropolitan areas in the USA. They do not distinguish possible price variations across neighbourhoods within a city, and the smallest geographic unit available is either a city or metropolitan area.

The COLI food price information consists of a grocery price list containing 63 items, 16 for specific foods at home, which are grouped into four categories in this study: (1) meats (T-bone steak, minced beef, sausage, tuna, frying chicken), (2) fruits and vegetables (potatoes, bananas, lettuce, canned peas, canned tomatoes, canned peaches, frozen corn), (3) dairy products (½ gallon whole milk, 12 eggs, margarine, parmesan cheese), and (4) soft drinks (2-l bottle of Coca-Cola). A fifth index has been created for food away from home, based on three items collected in the COLI data: the average price of a McDonald's Quarter-Pounder with cheese; the average price of an 11–12-inch thin crust regular cheese pizza (no extra cheese) at Pizza Hut and/or Pizza Inn; and the average of the lowest price of a fried chicken drumstick and thigh at Kentucky Fried Chicken and/or Church's Fried Chicken. Price indices for these five food groups were computed as follows. First, the average annual prices were computed from the quarterly data for the survey year for each individual food item. Next, the weighted average of prices of items in the food group were computed according to the item's share in the consumer basket (for fast food, the three items were averaged; for soft drinks, there is only one item). The weighted price was then divided by the overall COLI for the area to get a measure of relative food prices in real terms. One additional step was undertaken, namely normalizing each price variable to have a standard deviation of 1 in the sample. This does not change anything substantially, but improves the interpretation of coefficients in linear models and reduces numerical problems in non-linear model. In a linear model, the regression coefficients now correspond to an increase of a 1 standard deviation in real price.

The COLI in the data averages 110. Compared with this average, Rhode Island or Chicago would be approximately 20% more expensive, while the Midland, TX metropolitan area would be 20% cheaper.

The main explanatory variables are the five relative food price indices described above. These price indices were merged with individual-level data from the ECLS-K by matching prices of a COLI area whose centroid is closest to the centroid of the child's residential tract. Observations where the closest match would be 40+ miles away were excluded. The median and mean match distances in the sample were 9.9 and 12.4 miles, respectively. A square with a side length of 10 miles is approximately twice the mean area of a US Census tract (55 square miles, although urban tracts are much smaller). For comparison, the median county size in the USA is 622 square miles and the average is 1200 square miles. The final sample size is 4896. While there were 7838 children with data on the food frequency questionnaire, 2306 lived more than 40 miles away from the centre of an area for which prices were available and were therefore excluded. The remaining 5532 children attend 1361 different schools, located in 39 states. However, another 636 observations were excluded due to missing parent/family data (primarily because the parent interview was not completed), resulting in the final sample size of 4896 in the tables.

Dependent and explanatory variables

The dependent variables were the number of times per week that the child consumes fruit and vegetables, milk, soft drinks and fast food. The primary explanatory variables were price indices for meat, fruit and vegetables, dairy and fast food, standardized to have a standard deviation of 1. Individual characteristics were controlled for in all cases, including age in months, real family income (income adjusted by the cost of living in the area), gender (male as the reference group), mother's educational achievement (four categories, high school degree as the reference group), race/ethnicity (non-Hispanic White as the reference group). The measure of real income was total family income, not per-capita income, divided by cost of living in an area. Additional dummy variables were included for low- and high-income groups as income effects are not likely to be the same throughout the whole range of incomes. Typical hours per day spent watching television, days per week of vigorous physical activity, participation in reduced/free school lunch, school location (urban centre, suburban fringe or town/rural), indicator of private school, and two measures of parent–child interaction (how often parents help with homework or talk about friends) were also included in all models. These are measures that have been associated with obesity, and were therefore considered as potential cofounders in this analysis (although *ex post* it turned out that some were not related to consumption frequency).

Statistical analyses

The dependent variables are counts, i.e. non-negative integers. Preliminary functional form comparisons were conducted for two dependent variables (fruit/vegetable and fast food consumption), comparing Poisson, negative binomial, zero-inflated negative binomial, other generalized linear models and OLS. The study also tested for mis-specification using link tests. Based on these tests, the negative binomial regression model emerged as the most appropriate statistical model.

Marginal effects are reported instead of regression coefficients. For prices, the numbers in Table 2 can be interpreted as the change in frequency of consumption with a 1 standard deviation increase in real price. Own-price effects are changes in consumption frequency associated with an increase in price for those foods (e.g. the effect of fruit and vegetable prices on fruit/vegetable consumption); cross-price effects are the effect of other prices. For indicator variables, the marginal effects should be interpreted as a change from 0 to 1 (e.g. the difference between boys and girls).

The survey design sampled children clustered in schools within geographic regions, and adjustment was made for correlations across observations within the same school using nonparametric clustering adjustment. Point estimates are unbiased in a correctly specified model and provide the best estimate of an effect size, but because the sample sizes are small, even substantively large effects cannot be detected reliably. All models were estimated using STATA Version 11.0 (STATA, College Station, TX, USA).

Results

Table 1 provides the basic descriptive statistics for the analytic sample. On average, children reported eating fruit/vegetables 20 times in the past week and fast food approximately three times; they reported drinking 11 glasses of milk and having sodas or other sugared beverages (including sports drinks) six times per week. On average, children watched more than 1 h of television per day and took part in vigorous physical activity every other day. The sample was evenly split between boys and girls, but had slightly higher average income and education level than the US average.

The multivariate analysis initially focused on price indices, and tests were undertaken to determine whether there were interactions between the price indices and race/ethnicity and low income. However, these coefficients were not significant as a set and the final model did not include interactions. Table 2 shows the full estimation results for each of the four dependent variables (fruit and vegetables, milk, fast food and soft drinks).

The first row in Table 2 displays the own-price effects. A 1 standard deviation increase in the price index for fruit/vegetables is associated with a 0.82 times per week reduction in the frequency of consumption of fruit/vegetables. Since children report eating fruit/vegetables approximately 20 times per week (Table 1), this is a 4% reduction. Similarly, a 1 standard deviation increase in dairy prices predicts a reduction in milk consumption of two-thirds of a glass per week. As the average is approximately 11 glasses per week, this corresponds to a 6% reduction. Only the own-price effects for fruit/vegetables and dairy are highly significant and robust to changes in the statistical model (e.g. omitting other prices or omitting other individual variables). The effects on fast food and sugar-sweetened beverages are small and generally insignificant. The absence of a price effect for sugar-sweetened beverages may indicate no consumer sensitivity to small price variations. In the fast food column, Table 2 shows a significant coefficient for fast food and meat prices, but this is not a robust result and disappears in other specifications (it may be an artefact of the high collinearity between fast food and meat prices in the data). In the economics literature, the price response is often expressed as an elasticity, which is the ratio of a percentage change in demand to a percentage change in price. Translating the absolute changes in Table 2 to elasticities at the mean results in elasticities of 0.26 for vegetables/fruits and 0.47 for milk.

The second set of results in Table 2 are cross-price effects. If foods are substitutes, cross-price effects are expected to be positive; foods that are complements have negative effects. Beyond substitution in energy, there appears to be only one clear hypothesis, namely milk and meat prices. To the extent that consumers consider these key sources of protein, higher meat prices should increase milk consumption (and decrease meat consumption, but this study has no measure of meat consumption, unless fast food is a partial proxy of meat consumption in food away from home). Higher meat prices are predictive of a higher frequency of milk consumption.

Individual characteristics have the expected sign. Among the highly significant findings ($P<0.01$), girls drink milk less often, eat fast food less often and drink sugar-sweetened beverages less often than boys (they eat more fruit/vegetables according to the point estimates, significant at $P<0.05$); Hispanic children eat fruit and vegetables more frequently; Hispanic, Black and Asian children drink milk less often; Black and Hispanic children eat fast food more often; children whose mothers have a college degree eat fast food and drink sugar-sweetened beverages less often; and watching television is associated with more frequent fast food and soft drink consumption.

Sensitivity tests were conducted by estimating the model limited to specific subgroups to see whether results differ by race/ethnicity, poverty status or for children at risk for becoming overweight. However, with smaller sample sizes, all estimates become less precise, and this study did not have the precision to detect meaningful differences between groups.

Discussion

This paper describes the relationship between regional/metropolitan prices for specific food groups and consumption among elementary school students. Relative food prices were found to influence consumption patterns, particularly higher prices for fruit/vegetables predict lower frequency of fruit/vegetable consumption and higher dairy prices predict lower frequency of milk consumption.

Demand for food at the market level is not very responsive to price changes,[12] and that is true in this study that focuses on consumption frequency among elementary school students. For example, a 1 standard deviation decrease in real fruit/vegetable prices predicts a 4% increase in fruit/vegetable consumption frequency, and a 1 standard deviation decrease in dairy prices is associated with a 6% increase in milk consumption. The price effects for fast food and soft drink consumption were even smaller and inconsistently estimated. Translating the absolute changes in Table 2 to elasticities at the mean, a presentation sometimes preferred by economists, results in elasticities of 0.26 for fruit/vegetables and 0.47 for milk. These ratios are smaller than 1, which means that demand is inelastic, in agreement with a review of economic price studies.[12] In fact, the estimate for milk (0.47) is very similar to the average across 26 studies (0.59), while the estimate for fruit/vegetables (0.26) is smaller than the average vegetable elasticity (0.58). The main difference is that this study found no clear price effects for sugar-sweetened beverages and fast food. This could indicate that children's consumption is less price sensitive than overall market demand for sugar-sweetened beverages and fast food, but it could also be due to the limitations of the study.

Previous results found that food prices predict changes in BMI during elementary school.[10,11] Between kindergarten and fifth grade, a 1 standard deviation lower real price for fruit and vegetables predicted 0.2 less gain in BMI over 6 years. Can this new analysis relate those findings to a more likely causal mechanism? The new findings about fruit/vegetable and milk prices and consumption, **combined with** National Health and Nutrition Examination Survey (NHANES) results about obesity and fruit/vegetable and milk consumption in NHANES (at least for adolescents), qualitatively fit the picture.[13] Conceptually, there is still a gap in that higher consumption of any food does not prevent excess weight gain; it must be a reduction in other food consumption or increases in physical activity.

However, the relevant question is whether the magnitudes of price variations can alter consumption sufficiently to affect weight gain. This is much more difficult to assess. To the authors, the estimated magnitudes seem fairly small and it is unclear whether the changes in consumption that could be attributed to local price variation are substantively important for weight gain/prevention. The key gap in research to understand this issue is related to substitution between foods, and future research is needed to quantify those price effects.

Strengths and limitations

To the authors' knowledge, this is the first study to relate regional price levels to children's diet; a central question in the ongoing obesity debate. Obviously, there are a number of limitations that make this a first rather than a definite study. It is a cross-sectional observational design, a particularly weak design for causal inference. Regarding the dependent variable, only crude food frequency measures were used, without the detail on food items or quantity that would be collected in more extensive dietary interviews (e.g. 24-h dietary recalls). Regarding the main explanatory variable, this study relies on data collected for a different purpose by C2ER, namely for COLI. These are the best data available at this point, and there is no other data source with a similarly comprehensive regional coverage for the USA, but there are several limitations. The first that cannot be circumvented without very costly new primary data collection is that prices are averaged over larger geographic areas, and no data are available for smaller neighbourhood definitions within a city. Another limitation is non-coverage of some areas, especially less urbanized areas. Distances over 40 miles were excluded, and this is the main reason for the loss in sample size. Fast food prices adjusted for cost of living are highly correlated with meat (rho=0.79) and beverage prices (rho=0.79), and such multicollinearity reduces the quality of estimates. In sensitivity analyses, the vegetable/fruit and dairy results were robust, but no consistent price effects were found for fast food or sugar-sweetened beverages. Small sample sizes and multicollinearity also prevent comment on possible subgroup differences.

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Table 1

Descriptive statistics for sample (*n*=4896).

Variable and definition	Mean	SD
Continuous individual variables		
Age in months	134.3	4.6
Days/week child gets exercise that causes rapid breathing, perspiration and a rapid heartbeat for 20 continuous minutes or more	3.8	1.8
Hours/week child watches television	7.3	3.7
How often parents help with homework	4.2	2.9
How often parents talk with child about friends	5.3	0.9
Categorical variables	Percent	
Girls	51.1	
White	64.5	
Black	7.7	
Hispanic	18.2	
Asian	5.6	
Annual family income <$25,000	14.9	
≥25,000 and <75,000	46.0	
≥75,000	39.1	
Receives free/reduced lunch	25.6	
Mother's education: less than high school diploma	7.1	
High school diploma or equivalent	21.3	
Some college	35.9	
Bachelor's degree or higher	35.7	
Attends private school	20.4	
Frequency of food/beverage consumption:		
Number of times in past 7 days:		
- ate fruit or vegetables	19.9	17.9
- ate fast food	2.7	4.2
- drank milk (glasses)	11.1	9.4
- drank sugar-sweetened beverages	5.9	7.2

Note: unweighted statistics for estimation sample.

SD, standard deviation.

Table 2

Marginal effects results.

	Fruit and vegetables	Milk	Fast food	Sugar-sweetened beverages
Own-price effects	**−0.82** ** **(0.29)**	**−0.67** ** **(0.20)**	**0.21** ** **(0.08)**	0.10 (0.17)
Cross-price effects				
- Fruit/vegetables	-	**−1.07** ** **(0.16)**	0.13 * (0.06)	0.13 (0.15)
-Dairy	−0.08 (0.38)	–	0.10 (0.07)	0.05 (0.15)
-Meat	0.78 (0.42)	**1.20** ** **(0.21)**	**−0.24** ** **(0.08)**	−0.43 * (0.17)
-Fast food	−0.88 * (0.39)	−0.12 (0.22)	-	0.29 (0.15)
-Sugar-sweetened beverages	−0.07 (0.40)	0.30 (0.25)	−0.14 (0.08)	-
Individual characteristics				
Age in months	0.02 (0.05)	0.003 (0.02)	−0.01 (0.01)	0.001 (0.02)
Family income (continuous)	0.01 (0.007)	−0.000 (0.003)	−0.000 (0.001)	−0.005 (0.003)
Income <25,000 indicator	**2.87** ** **(1.07)**	0.051 (0.52)	0.27 (0.20)	0.40 (0.36)
Income >75,000 indicator	−0.52 (0.77)	0.72 (0.41)	−0.09 (0.14)	0.11 (0.31)
Girl	1.18 * (0.52)	**−1.04** ** **(0.27)**	**−0.40** ** **(0.10)**	**−0.89** ** **(0.19)**
Black	1.81 (1.12)	**−3.18** ** **(0.52)**	**1.46** ** **(0.30)**	−0.19 (0.41)
Hispanic	**2.30** ** **(0.84)**	**−1.09** ** **(0.41)**	**0.60** ** **(0.18)**	0.13 (0.31)
Asian	2.99 * (1.19)	**−2.13** ** **(0.51)**	−0.25 (0.22)	**−2.09** ** **(0.31)**
Mother's education				
-Less than high school	1.23 (1.25)	−0.12 (0.61)	0.40 (0.24)	−0.18 (0.42)
-Some college	0.20 (0.72)	−0.45 (0.38)	−0.21 (0.13)	−0.54 * (0.25)
-Bachelor's degree or higher	1.06 (0.79)	0.82 * (0.40)	**−0.78** ** **(0.14)**	**−1.58** ** **(0.28)**
Days/week child takes part in vigorous exercise	0.32 * (0.15)	−0.01 (0.08)	−0.02 (0.03)	0.13 * (0.05)
Participates in free/reduced school lunch programme	1.17 (0.83)	−0.01 (0.44)	0.34 * (0.17)	−0.13 (0.31)
Hours/week child watches television	**−0.20** ** **(0.07)**	−0.08 (0.04)	**0.04** ** **(0.01)**	**0.16** ** **(0.02)**
Homework help	0.21 * (0.08)	0.003 (0.05)	**0.08** ** **(0.02)**	0.03 (0.03)
Talk about friends	0.64 (0.28)	0.12 (0.16)	0.10 (0.06)	0.17 (0.12)
Private school	0.53 (0.64)	−.050 (0.41)	−0.06 (0.15)	−0.31 (0.38)
Urban centre	0.01 (0.78)	−0.28 (0.46)	0.35 (0.17)	−0.11 (0.32)
Suburban	−0.99 (0.74)	−0.77 (0.43)	0.17 (0.15)	−0.20 (0.29)

Note: individually significant coefficients at $P<0.01$ in bold.

* Significant at $P<0.05$.

** Significant at $P<0.01$.

Boy, mother without high school diploma, non-Hispanic White and other, town/rural are reference groups. $n=4896$.