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Food prices and weight gain during elementary school: 5-year update

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Introduction

Childhood overweight has increased rapidly over the last two decades.[1,2] Food supply characteristics, such as relative prices of different types of food, are thought to play an important role in what children eat. The energy density of a diet has been implicated as a cause of obesity and energy-dense foods are cheaper per calorie, which has been suggested as a partial explanation for why the highest rates of obesity continue to be observed among groups of limited economic means.[3,4]

It is a quickly emerging research area. Half of all articles found with a MEDLINE search for 'food prices' and 'obesity' were published in the last 2 years, although none of those articles provide new empirical data that directly link prices and weight. More data are needed urgently to inform the debate.

Previously, we reported that children living in areas with higher real fruit and vegetable prices (i.e. prices relative to cost of living) showed a greater increase in body mass index (BMI; weight in kilogrammes divided by height in metres squared) between kindergarten and third grade compared with children living in areas with lower prices.[5] Since then, another round of data has been collected during these children's last year of elementary school (fifth grade). This short communication provides an update.

The data are from the Early Childhood Longitudinal Study - Kindergarten Class (ECLS-K), a survey of a nationally representative cohort of children starting school in the 1998–99 school year from over 1000 schools in the USA, merged with metropolitan-level data on food prices from the Council for Community and Economic Research (formerly known as ACCRA). In each wave, the ECLS-K conducted interviews with the children and their parents, and measured the children's height and weight. ACCRA data are quarterly-published data on cost-of-living differentials in approximately 311 metropolitan areas in the USA. Food price indices were calculated, adjusted for the cost of living, to get a measure of relative food prices in real terms. Price data are from the fourth quarter in 1999, which corresponds to the autumn of kindergarten. Details on the methods have been published previously.[5] Identical models were used with the new data.

The main dependent variable was the change in BMI between the spring of kindergarten and the spring of fifth grade, and the main explanatory variable was the price index for fruit/

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vegetables. We controlled for individual characteristics in all cases, including baseline BMI (spring of kindergarten), birth weight, real family income (adjusted by the cost of living in the area), gender, mother's educational achievement (four categories) and race/ethnicity. To take into account the likely non-linear effects of income, linear splines were used with knots at the 25th, 50th and 75th percentiles of real income. Thus, the coefficients in Table 1 correspond to the effect of an additional $1000 in income (allowed to change across quartiles). In addition, parent-reported typical hours per day spent watching television, parent-reported days per week of physical activity, hours per week of physical education in school, and number of activities in which a parent participates with the child (reading, story telling) at baseline (spring of kindergarten) are included. All models were estimated using STATA 9.0.[6] The survey design sampled children clustered in schools within geographic regions, and hierarchical (multi-level) models with school random effects were used to adjust for correlations across observations within the same area for mean (i.e. least squares) regression.

The median BMI for boys in the ECLS-K increased by 3.2 units from 16.0 to 19.2, and for girls increased by 3.4 units from 15.8 to 19.2 from kindergarten to fifth grade. The average BMI was even higher: 20.5 for boys and 20.3 for girls in fifth grade. This increase is far greater than can be expected according to growth charts published by the Centers for Disease Control (which reflect populations prior to the obesity epidemic).[7] According to the growth charts, the median (50th percentile) BMI should increase from 15.4 to 17.3 (1.9 units) for boys and from 15.2 to 17.5 (2.3 units) for girls from kindergarten to fifth grade. Thus, children experience a remarkable increase in excess BMI during elementary school. In fact, by fifth grade, the median BMI in the data corresponds to the 75th percentile in the growth charts.

Table 1 shows the multivariate results, now subset to children with complete data in all years. There is substantial attrition; the original 3-year results were based on 6918 children whereas the 5-year results are based on 4557 children. Attrition was unrelated to individual characteristics except for race, and was significantly higher for Blacks [odds ratio (OR) 1.2, $P = 0.03$] and significantly lower for Hispanics (OR 0.75, $P = 0.01$) than for non-Hispanic Whites. In order to avoid potential confounding through attrition biases, the first set of results in Table 1 repeats the original 3-year results for the subset data (rather than showing the original results), and the second set shows the new 5-year results. The only substantive change in the 3-year results using the subsample compared with the original publication is that the coefficient for Hispanics becomes significant.

Table 1 shows that the price index for fruit and vegetables is highly significant, and implies that in areas where fruit and vegetable prices are one standard deviation higher, the BMI of children increases by an additional 0.11 units by third grade and 0.20 units by fifth grade compared with lower price areas. Thus, there is a consistent long-term effect which shows that areas with higher real fruit and vegetable prices experience greater increases in BMI. The 5-year results also show an increase in sociodemographic disparities. Race/ethnicity and family income were not associated with weight gain during the first year of school, although Black and Hispanic children gained significantly more weight until third grade.

The 5-year results show a highly significant effect of mother's education and family income. The coefficients are the gradients associated with an increase of $1000, not differences between groups. For example, the coefficient of −0.016 in the 50–75th income percentile (which ranges from $40,000 to $65,000) means that a child in a family with an income of $60,000 would be expected to have a BMI that is 0.32 (20*0.016) units lower than an otherwise similar child in a family with an income of $40,000. The coefficient is only

significant and negative (higher income – lower increase in BMI) in the upper half; thus, higher income only has a protective effect above median income.

The preliminary analysis in this short communication has several limitations that need to be addressed in future research. This analysis does not establish a causal pathway because it only associates food prices and changes in BMI. However, the fifth grade survey has added a food consumption questionnaire and, at least crosssectionally, it will be possible to study the link between prices and consumption. Methodologically, the analysis can also be strengthened by modelling individual growth curves and studying price changes over time. An alternative dependent variable might be BMI percentile rather than change in BMI, and that would avoid possible problems caused by the non-linear relationship between average/expected BMI and age. We measures for food prices are at the metropolitan-area level, and no measures for neighbourhood differences are available. This is a more difficult problem to overcome, although efforts to collect such data are underway and may become useful for future surveys.

Is it plausible that fruit and vegetable prices can affect consumption sufficiently to affect weight gain? Low-income families in the USA spend much less on fruit and vegetables, and in a given week are twice as likely as higher income families not to buy any fruit or vegetables (19% vs 10%).[8] However, small changes in income do not appear to affect purchases and there are conflicting United States Department of Agriculture estimates on how strongly individuals respond to prices. However, school meals are an important source of food for children, and school food managers are likely to be very responsive to price changes because federal reimbursement rates for school meals are fixed.

Recent work suggests links between the incidence of obesity and areas with limited access to stores that sell a variety of fresh fruit and vegetables.[9,10] That area of work focused on the relative presence or absence of groceries. The present research broadens the perspective and suggests that prices may be as important as physical availability.

In summary, this study confirms initial evidence for an association between weight gain among elementary school children and relative food prices in their environment. In particular, lower real prices for fruit and vegetables relative to other goods and services (including other foods, housing) may slow excess weight gain.

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Table 1

Main regression results

	BMI change Kindergarten–third grade			BMI change Kindergarten–fifth grade		
Regressor variable	**Coefficient**	**SE**	***P*-value**	**Coefficient**	**SE**	***P*-value**
Food price indices						
Fruit and vegetables	**0.094**	**0.031**	**0.002**	**0.182**	**0.045**	**<0.001**
Meats	0.007	0.030	0.825	0.076	0.043	0.078
Individual characteristics						
BMI (spring of kindergarten)	**0.334**	**0.012**	**<0.001**	**0.483**	**0.018**	**<0.001**
Age in months at assessment (spring of kindergarten)	**0.021**	**0.006**	**0.001**	0.003	0.010	0.749
Girl	**0.174**	**0.054**	**0.001**	0.146	0.077	0.058
Real family income in $1000 (slope)						
Below 25th percentile	−0.002	0.008	0.790	−0.005	0.011	0.686
25–50th percentile	0.011	0.006	0.067	**0.019**	**0.009**	**0.034**
50–75th percentile	−0.005	0.004	0.218	**−0.016**	**0.005**	**0.002**
Above 75th percentile	−0.001	0.0007	0.065	**−0.002**	**0.001**	**0.05**
Black	**0.195**	**0.096**	**0.042**	**0.428**	**0.139**	**0.002**
Hispanic	**0.232**	**0.081**	**0.004**	**0.333**	**0.117**	**0.004**
Asian	0.040	0.119	0.734	0.011	0.172	0.947
Other	−0.089	0.140	0.523	0.141	0.202	0.486
Mother’s education						
High school diploma or equivalent	−0.111	0.099	0.260	**−0.354**	**0.143**	**0.013**
Some college	−0.131	0.107	0.221	**−0.497**	**0.154**	**0.001**
Bachelor’s degree or higher	**−0.288**	**0.113**	**0.011**	**−0.709**	**0.162**	**<0.001**
Days/week child gets exercise that causes rapid breathing, perspiration and a rapid heartbeat for 20 continuous minutes or more (spring of kindergarten)	0.010	0.012	0.397	0.010	0.17	0.569
Hours/day child watches television (spring of kindergarten)	**0.078**	**0.025**	**0.002**	**0.108**	**0.036**	**0.003**
Hours/week of physical education instruction in school (spring of kindergarten)	0.027	0.034	0.429	−0.008	0.049	0.871
No. of activities (up to nine) in which a parent participates with the child (autumn of kindergarten)	0.010	0.024	0.668	0.017	0.034	0.615
Birth weight (pounds)	−0.039	0.021	0.063	−0.041	0.030	0.177

	BMI change Kindergarten–third grade			BMI change Kindergarten–fifth grade		
Regressor variable	**Coefficient**	**SE**	***P*-value**	**Coefficient**	**SE**	***P*-value**
Variance decomposition						
Sigma U	0.189			0.305		
Sigma E	10.744			20.52		
Rho (fraction of variance due to u)	0.012			0.014		
Number of observations	4557			4557		

BMI, body mass index; SE, standard error.

Note: Individually significant coefficients at $P < 0.05$ in bold. Two-level hierarchical model with individual- and school-level random effects. White and mother without high school diploma are reference groups.