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Competitive Food Sales in Schools and Childhood Obesity: A Longitudinal Study

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Abstract

The vast majority of American middle schools and high schools sell what is known as "competitive foods", such as soft drinks, candy bars, and chips, to children. The relationship between consumption of sugar-sweetened drinks and snacks and childhood obesity is well established but it remains unknown whether competitive food sales in schools are related to unhealthy weight gain among children. We examined this association using data from the Early Childhood Longitudinal Study Kindergarten Cohort. Employing fixed effects models and a natural experimental approach, we found that children's weight gain between 5th and 8th grades was not associated with the introduction or the duration of exposure to competitive food sales in middle school. Also, the relationship between competitive foods and weight gain did not vary significantly by gender, race/ethnicity, or family SES, and remained weak and insignificant across several alternative model specifications. One possible explanation is that children's food preferences and dietary patterns are firmly established before adolescence. Also, middle school environments may dampen the effects of competitive food sales because they so highly structure children's time and eating opportunities.

Introduction

Schools are often blamed for the production and perpetuation of widespread social problems and inequalities. Yet growing evidence suggests that we may be blaming schools for problems that originate in children's homes and neighborhoods (Downey, von Hippel, and Hughes 2008; Downey, von Hippel, and Broh 2004), including the problem of childhood obesity (von Hippel et al. 2007). Here, we focus on the influence of "competitive foods" on children's weight. Competitive foods are sold in competition with the National School Lunch and National School Breakfast Programs and include items such as soft drinks, candy bars, potato chips, cookies and doughnuts. These foods are often sold in vending machines or snack bars and are not required to meet the nutrition guidelines for school meals established by the U.S.D.A. (Larson and Story 2010).

Over the past decade, pressure has been placed on schools to reduce or eliminate vending machines and the sale of junk food to children (Committee on School Health 2004; Price, Murnan and Moore 2006; Sothern 2004), and in 2006, the American Beverage Association pledged to stop selling sugar-sweetened soda in public schools. However it remains unclear whether this focus on schools will reduce the prevalence of child obesity. Children's environments at home and in their communities may provide so many opportunities to eat unhealthy foods that competitive food sales in schools have little influence on children's weight. And, children may snack less at school than at home because schools structure children's time and activities, including meals. Although prior research has found associations between competitive food sales in schools and children's diet and weight, these

studies are inconclusive due to reliance on small samples and cross-sectional data, and limited attention to group variations in the effects of competitive food sales.

We contribute to the literature in two key ways. First, we make several methodological innovations in an effort to better approximate the causal effects of competitive food sales. At least two studies have used instrumental variable methods with cross-sectional data to approximate the effects of competitive foods on children's weight status (Anderson and Butcher 2006; Datar and Nicosia 2009). We build on these efforts by using longitudinal data to estimate the association between the introduction of competitive food sales in children's schools and weight gain from fifth grade to eighth grade, and we exploit variation in the timing of the transition from elementary to middle school to estimate exposure to competitive foods in middle school environments. Second, to gain a more complete assessment of the effects of competitive foods, we assess whether the estimated associations of competitive foods with weight gain vary significantly by gender, race/ethnicity, and family socioeconomic status.

Background

Obesity and Competitive Food Sales in Schools

The percentage of overweight and obese children in the United States quadrupled during the past 25 years (National Center for Health Statistics 2004). The most recent estimates suggest that 35.5% of 6–11-year-olds are either overweight or obese and 19.6% are obese (Ogden et al. 2010). These trends are often attributed to the types and amounts of foods and drinks available to children, including those offered for sale in schools. Between 1994 and 2000, the share of middle schools selling soda in vending machines on school grounds increased from 61 to 67 percent, and the share of high schools doing so increased from 88 to 96 percent (Anderson, Butcher and Levine 2003). These percentages appear to have increased even further in recent years (Johnston, Delva, and O'Malley 2007).

Competitive foods sold in school could directly increase the calories children consume by increasing opportunities to purchase and consume energy-dense sweets, salty snacks, and sugar-sweetened beverages. Currently, soft drinks account for 20% to 24% of calories consumed by adolescents (Price, Murnan and Moore 2006). On a 2000-calorie diet, this amounts to between 3 and 4 cans of non-diet soda per day. And, soda and other sugar-sweetened drinks have consistently been found to increase the odds of overweight among children and adolescents and significantly contribute to the calories they consume (Cullen et al. 2002; Harnack, Stang and Story 1999; James and Kerr 2005; Ludwig, Peterson and Gortmaker 2001; Malik, Schulze and Hu 2006; O'Connor, Yang and Nicklas 2006).

Competitive foods may also increase children's weight indirectly through advertising, which could increase demand for soft drinks and snacks both in and outside school. Soft drink companies try to build life-long brand loyalty by marketing to children in schools (Nestle 2000). Schools and school districts negotiate "pouring rights" contracts in which drink and snack vendors give schools upfront money (sometimes millions of dollars) and "incentive items" such as cups, t-shirts, poster, drink bottles, scholarships, and scoreboards in exchange for exclusive rights to sell their products in schools (Johanson, Smith and Wootan 2006; Price, Murnan and Moore 2006). Often, these contracts include specifications about the contents and placement of vending machines in high traffic areas, hours during which vending machines are made available to students, and financial penalties for lower-than-expected sales (Price, Murnam, and Moore 2006).

But these arguments are somewhat naïve. They merely demonstrate the capacity of competitive foods to contribute to obesity. Competitive foods will not do so if children

rarely purchase them. Additionally, the calories from competitive foods purchased at school may only replace, not supplement calories, consumed outside of school. Despite pressure to restrict the placement, contents, and access children have to vending machines and competitive foods (e.g., Sothern 2004), the complete elimination of competitive food sales is controversial because of the lack of evidence of the harm of competitive foods and because many schools use the proceeds to build or buy sports facilities and equipment, furniture, sound systems, computers, and to fund scholarships or extracurricular activities (Nestle 2000; U.S. Government Accountability Office 2005). Several perspectives have consistently emerged in this debate. One position, the *external* perspective, is formulated from psychological theories about how people respond to food cues in their environment. An alternative idea derives from developmental models of how children develop food preferences and dietary patterns. To these, we add another argument drawn from the sociological literature on how schools organize children's time and activities.

Why Competitive Food Sales May Raise the Risk of Child Obesity

The *external* perspective posits that competitive food sales are likely to raise the risk of child obesity. The key idea is that children primarily consume the foods, either healthy or unhealthy, that are easily available or promoted in their immediate environments, regardless of their level of hunger or food preferences. This position is supported by laboratory studies showing that people will eat more food when it is visible and easier to obtain (e.g., Wansick 2004; Wansink, Painter, and Lee 2006). In addition, several small-scale experimental or quasi-experimental studies suggest that children are responsive to food cues in school environments. One study (Cullen et al. 2004) examined changes in children's diets as they moved from fourth grade (when they only had access to school lunches) to fifth grade (when they also had access to a snack bar). They found that the children consumed fewer healthy foods and more sweetened drinks in fifth grade. Another study found that high school students were less likely to purchase food from vending machines when there were fewer of them or operational for fewer hours (Neumark-Sztainer et al., 2005). Finally, another study examined children's diets from three middle schools that replaced all snacks and drinks of low nutritional quality. Contrasted with children attending three comparison schools, the children attending the study schools reduced their consumption of junk food at school with no compensatory increase at home (Schwartz, Novak, and Fiore 2009). Additional evidence for the external perspective comes from a national-level study conducted by Anderson and Butcher (2006). Using an instrumental variable approach, they found that a ten percent increase in the proportion of schools in the county that sold junk food was associated with a one percent increase in students' BMI.

Why Competitive Food Sales May Not Raise the Risk of Child Obesity

Alternative perspectives suggest that competitive food sales in schools are unlikely to influence children's weight. According to a developmental perspective, children may be relatively insensitive to food choices at school because their food preferences and dietary patterns were already well established in early childhood (Davidson and Birch 2002; Fiorito et al. 2010, Krahnstoever, Francis, and Birch 2005; Van Hook, Baker and Altman 2009). If schools restrict children's food and drink choices, children may simply seek these foods elsewhere. Certainly, early childhood experiences and home environments have profound effects on children's dietary patterns (Davidson and Birch 2002; Krahnstoever, Francis, and Birch 2005). Some research suggests that children can lose the ability to self-regulate food consumption (and stop eating when full) in early childhood, largely as a consequence of child feeding practices. Daughters whose mothers are restrictive will eat more when given the opportunity to eat forbidden foods than other girls (Fisher and Birch 1999; Krahnstoever, Francis and Birch 2005; Savage, Fisher, and Birch 2007). Another study showed a strong correlation between beverage consumption at age five and beverage consumption in middle

childhood and adolescence (Fiorito et al. 2010). Still another study showed that children's weight trajectories between kindergarten and fifth grade are largely explained by children's kindergarten weight (Van Hook, Baker, and Altman 2009).

Constraints within school environments may further limit the effects of competitive food sales on weight status. Schools tend to exert much more control over children's time and activities than do non-school environments. School days are scheduled from beginning to end, including circumscribed times for eating. Within a 15 to 30 minute time slot, children eat at the same time in the same place with the same children each day. This differs considerably from home environments, where mealtimes are less regular, eating blends with other activities such as TV viewing, opportunities for snacking are greater, and food consumption is less closely monitored, especially for children staying home alone (Anderson, Butcher and Levine 2003). In general, situations that fail to provide clear signals of when and how much to eat often lead to "mindless" eating, that is, snacking without limit and without recognition of the quantity of food consumed (Wansick 2006). For example, adults eat more on the weekends when they spend more time at home than on weekdays (Haines, Hama, Guilkey, and Popkin 2003). So even if children consume unhealthy food from vending machines and snack bars in schools, it is possible that schools structure children's eating times so much that children do not have the opportunity to go back for more, like they might if they were at home.

Some evidence supports this idea. For example, children appear to consume relatively little soda while they are actually in school. One study based on an analysis of the 1994 and 1998 USDA food consumption surveys found that only 6 percent of soda consumed by children ages 6–17 was obtained from vending machines or school cafeterias (French, Lin and Cuthrie 2003). Similarly, Fletcher, Frisvold, and Tefft (2010) analyzed fifth and eighth grade children in the Early Childhood Longitudinal Survey (ECLS-K) and found that children attending schools with vending machines reported consuming more soda at school but the same overall amount of soda (consumed both in school and out of school) as children whose schools do not have vending machines.

Overall, these ideas about child development and school schedules shift the focus from schools to homes as the key environment that influences children's diets. The limited power of school-based competitive foods is reflected in empirical studies of children's weight. Fletcher, Frisvold and Tefft (2010) found no significant differences in body mass index or the prevalence of overweight and obesity between children attending schools with and without vending machines, although their analysis was purely descriptive and did not control for other characteristics of children and schools. In a more rigorous analysis of the same data (ECLS-K), Datar and Nicosia (2009) employed an instrumental variable approach to reduce bias due to the selection of heavy (or light) children into certain schools. They found no relationship between children's fifth grade weight status and the presence or sale of competitive foods in their school. Finally, Von Hippel and his colleagues (2007) used the ECLS-K to examine children's weight gain between kindergarten and the end of first grade. They found that young, school aged children gain more weight in the summer months than during the school year, suggesting that influences in children's homes and communities are more important than school environments for the current childhood obesity epidemic.

The Current Study

These ideas raise important questions about the effects of competitive food sales on children's weight. Unfortunately, most of the evidence on this topic is inconclusive because, aside from a few studies (notably Anderson and Butcher 2006, and Datar and Nicosia 2009), they do not adequately account for selection effects. As noted above, early childhood experiences and home environments have profound effects on children's dietary patterns

(Davidson and Birch 2002; Fiorito et al. 2010, Krahnstoever, Francis, and Birch 2005; Van Hook, Baker and Altman 2009). Heavier children may be more likely to attend schools with competitive food sales because parents who tend to raise overweight or obese children may also be less likely to pressure school administrators to eliminate the sale of junk food at school.

Some research has used instrumental variable approaches to address this concern (Datar and Nicosia 2009; Anderson and Butcher 2006). Anderson and Butcher (2006) used school funding levels as instruments for the percentage of schools in a county selling competitive foods. Datar and Nicosia (2009) used the school grade structure as an instrument for competitive food sales, with the idea that schools with younger students are less likely offer competitive food sales to children. Instrumental variable approaches can yield valid causal estimates because they decouple treatment (exposure to competitive foods) from selection into treatment. But this analytic strategy depends on the assumption that the instrument is not directly related to the outcome (Angrist and Pischke 2009; Angrist and Kreuger 1991). For example, the Anderson and Butcher (2006) study rests on the assumption that school funding levels have no direct effect on children's weight, even though school funding levels may be correlated with community-level perspectives about food and the perceived threat of child obesity,

Here, we use an alternative approach, a longitudinal research design, to examine the association of the introduction of competitive food sales in schools and children's weight gain. We specifically use fixed effect models to assess how changes in school environments are related to changes in weight. As asserted in a recent literature review, "no longitudinal studies have examined the possible links between access to competitive foods and students' weight"(Larson and Story 2010, p. 433). Although longitudinal studies alone cannot establish causality, they do not rely on the same assumptions as instrumental variable estimation strategies, and they can be used to rule out the possibility of selection of heavier children into schools that sell competitive foods, as opposed to gaining weight only after attending such schools.

A second contribution is that we examine gender, race/ethnic, and socioeconomic variations in the association of competitive food sales with children's weight. Competitive foods may more strongly influence boys than girls if girls are more likely to engage in "social dieting", eating less in the company of their peers at school. Our expectations about racial minority and poor children are less clear. On the one hand, racial minority and poorer children may be less vulnerable to competitive food sales. They have less money to purchase food and drinks from vending machines and snack bars than students from high socioeconomic households. Additionally, low-SES schools are less likely to sell competitive foods than high-SES schools (Anderson and Butcher 2006). On the other hand, they may be more vulnerable because they are more likely to attend schools that allow soft drink companies to advertise on school buildings, school grounds, and school buses (Johnston, Delva, and O'Malley 2007).

Methods

Data and Sample

We used data from the Early Childhood Longitudinal Study Kindergarten Class of 1998–99 (ECLS-K). Conducted by the National Center for Education Statistics, the ECLS-K followed a nationally representative sample of roughly 21,410 children from the fall of kindergarten through the fall of eighth grade (1998/1999 through 2006/2007 school years)[1]. The data therefore pertain to a time period when the drive to restrict junk food sales in schools was gaining momentum. The study randomly selected 1,000 public and private schools within

100 Primary Sampling Units (counties or groups of counties), and about 23 kindergarteners from each school. The survey collected information from parents, teachers, and school administrators.

Many children in the sample had changed schools between kindergarten and eighth grade. For children who moved between fifth and eighth grade, we do not know how long children had been attending a school with a vending machine, snack bar or al a carte vendor because this information was collected only from the schools children attended in fifth and eighth grades. To reduce this source of measurement error, we conducted the analyses only for students who attended a school in the same county between fifth and eighth grade[2]. Because of attrition and residential mobility, our sample of eight grade non-movers was considerably smaller than the original kindergarten cohort. For example, out of the original 21,410 kindergarten children, 11,000 remained in the 5th grade sample and had a valid BMI score. In addition, like most longitudinal data sets, the ECLS-K has missing values. We used multiple imputation using the ICE procedure in Stata (Royston 2007) to fill in missing values on all variables. We used sequential regression multivariate imputation and estimated five distinct values that represent a distribution of plausible values (Rubin 2004) for each missing data point. The imputed values were inserted for the missing data to form 5 different datasets, all of which were used to generate 5 sets of multivariate results. We combined the results into one set of regression coefficients and standard errors. In this analysis we imputed the dependent variable, following the recommendations of Johnson and Young (Forthcoming)[3]. Prior to using the imputed data for analysis, the data was checked for irregularities in the means, standard deviations, and ranges, and none were found. The final imputed data set included 19,450 children who attended school in the same county in both 5th and 8th grades.

Measures

Descriptive statistics for all of our measures are presented in Table 1.

Body Mass Index (BMI)—Our dependent variable is children's weight status in 8th grade. Although competitive food sales are hypothesized to increase children's weight through increased consumption of soda and snacks at school, we do not analyze the food intake measures that are available in the ECLS-K. The reason is that these measures are self-reported by the children for consumption in the previous 7 days. Dietary recall is an extremely poor indicator of food intake particularly for children (Collins, Watson, and Burrows 2010; Guinn et al. 2010; Moore et al. 2010), so the results of such analyses would be inconclusive.

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[1]Following NCHS data disclosure rules, we round sample size numbers to the nearest 10s place.

[2]We originally restricted the sample to children who attended school in the same district in 5th and 8th grade, but we grew concerned about the possibility that some areas have separate primary and secondary school districts, and so children living in these areas would be inaccurately coded as a "movers". Therefore, we instead restricted the sample to children whose school is in the same county in both 5th and 8thgrades. We also controlled for whether or not students change school districts between fifth and eighth grade. Students who attend a school in the same county are unlikely to change school districts; almost 92% of students who do not change school counties remain in the same school district between fifth and eighth grade.

[3]Von Hippel (2007) suggests a strategy called multiple imputation, then deletion (MID) where the dependent variable is included in the imputation but then deleted for analysis. MID is most useful when the values of the dependent variable are problematic or when there is a great deal of missing values on the dependent variable (von Hippel 2007). However, both Johnson and Young (forthcoming) and von Hippel (2007) indicate that MID only offers only *minute* improvements in the efficiency (e.g., at the 10th decimal place) of estimates when the imputed values of the dependent variable are acceptable, as is the case for our data (for more information see Young and Johnson 2010). Additionally, in preliminary analyses, we tested alternative approaches in which we dropped all cases with missing values on any of the dependent or independent variables, and alternatively, imputation then deletion. The results were the same regardless of which imputation approach we used.

Height and weight measures were collected from the children during the spring and fall of kindergarten and first grade, and during the spring of third, fifth, and eighth grades, which were converted to percentile BMI in accordance with CDC guidelines (Kuczmarski, Ogden and Guo 2002). Children were classified as "overweight or obese" if their BMI was greater than or equal to the 85th percentile within age- and gender-specific groupings. Percentile BMI was used as the dependent variable in the multivariate models. In our sample, the unweighted mean percentile BMI in fifth grade was 66.9, and 39.1% were overweight or obese.

School Competitive Food Sales—In the fifth and eighth grade waves of data collection, school administrators were asked a series of questions about the availability of competitive foods for students to purchase: "At this school, can students purchase food or beverages from one or more vending machines at the school, a school store, canteen, or snack bar?" and "Does this school offer a la carte lunch or breakfast items to students, that is, items not sold as part of the NSLP School Lunch or the School Breakfast Program?" Children were also asked the types of food available for purchase at school. We used the information gathered from the principals because of concerns about the quality of the children's responses[4].

For both 5th and 8th grades, we created a dichotomous measure of competitive food sales for schools that sold food through at least one competitive food venue (i.e. vending machines, snack bars, or a la carte). In 5th grade, 59.2% percent of children attended a school selling competitive foods, and by 8th grade, 86.3% did so. To assess the effects of exposure to competitive foods in middle school, we also examined the interaction between the number of years the child had attended middle school between 5th and 8th grades (average = 3.1 years).

Additionally, school administrators were asked about the types of foods students could purchase from vending machines, school stores, canteens, snack bars, or a la carte during school hours. Table 2 shows the types of competitive food sold in 5th and 8th graders' schools. Clearly, not all competitive food is high-calorie junk food. For example, among 8th grade children attending a middle school that sold competitive foods, 43 percent attended a school that sold soda or other drinks that are not 100% juice, but 61 percent attended a school that sold fruits or vegetables and 84 percent attended a school that sold bottled water. Recognizing that the type of food sold may affect children's weight gain, we conducted supplementary analyses of the types of food sold using two competitive food scales. The healthy food scale (alpha = 0.79 in both years) is the sum of items such as skim milk, fruits or vegetables, low fat yogurt, bottled water, and 100 percent vegetable or fruit juice. The unhealthy food scale (alpha= 0.82 in 5th grade and 0.79 in 8th grade) included candy and chocolate, baked goods, salty snacks, ice cream, and soda.

Unfortunately, ECLS-K did not collect data about the placement of vending machines or snack bars, hours of operation, and other rules or regulations concerning the sale of competitive foods in the school. Schools vary in the extent they actively sell food to students, so the effect of competitive food sales is likely to vary across schools. Because we are unable to differentiate among specific competitive food policies, our estimates represent the average effects of competitive food sales across all types of schools.

[4]Sometimes, children's and principals reports conflicted. For example, among the fifth grade children in our imputed analytic sample reporting that salty, sweet, or non 100% juice drinks are available for purchase at school, only 71.2 percent of their principals indicated that the school sold competitive foods through vending machines, snack bars and canteens, or a la carte. This may reflect misreporting by principals, but we speculate that it is more likely that some fifth grade children reported about food purchases outside school. The discrepancy could also be due to the fact that students were only asked about the general availability of certain categories of competitive foods while principals are asked about the venues of food sales.

Controls—We controlled for a number of time-varying school and family characteristics. School characteristics included the percentage of students receiving a free lunch (37.1% in 5th grade) and reduced-price lunch (9.1% in 5th grade); school size (number of students as a categorical variable); and the percentage of students who are racial or ethnic minorities (2.8% in 5th grade). We also controlled for quality of the school facilities. The school facilities scale was based on several questions assessing the adequacy of the school playground, library, hallways, classrooms, gym, etc. Higher scores indicated more adequate facilities and school amenities (alpha = 0.65; mean=0 in both years). Because prior research found the level of funding received by a school is associated with vending machines and soda contracts and snack bars, we also control for school revenues per student from state and local tax sources (in $1,000).

Family characteristics included parental marital status (73% married in fifth grade); maternal employment (51.5% of mothers work fulltime); family socioeconomic status (a standardized scale created by the ECLS-K survey team based on up to five measures of SES); parental involvement in school; and school choice. To measure involvement, parents were asked about their participation in school fundraisers, volunteer opportunities, school events, parent-teacher conferences, parent-teach associations, and a school open house. A higher score indicated greater parental involvement (alpha= 0.59; mean = .00 in 5th grade). School choice was assessed by a question asking parents whether the school their child attends is the regularly assigned school or a school chosen by the parents (35% in chosen school in 5th grade; 31.7% in 8th grade). Finally, we controlled for the age of the child at the time of assessment to account for the relationship between maturation and weight status (mean = 134.6 in 5th grade; 171.4 in 8th grade).

Analysis

Estimates of the simple association between school food policies and children's weight could be biased by the selection of heavy (or lighter) children into schools that sell competitive foods. Our approach is to estimate fixed effects models, which model changes in children's weight as a function of changes in competitive foods. The advantage of fixed effects models is that they control for unobserved non-time-varying variables (Allison 2005). To estimate the models, we produced a child-grade file that includes two records for each child, one from fifth grade and another from eighth grade[5]. The model is specified as:

$$W_{it}=a+B_1CF_{it}+\mathbf{Z_{it}B_4}+e_i \qquad \text{(eq. 1)}$$

where W_{it} is child i's percentile BMI at time t (5th or 8th grade), CF_{it} is a dummy variable indicating competitive food sales in the child i's school at time t, Z_{it} is a vector of school, family, and child characteristics for child i at time t, and e_i is an individual-level error term[6]. B_1 provides an estimate of the effects of the introduction of competitive food sales on changes in children's percentile BMI.

Although fixed effects models control for unobserved characteristics that do not change over time, it remains possible that time-varying unmeasured factors may bias the results if they are associated with both the introduction of school competitive foods and children's weight gain. For example, communities that continued to permit competitive food sales in middle school even after the national movement to restrict them took hold in the mid-2000s may also foster behaviors that lead to weight gain for young adolescents. Fortunately, we are able to take advantage of a "natural experiment", a policy that produces variation in children's exposure to competitive foods but nevertheless is not systematically related to the selling of

[5]We performed the multiple imputation procedure on the child file before producing the child-grade file.
[6]We used Stata's xtreg command with the fe option to estimate this model.

competitive foods in schools. Middle schools are more likely to offer competitive foods than elementary schools (86.3 versus 59.2%, respectively). About 18% of the children in the ECLS-K transition from a school environment without competitive foods to one with them between fifth and eighth grade. Our insight is that school districts differ with respect to the timing of this transition, and thus, they inadvertently differ in the number of years they expose children to competitive food sales. Among the 8th graders in the ECLS-K sample, 46.8% started middle school in 6th grade, 20.5 % started in 7th grade, and nearly all of the rest started in 5th or 8th grade. The timing of the transition from elementary to middle school is itself weakly related to whether or not middle schools have competitive foods.

Of course, children who transition to middle school in 6th grade have a very different 6th grade experience than those who transition in 7th grade, and their experience differs in more ways that simply by whether their school offers competitive foods (Barber and Olsen 2004; Rudolph et al. 2001). Children remaining in elementary school will typically be assigned to a single classroom with the same teacher for much of the school day. Also, they are the oldest, not the youngest, children in the school. Some argue that when children spend 6th grade in elementary school, they gain an additional year of childhood free from the influences of older adolescent peers. Thus, earlier transitions to middle school could be associated with faster or earlier weight gain. On the other hand, if middle schools offer children more opportunities for physical activity and sports, earlier transitions to middle school could be associated with slower weight gain. Regardless, it is critical to take into account the possible effects of the timing of the transition to middle school independent of the sale of competitive foods.

We therefore employed a “double difference” approach. We estimate the change in percentile BMI of children who attend schools with competitive food sales versus other children, and then compare these differences across durations of exposure to middle schools. If exposure to competitive foods contributes to weight gain, then an additional year in a middle school with competitive foods should be associated with greater weight gain than an additional year in a middle school without competitive foods, assuming that the underlying effect of years in middle school is the same across schools. To estimate this “double difference,” we tested the interaction between the number of years students spend in middle school in their school district (YRS_i) and competitive foods (CF_{it}):

$$W_{it}=a+B_1CF_{it}+B_2(CF_{it} * YRS_i)+\mathbf{Z_{it}B_3}+e_i \quad \text{(eq. 2)}$$

Thus, B_1 is the association of the introduction of competitive foods with changes in children’s weight, and B_2 represents the association with children’s weight gain of an additional year of exposure to a middle school with competitive foods compared to children attending a middle school without competitive foods (i.e., the “double-difference”).

We estimated these models for four groups: (1) all children; (2) children who were not overweight in fifth grade (<85th percentile); (3) children whose school in fifth grade did not sell competitive foods; and (4) children who were not overweight and whose school did not sell competitive foods in fifth grade[7]. All four analytic samples were restricted to children who attended school in the same county in both fifth and eighth grade. By restricting some

[7]The sample size declines as the models become increasingly selective. The smaller sample sizes in third and fourth group of models are expected because only students who have an exact value of 0 on competitive foods in the fifth grade are included in the analysis. While multiple imputation helps to fill in the missing data, it often produces non-integer values regardless of how close they are to 0 or 1. We experimented with alternative cut-offs for inclusion in the sub-samples (for example, including children in the third sub-sample if they had a value of .5 or lower on their fifth grade competitive foods imputed variable). Although this increased the sample size for the sub-samples, it did not change the results.

models to those without competitive foods or those who were normal weight in fifth grade, we ensured that when the child started middle school, he/she had not been exposed to school competitive foods in the past nor had a prior weight problem. We expect the estimate from the final set of models to provide the strongest evidence of the effects of competitive food sales.

Finally, we tested whether the association of competitive foods with children's weight varied by gender, race/ethnicity, and family SES. Although fixed effects models do not permit the inclusion of time-constant variables as predictors (such as sex and race/ethnicity), it is possible to include interaction terms between time-constant and time-varying variables (Allison 2005). We tested all of the possible interactions between gender, race/ethnicity, and family SES and the competitive foods measures and, in the second set of models, their interactions with years in middle school (i.e., three-way interactions between competitive foods, years in middle school, and gender, race/ethnicity or family SES).

For all analyses, we adjusted the standard errors in all models to account for the clustering of children within their kindergarten schools.

Results

Descriptive Findings

To assess the effects of competitive foods on children's weight, we first adopt a cross-sectional approach taken by most prior research. We compare children's weight by whether their 8th grade school sold competitive foods or not, and find no support for the idea that competitive foods increases the risk of obesity. As shown in the upper panel of Table 3, children whose 8th grade school sold competitive foods tended to weigh slightly more in 8th grade than other children. However, these differences are extremely small and not statistically significant.

When we take advantage of the longitudinal data, we again fail to find support for the idea that competitive food sales increase the risk of childhood obesity. We first compared children who moved into a middle school with competitive foods with those who were never exposed. As shown in the lower panel of Table 3 children who moved into middle schools with competitive foods ("Competitive Foods in 8th grade, not in 5th grade") actually lost weight over time; their percentile BMI did not change significantly but the percentage overweight or obese significantly declined by 4 points. By comparison, children who never attended a school with competitive foods ("No Competitive Foods Ever") did not experience a significant change in weight. Moreover, we find no statistically significant differences in the change in children's weight or weight status over time. We find similar results when we compare children who always attended a school that sells competitive foods (in both 5th and 8th grades) with children who moved out of such a school (competitive foods in 5th grade only). The children who were always exposed to competitive foods did not gain (or lose) more weight over time than the other children.

Multivariate Findings

The multivariate analysis similarly provides no support for the idea that competitive food sales in schools contributes to children's weight gain. The first set of fixed effect models (based on equation 1) are shown in Table 4. The results show that changes in competitive foods sales in school are not associated with changes in children's percentile BMI. This finding cut across all four analytic samples. Moreover, we found no evidence that greater exposure to competitive foods increases children's weight. The interaction of competitive food sales with years in middle school (the double difference) was insignificant in all four models shown in Table 5 (based on equation 2).

These weak and insignificant results represent average effects across all children. But perhaps the effects of competitive food sales vary across groups. To explore this possibility, we tested interactions of each of these variables with competitive foods and years in middle school. None of the interactions were statistically significant. This suggests that our basic conclusion— that the effects of competitive foods are weak and insignificant—does not vary by gender, family SES, and race/ethnicity.

We next conducted a series of robustness checks. We re-estimated all of the models using dichotomous "overweight" indicator as the dependent variable rather than percentile BMI. The results were consistent with the results presented here. Additionally, we estimated the models on a sample of children who were overweight or obese (with a BMI at or above the 85th percentile) in 5th grade. The results mirror those for normal weight students. Next, we explored the effects of venue. We tested the effects of vending machines alone, snack bars alone, and the sum of all types of competitive food sales. Again, we found no significant effects. Finally, we explored the possibility that the effect of competitive food sales depends on the type of food sold. We estimated the fixed effects models using the healthy and unhealthy food scales in place of the dichotomous competitive foods measure. We found that the type of competitive food purchased during school, whether healthy or unhealthy, was not significantly associated with weight gain.

Finally, we point out that no school, family, or child characteristics were significantly related to changes in children's weight between 5th and 8th grades. It isn't just competitive foods that make no difference. In preliminary work, we examined children's weight cross-sectionally, and we found strong associations between children's 8th grade weight and factors like family SES, indicators of school SES, race/ethnicity, maternal employment, and parental nativity. However, none of these factors explain weight *gain* among young adolescents. Overall, the results suggest that weight during early adolescence is no longer a direct function of these aspects of family and school contexts (at least, not the characteristics we are able to measure), but rather, is strongly shaped by how heavy children were when they were younger.

Discussion

One of the policy responses to the growing trend in childhood obesity has been to try to reduce children's opportunities to purchase competitive foods in schools or improve the nutritional quality of foods sold. Yet it has remained unclear what impact, if any, these efforts are likely to have on children's weight. The research presented here uses longitudinal data to assess the association of the introduction of and exposure to competitive foods with weight gain among children in middle school. The results suggest that the sale of competitive foods in school is unassociated with weight gain among middle-school children. The estimated effect was small and statistically insignificant regardless of how we measured competitive food sales or weight status or which statistical modeling technique we used. Moreover, this basic conclusion did not vary by children's gender, race/ethnicity, or family SES.

This finding should be interpreted within the context of the study's limitations. First, although we go beyond other research by following children's weight and exposure to school environments over time for a nationally-representative sample, our study is observational and therefore does not provide true causal estimates such as can be obtained from random-controlled experimental designs. Second, our results do not preclude the possibility that specific school food policies are associated with weight gain among children, such as aggressive advertising efforts or school activities and schedules that actively encourage children to purchase soda, juice, or candy from vending machines. Furthermore,

we do not explore variations in this effect with respect to the amount and cost of food and drinks being sold and consumed in schools. In recent years, school districts have restricted the types of foods and beverages sold in vending machines and snack bars, so it would be interesting to assess whether these policy changes have altered food consumption patterns and reduced the risk of obesity among students, as suggested would be the case by a recent study (Schwartz, Novak, and Fiore 2009). Third, it is important that our findings not be generalized to older children. The effects may be greater for high school students (as found by Anderson and Butcher, 2006) because older adolescents have less rigid school schedules and more freedom and money to purchase competitive foods than the middle school children in our study. Finally, it is important to understand that we estimate average population–level effects. It remains possible that some individual children may gain weight when given opportunities to purchase competitive foods because they tend to select higher-calorie foods or purchase a lot of food.

Despite these limitations, our study of the average effects of competitive food sales lends support to a growing body of evidence (Datar and Nicosia 2009; von Hippel et al. 2007; Fletcher, Frisvold and Tefft 2010) that competitive food sales in elementary and middle schools should not be blamed for the growing obesity epidemic or disparities in childhood obesity at the population level. This conclusion seems inconsistent with the *external* perspective on children's susceptibility to food cues in school environments. Given the limitations of our study and the strength of prior research, we do not take issue with the basic conclusion about the unhealthy effects of consuming high-calorie food and beverages of low nutritional value, or with the idea that easy access to food increases intake. However, we do suggest that cross-sectional studies may be flawed because they do not account for how heavy children were before they attended schools that sell competitive foods. As suggested by the developmental perspective, children's dietary patterns, food preferences, and therefore their weight trajectories, may be firmly established by the time they reach middle school. Additionally, as suggested by von Hippel and his colleagues (2007), children may face greater risks for obesity at home than at school, even if their school sells competitive foods. Schools are highly structured, hierarchical, and effective at organizing students' time, and structure like this may reduce the time children spend snacking. More research is necessary to assess this idea.

To the extent that the findings reported here are robust to their limitations, they may prove disappointing for those seeking to design school-based interventions to improve children's health. Schools seem to be natural places in which to enact cost-effective interventions. Because students are captive audiences, schools can communicate and interact with millions of children for extended periods of time. Schools also have the institutional capacity to coordinate and deliver consistent and well-defined interventions through an army of teachers and administrators. Yet, schools may not be good at addressing the root causes of childhood obesity that originate in children's homes and communities. Not only do we find that competitive food sales within schools are, on average, unrelated to obesity, but other research suggests that school-based interventions to reduce childhood obesity are often unsuccessful (Sharma 2006; Kropski et al. 2008). Overall, schools may help promote better eating and provide opportunities for physical activity, but they do not seem to be effective at changing a student's weight. The challenge is to develop interventions that reach into the home and community. Perhaps those interventions can start with schools, but they probably need to reach beyond them to be effective.

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Table 1

Descriptive statistics for the analytic sample

	5th Grade		8th Grade	
	Mean or %	**SE**	**Mean or %**	**SE**
Depedent Variables				
Percentile BMI	66.9	0.29	66.5	0.23
Overweight/Obese (BMI>=85)	39.1%		35.4%	
Independent Variables				
School Characteristics				
Competitive Foods	59.2%		86.3%	
Years in Middle School	3.1	0.02	3.1	0.02
Percentage Free Lunch	37.1	0.38	33.6	0.32
Percentage Reduced Lunch	9.1	0.09	10.2	0.17
School Size	3.4	0.02	3.8	0.02
Percent Minority	2.8	0.03	2.8	0.03
Quality of School Facilities	0.0	0.02	0.0	0.01
Local Revenue per capita ($1000)	3.8	0.08	2.1	2.24
State Revenue per capita ($1000)	4.2	0.09	4.7	0.22
Family Characteristics				
Married Parents	73.2%		74.7%	
Mother is employed full time	51.5%		54.8%	
Family SES	0.0	0.01	0.0	0.01
Parental Involvement in School	0.0	0.01	0.0	0.01
School Chosen	31.7%		28.9%	
Child Characteristics				
Age in Months	134.6	0.06	171.4	0.06

Imputed Data using Multiple Imputation (N = 19,450 children who attended school in the same county in 5th and 8th grades)

Standard Errors are clustered at the Fall Kindergarten school

Table 2

Types of food sold in children's schools (among those attending schools with competitive foods)

	5th Grade	8th Grade
	%	%
Chocolate Candy	12.19	13.16
100% Vegetable Juice	8.74	14.61
Other types of Candy	15.31	16.17
Salty Snacks	41.62	33.65
Ice Cream or Frozen Yogurt	41.68	35.04
Low Fat/Non Fat Yogurt	22.14	38.67
Baked Goods	46.25	40.31
Low Fat Ice Cream or Frozen Yogurt	26.17	43.49
Drinks not 100% Juice (i.e. Soda)	36.28	43.77
Bread Products	26.85	44.57
Fruits or Vegetables	39.33	60.57
1% or Skim Milk	48.95	61.22
2% or Whole Milk	67.89	62.20
Low Fat Baked Goods	28.69	62.32
Low Fat Salty Snacks	40.75	68.64
100% Fruit Juice	56.15	77.18
Bottled Water	50.38	83.98

Imputed Data using Multiple Imputation (N = 19,450 children who attended school in the same county in 5th and 8th grades)

Table 3

Mean Percentile BMI and Percent Overweight/Obese by Competitive Food Sales in 5th and 8th Grades

	5th Grade	8th Grade	change
Cross-sectional Analysis			
Percentile BMI			
Competitive Foods in 8th Grade	---	66.5 (0.3)	---
No Competitive Foods in 8th Grade	---	66.2 (0.8)	---
Difference	---	0.3 (0.9)	---
Overweight Status (percentile BMI >=85)			
Competitive Foods in 8th Grade	---	35.5 (0.5)	---
No Competitive Foods in 8th Grade	---	34.8 (1.2)	---
Difference	---	0.7 (1.3)	---
Longitudinal Analysis			
Percentile BMI			
Competitive Foods in 8th Grade, not in 5th Grade	67.8 (0.6)	66.7 (0.5)	−1.1 (0.8)
No Competitive Foods Ever	66.5 (1.9)	65.7 (1.5)	−0.8 (2.4)
Difference	1.3 (2.0)	1.0 (1.6)	−0.3 (2.5)
Competitive Foods in both 5th and 8th Grade	67.4 (0.6)	66.1 (0.5)	−1.3 (0.8)
Competitive Foods in only 5th Grade	65.6 (1.5)	65.9 (1.1)	0.3 (1.9)
Difference	1.8 (1.6)	0.2 (1.2)	−1.6 (2.0)
Overweight Status (percentile BMI >=85)			
Competitive Foods in 8th Grade, not in 5th Grade	39.5 (1.2)	35.5 (1.1)	−4.0 (1.6)
No Competitive Foods Ever	37.5 (2.4)	34.6 (2.8)	−2.9 (3.7)
Difference	2.0 (2.7)	0.9 (3.0)	−1.1 (4.0)
Competitive Foods in both 5th and 8th Grade	40.0 (1.3)	35.1 (0.9)	−4.9 (1.6)
Competitive Foods in only 5th Grade	36.8 (2.2)	34.1 (2.3)	−2.7 (3.2)
Difference	3.2 (2.6)	1.0 (2.5)	−2.2 (3.6)

Imputed Data using Multiple Imputation (N = 19,450 children who attended school in the same county in 5th and 8th grade Standard Errors (in parentheses) are clustered at the Kindergarten school

Table 4

Fixed Effects Models of Children's Percentile BMI and Competitive Food Sales at School (equation 1)

	Non-Movers[1]		Normal Weight[2] Non-Movers[1]		No 5th CF[3] Non-Movers[1]		Normal Weight[2] No 5th CF[3] Non-Movers[1]	
	B	**SE(B)**	**B**	**SE(B)**	**B**	**SE(B)**	**B**	**SE(B)**
School Characteristics								
Competitive Foods	−0.59	0.59	−0.11	0.77	−0.78	1.96	1.35	1.97
Percentage Free Lunch	0.00	0.01	0.00	0.01	0.00	0.02	−0.01	0.03
Percentage Reduced Lunch	−0.02	0.04	−0.01	0.04	0.02	0.05	0.00	0.07
Changed Districts Between 5th and 8th Grades	0.79	1.20	1.26	1.49	0.40	2.48	2.50	3.25
School Size	0.10	0.57	0.16	0.53	−0.08	0.65	−0.01	0.69
Percent Minority	−0.07	0.35	0.12	0.32	−0.04	0.49	0.23	0.50
Quality of School Facilities	0.01	0.39	0.09	0.37	0.23	0.50	0.56	0.57
Local Revenue per capita ($1000)	0.02	0.02	0.04	0.10	−0.04	0.22	−0.10	0.28
State Revenue per capita ($1000)	0.00	0.03	−0.03	0.10	−0.03	0.41	−0.03	0.42
Family Characteristics								
Married Parents	−0.81	0.62	−0.46	0.63	−0.58	1.29	−0.68	2.00
Mother is employed full time	0.26	0.58	0.05	0.61	0.84	0.95	0.37	1.21
Family SES	−0.05	0.60	−0.20	0.53	−0.37	0.66	−1.08	0.78
Parental Involvement in School	0.11	0.31	0.02	0.33	0.17	0.55	0.17	0.64
School Chosen	−0.15	0.81	0.16	0.85	−0.02	1.03	0.68	1.18
Age in Months	−0.01	0.01	0.33 ***	0.01	−0.01	0.05	0.26 ***	0.05
Constant	69.16 ***	2.63	7.28 *	2.79	69.35 ***	7.88	18.15 *	8.22
Obervations (Child-years)	38,900		25,990		7,890		5,220	

† p<0.10

* p<0.05

** p<0.01

*** p<0.001

Imputed Data using Multiple Imputation

[1]Non-Mover indicates the student has attended a school in the same county in 5th and 8th grades.

[2]Normal Weight indicates the child's 5th grade percentile BMI < 85.

[3]This group did not have competitive foods in their 5th Grade School.

Table 5

Fixed Effects Models of Children's Percentile BMI, Competitive Food Sales at School, and Years in Middle School (equation 2)

	Non-Movers[1]		Normal Weight[2] Non-Movers[1]		No 5th CF[3] Non-Movers[1]		Normal Weight[2] No 5th CF[3] Non-Movers[1]	
	B	**SE(B)**	**B**	**SE(B)**	**B**	**SE(B)**	**B**	**SE(B)**
School Characteristics								
Competitive Foods	−1.04	2.22	−1.67	2.25	−0.35	4.04	2.10	3.94
*Years in Middle School	0.14	0.67	0.50	0.74	−0.14	1.07	−0.25	1.10
Percentage Free Lunch	0.00	0.01	0.00	0.01	0.00	0.02	−0.01	0.03
Percentage Reduced Lunch	−0.02	0.04	−0.01	0.04	0.02	0.05	0.00	0.07
Changed Districts Between 5th and 8th Grades	0.79	1.20	1.25	1.49	0.39	2.48	2.52	3.24
School Size	0.10	0.57	0.16	0.53	−0.08	0.65	0.00	0.69
Percent Minority	−0.07	0.35	0.12	0.32	−0.04	0.49	0.23	0.49
Quality of School Facilities	0.01	0.39	0.09	0.37	0.23	0.50	0.56	0.56
Local Revenue per capita ($1000)	0.02	0.02	0.04	0.10	−0.04	0.23	−0.10	0.28
State Revenue per capita ($1000)	0.00	0.03	−0.03	0.10	−0.03	0.40	−0.03	0.42
Family Characteristics								
Married Parents	−0.81	0.62	−0.45	0.63	−0.58	1.29	−0.69	2.00
Mother is employed full time	0.26	0.58	0.05	0.61	0.84	0.94	0.38	1.20
Family SES	−0.05	0.60	−0.20	0.53	−0.37	0.66	−1.08	0.78
Parental Involvement in School	0.11	0.31	0.02	0.33	0.17	0.55	0.17	0.64
School Chosen	−0.15	0.81	0.16	0.85	−0.02	1.03	0.68	1.18
Age in Months	−0.01	0.01	0.33 ***	0.01	−0.01	0.05	0.26 ***	0.05
Constant	69.15 ***	2.64	7.25 *	2.80	69.36 ***	7.89	18.18 *	8.23
Obervations (Child-years)	38,900		25,990		7,890		5,220	

† p<0.10

* p<0.05

** p<0.01

*** p<0.001

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Imputed Data using Multiple Imputation

[1]Non-Mover indicates the student has attended a school in the same county in 5th and 8th grades.

[2]Normal Weight indicates the child's 5th grade percentile BMI < 85.

[3]This group did not have competitive foods in their 5th Grade School.