School Breakfast Participation and Obesity among American Middle School Children

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Introduction

Childhood obesity is one of the most pressing health concerns today, with 16.9% of American children classified as obese according to recent estimates (Ogden et al., 2012). This is more than twice the obesity prevalence in 1980 of 7% (CDC, 2012). This is a worrying trend due to the strong links between obesity and numerous chronic diseases including diabetes and cardiovascular disease ("The Surgeon General's Vision for a Healthy and Fit Nation," 2010, Freedman et al., 2005). School is a key social environment for children and one in which many behaviors relevant to weight develop (Crosnoe & Muller, 2004). Regulations requiring better nutrition in schools offer a promising strategy for collectively improving eating behavior and health among a large majority of American children (Gostin, 2007). Indeed, modification of the school environment has been shown to affect other child behaviors, such as activity levels (Kohl III & Hobbs, 1998). This study focuses on the School Breakfast Program (SBP), which serves meals to over 12 million children every day according to specific nutritional guidelines (USDA, 2012). This program is a promising tool given that numerous studies report that eating breakfast may be associated with better overall nutrition, lower likelihood obesity, and better academic performance.(Dubois et al., 2006; G. Rampersaud, 2005; Timlin et al., 2008) The promise of school breakfast programs is that they can provide a nutritious breakfast to children who would otherwise eat a less nutritious breakfast or none at all and thus can promote better nutritional intake and healthier weight in children. We evaluated the relationship between school breakfast participation and children's weight change during the transition between elementary and middle school, employing a rich nationally-representative longitudinal dataset, the ECLS-K, which includes information on breakfast from both school administrators and parents.

Breakfast and Obesity

Eating breakfast is associated with better overall nutrition, lower likelihood of obesity and progression to obesity,(Dubois et al., 2006; Dubois et al., 2008; G. C. Rampersaud et al., 2005; Timlin et al., 2008; Williams et al., 2008) and better mental and academic performance.(Mahoney et al., 2005; G. Rampersaud, 2005; G. C. Rampersaud et al., 2005) Adults who consumed breakfast less than 75% of days had significantly higher odds of obesity compared to those who consumed over that threshold (Ma et al., 2003). Among adolescents followed over five years, those who ate breakfast had significantly smaller increases in BMI than those who never ate breakfast , even after accounting for baseline breakfast consumption and BMI, and dietary intake, among other characteristics (Timlin et al., 2008). Additionally, those who occasionally ate breakfast had significantly lower mean BMIs than those who never ate breakfast, indicating an inverse dose-response relationship between breakfast consumption and mean BMI (Timlin et al., 2008). Among pre-school children, those who skipped breakfast and who had breakfast less frequently were heavier and more likely to be obese(Dubois et al., 2006) (Haerens et al., 2010).

The benefits of breakfast may be explained by reductions in dietary fat intake and impulsive snacking throughout the day among children who consume breakfast regularly.(Dubois et al., 2008; Schlundt et al., 1992) The size of the breakfast matters, with those who had very small meals benefiting less from eating breakfast (Benton & Jarvis, 2007). Nonetheless, breakfast is the meal that is most often skipped by young people (Pearson et al., 2008). In a study of 1520 Canadian pre-school children, ages 3-4 years, those who skipped breakfast were more likely to eat larger lunches and dinners, while also eating more snacks in the afternoon and evening compared to those who ate breakfast (Dubois et al., 2009). This result suggests that breakfast may play a role in obesity prevention by providing some as-of-yet unknown positive metabolic characteristics. Also of note, children who ate breakfast consumed significantly greater quantities of vegetables, grains, and milk indicating that breakfast consumption may lead to better dietary quality throughout the day (Dubois et al., 2009). Alternatively, it is possible that those who ate breakfast consumed less food later in the day when physical activity is less common as a result of normal behavioral patterns such as bedtime and staying indoors when dark (Bellisle et al., 1988).

School Meal Policies and Implementation

The school meal program originally began as a lunch program in 1946 and has now expanded to include breakfast and after-school programs. The school breakfast program (SBP), like the school lunch program, provides funding and guidelines for schools to serve meals for their students. As of 2011 the SBP served over 12 million children per day and operates in over 89,000 public and non-profit private schools and residential childcare institutions from kindergarten to 12th grade (USDA, 2012). It should be noted that of the roughly 12 million served, 10.1 million children received their meals at free or reduced prices. Current dietary regulations for schools are based on the *Dietary Guidelines for Americans* (DGA) ("Dietary Guidelines for Americans," 2010). Developed by the USDA, the DGA provides the rules for how these regulations are to be followed. Specifically, meals must not contain more than 30% of calories from fat and no more than 10% of their calories should be from saturated fats ("Dietary Guidelines for Americans," 2010). School breakfasts must provide a fourth of the Recommended Dietary Allowance (RDA) for calories, protein, and other nutrients ("Dietary Guidelines for Americans," 2010). Federal standards set forth by the DGA are minimum requirements; necessary to be eligible for federal funding as part of the national school meal program. However, administrative units for school meal programs can develop more stringent nutritional standards if they wish.

The current nutritional regulations were shaped by prior evaluations of school meal programs. Originally there were concerns about the extent to which school lunches met nutritional goals, especially with respect to percent of calories from fat (Burghardt & Devaney, 1993). In response to these concerns, the Healthy Meals for Healthy Americans Act of 1994 required schools to provide meals that were consistent with the DGA in order to be eligible for federal school meal funding. Subsequent nutritional evaluations of school lunches have shown some improvements, (Fox et al., 2001), though the majority of schools continued to not meet guidelines (Fox et al., 2001; Gordon et al., 2009). The school breakfast program, unlike the school lunch program, has been found mostly fall in line with DGA: according to the most recent school meal evaluation in 2005, more than 90% of schools met nutritional standards for their breakfast program, compared with 20% for lunch programs (Gordon et al., 2009). Among schools offering breakfast, 88% served breakfasts that met the total fat benchmark and 75% met the saturated fat benchmark (Gordon et al., 2009). When looking at what children actually consumed from the meals provided to them, it was shown that 81% and 69% of schools met the benchmark for total fat and saturated fats respectively (Gordon et al., 2009).

School Breakfast, Nutrition, and Obesity Risks

Since breakfast has been associated with improved weight outcome, school breakfasts have become a potential tool to address childhood obesity (Dubois et al., 2006; Haerens et al., 2010; Ma et al., 2003; Timlin et al., 2008). In the first School Nutrition Dietary Assessment (SNDA I), using data collected in 1992, it was found that among a nationally representative sample of 3350 students in grades 1-12, caloric intake from breakfast program meals generally falls in line with RDA recommendations. Total daily energy consumption was similar among children who did and did not participate in the SBP (Burghardt et al., 1995). In a study using the same sample of students it was found that higher intakes of some nutrients among SBP participants appeared to be a result of their consumption of larger amounts of food, rather than from consumption of more nutrient-dense foods (Gordon et al., 1995). Additionally, though SBP participants consumed more calories at breakfast than non-participants, there was no statistically significant difference in caloric consumption over the course of the 24 hour recall period, indicating that participants ate fewer calories over the rest of the 24 hour study period (Gordon et al., 1995).

The most recent School Nutrition and Dietary assessment study found that a one-breakfast-per week increase in usual school breakfast program participation was associated with a 0.15 point decline in BMI ($p<XXX$, $n=2314$)—SBP participants also had significantly lower BMI z-scores compared to non-participants. Another published study by Bhattacharya et al., used a nationally representative sample of children ages 5-16 from the NHANES study to examine the relationship between the SBP and nutrition. Using a difference-in-difference study design to control for unobserved differences between SPB participants and non-participants, SBP participants were found to have many significantly improved nutritional outcomes: SBP participants had higher composite healthy eating index scores (63.03 for participants compared to 60.93 for non-participants), consumed a lower percentage of calories from fat, and had a lower probability of consuming low fiber diets (Bhattacharya et al., 2004). An important result was that SBP participants did not have a significantly higher calorie intake compared to non-participants, indicating that their better nutritional indicators were a result of eating healthier food rather than eating a larger quantity of less healthy food. Despite the positive outcomes on dietary intake, the longer-term effects of SBP participation on weight status was not examined (Bhattacharya et al., 2004).

While other studies have focused on just school meal participation and a potential link to obesity, this study will examine the association between the school breakfast program and obesity; both at the school and individual level, using cross-sectional and longitudinal models. Specifically, we will examine (1) how school breakfast program (SBP) participation (at the school level) affects the likelihood of consuming school breakfasts, (2) whether SBP participation (at the school level) is associated with obesity and (3) whether participation in the SBP (at the individual level) is associated with obesity. In addition to these analyses we examined whether these associations were modified by the student's family meal environments and other school level factors.

Data

The data used in this study are from the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K), developed by the National Center for Education Statistics (NCES) of the US Department of Education.(U.S. Department of Education - National Center for Education Statistics, 2006) This study of children's early school experiences followed a cohort of children from kindergarten into 8th grade. Multistage probability sampling was used to select an originally nationally representative sample (though through attrition this sample did not remain nationally representative during the 5th and 8th grade years) and data was collected from 1998 to 2007. (Tourangeau et al., 2006) We use data from the 5th and 8th grade waves, which included information about food and drink consumption from parents, children and school administrators.

The size of our sample varied depending upon the given school year, and the completion of the school meals portion of our survey. The dummy variable adjustment method was used to retain children who were missing information for our control variables. For variables with missing values, we assigned an arbitrary constant in place of the missing value. In addition, we created a dichotomous indicator equal to 1 for any observations where missing values were replaced by the arbitrary constant. The breakfast variables, race, gender, age, and census region were not dummy variable adjusted. Appropriate weights and survey adjustments were used to ensure the representative nature of the data (Tourangeau et al., 2009).

Variables

In the ECLS-K questionnaire parents were asked "During the last five days (child) was in school, how many school breakfasts did (he/she) receive?" where responses ranged from 0-5. Based on this question, two variables were created to characterize school breakfast consumption: the first is a continuous variable ranging from 0 to 5 equal to the number of school breakfast consumed by a child in the past week; the second is a dichotomous indicator equal to 1 if a child ate any school breakfast in the past week. In order to assess any associations related to the availability of school breakfasts, a dichotomous indicator was created and equal to 1 if parents answered yes to the question, "Does (child)'s school offer breakfast for its students?".

The ECLS-K records height and weight, each measured twice per wave by trained assessors. Height was measured in inches to the nearest 0.25 inch using a Shorr Board and weight was measured in pounds using a digital scale (U.S. Department of Education - National Center for Education Statistics, 2004). This presents a significant advantage over other nationally representative studies, which collect self-reported or parent-reported weight and height—methods documented to be systematically biased.(Bogaert et al., 2003; Datar et al., 2004). We use the CDC growth reference charts for school-aged children to give us adjusted BMI scores based on a representative sample of American children, controlling for age and gender, . These were calculated using a CDC-developed SAS macro (Kuczmarski et al., 2002). BMI z-scores greater than or equal to 1.96 ($\geq 95^{th}$ percentile) were coded as obese and BMI z-scores less than 1.96 and greater than or equal to 1.4395 as overweight ($\geq 85^{th}$ percentile) (Must & Anderson, 2006). Individuals with a BMI z-score less than 1.4395 were considered normal-weight (Must & Anderson, 2006). Normal-weight and overweight individuals were grouped together for most of the stratified and binary logistic analyses.

Analyses accounted for several factors that may be associated with children's weight and with breakfast patterns. We used two indicators of home meal environments: Parents were asked, "In a typical week, please tell me the number of days at least some of the family eats breakfast together," with values ranging from 0-7. They were also asked, "In a typical week, please tell me the number of days the family ate dinner together" with valid responses ranging from 0-7. Children's activity level was included as a continuous variable ranging from 0-7 equal to the number of days in the past week a child exercised for at least 20 minutes. This question was asked to parents and only available for the 5th grade wave but was used in all the models.

Child characteristics that have been shown to be related to weight include gender, race/ethnicity, age, and socioeconomic status, all of which were included as control variables. Gender was included as a dichotomous variable equal to 1 if a child was male. Race was included as 3 dichotomous dummy variables for black, Hispanic, and Asian/other race with white omitted as a reference group. Age was included as 2 dichotomous dummy variables for ages 11 to 11.4 years old and ages 11.5 to 13.8 years old with ages 9.2 to 10.9 years old omitted as a reference group. Socio-economic controls include an SES scale created in the ECLS-K based on data about parents' occupational prestige and income, and maternal employment. The SES quintile variable was included as dichotomous dummy variables with the first quintile omitted as a reference group. A dichotomous variable equal to 1 for children who lived in families below the federal poverty line was included for models assessing the interaction of poverty and school breakfast consumption. Maternal employment status was included as 2 dichotomous dummy variables for part-time employment and full-time employment with unemployed omitted as a reference group. Parental marital status was included as a dichotomous variable equal to 1 if a child's parents were married at the time the survey was administered. A dichotomous variable equal to 1 for children that changed schools between 5th and 8th grade was also included to control for changes in school environments.

School characteristics that can be correlated to weight were included in the analyses as well. These include school type, census region, and urban status. School type was included as dichotomous variable equal to 1 if a school was public. We also control for US region and whether the child lives in an urban, suburban, or rural area. Census region was included as 3 dichotomous dummy variables for the Midwest, South, and West with the Northeast omitted as a reference group. Urban status was included as 2 dichotomous variables for large/mid-size suburb and large town and small town/rural with large/mid-size city omitted as a reference group.

Statistical analyses

SAS9.3 was used to conduct the analyses presented in this paper(Institute, 2011).. The association between school breakfast consumption and school breakfast availability was examined using three linear regression models: cross-sectional models for the 5th and 8th grade years and a fixed effects longitudinal model. The primary predictor was the dichotomous school breakfast available variable; the primary outcome was the continuous measure of the number of school breakfasts consumed in the past week. The two cross sectional models controlled for all covariates. Gender, race/ethnicity, SES quintiles, activity level, and school dropped out of the fixed effects models due to no variation between 5th and 8th grade. The fixed effects model additionally included a dichotomous indicator equal to 1 if data was from the 8th grade survey wave. All models controlled for dummy variable adjusted data.

The bivariate association between the main predictor variables and obesity was examined two ways. First, two sample t-tests were conducted to determine statistically significant differences in variable means between obese and non-obese children. Second, bivariate logistic regressions were conducted between a dichotomous variable equal to 1 if a child was obese and three measures of school breakfast: the continuous variable for number of school breakfasts consumed in the past week, the dichotomous variable equal to 1 if a child consumed any school breakfast in the past week, and the dichotomous variable equal to 1 if breakfast was available at a school.

The association between school breakfast and obesity controlling for relevant variables was examined using multivariable logistic regression models in four specifications: pooled cross-sectional models for the 5th and 8th grade years, longitudinal models that used 5th grade variables to predict 8th grade obesity, and fixed effect longitudinal models. The primary outcome for all models was the dichotomous indicator equal to 1 if a child was obese. Within each specification, 3 separate regressions were conducted corresponding to each of the 3 school breakfast predictors of interest. These regressions were also conducted after omitting the number of breakfasts eaten together as a family variable to investigate whether the inclusion of this variable affected the magnitude of the main predictors. The cross-sectional and 5th grade predicting 8th grade models controlled for all covariates; gender, race/ethnicity, SES quintiles, activity level, and school change dropped out of the fixed effects models due to no variation between 5th and 8th grade. All models controlled for dummy variable adjusted data.

The relationship between school breakfast and obesity was further examined within schools that provide school breakfast using multivariable logistic regression models in four specifications: pooled cross-sectional models for the 5th and 8th grade years, longitudinal models that used 5th grade variables to predict 8th grade obesity, and fixed effects longitudinal models. The primary outcome for all models was the dichotomous indicator equal to 1 if a child was obese. Within each specification, 2 separate regressions were conducted corresponding to 2 predictors of interest: (1) the continuous measure of the number of school breakfasts consumed in the past week; and (2) the dichotomous indicator equal to 1 if a child ate any school breakfast in the past week. The cross-sectional and 5th grade predicting 8th grade models controlled for all covariates; gender, race/ethnicity, SES quintiles, activity level, and school change dropped out of the fixed effects models due to no variation between 5th and 8th grade. All models controlled for dummy variable adjusted data.

The interaction of the school breakfast variables and poverty status on obesity was examined using two sets of multivariable logistic regression models in three specifications: pooled cross-sectional models for the 5th and 8th grade years and longitudinal models that used 5th grade variables to predict 8th grade obesity. First, simple regression models were estimated with just the school breakfast indicator, dichotomous poverty indicator, and the interaction term of specific school breakfast indicator and poverty status. A second set of regression models were then estimated controlling for all covariates except wealth quintiles. Wealth quintiles were dropped from the interaction model because they were highly correlated with the poverty status indicator and could potentially bias the coefficient estimates of the interaction and poverty variables. Fixed effects models were not possible since the indicator for poverty status did not vary between years.

Results

Of the 7,290 children included in our sample of the 5th grade wave, 896, or 12.3%, were obese according to the CDC growth chart definitions (Table 1). Most of the children attended schools that offered breakfast (76%). On average, children did not consume many school breakfasts in the week prior to being interviewed (1.07), and only 23.7% of children reported eating at least 1 school breakfast. Most of the children in the sample attended a public school (88.6%) with the greatest proportion of children attending schools in the South (37.9%). In the 5th grade, the greatest proportion of children (44.9%) was between ages 11 and 11.4 with a near equal number of male and female children (50.7% male). The majority of children were white (57.3%) with Hispanic children as the second largest group (18.8%).

Based on two-sample t-tests comparing obese and not-obese children, obese children were found to consume a greater number of school breakfasts per week (1.46 breakfasts per week compared to 1.02 breakfasts per week) and were more likely to have consumed any school breakfast (31.7% compared to 22.6%). However, obese children were more likely to attend a school that serves breakfast (85.3% compared to 74.8%), which might partially explain the association between school breakfast consumption and obesity.

When looking at the bivariate regression results in all 3 specifications, we find evidence that school breakfast availability increases the number of school breakfasts consumed per week by children. Compared to children who attended schools that did not serve breakfast, children who attended schools that served breakfast consumed more breakfasts per week in the 5th grade, 8th grade, and longitudinal fixed effects model (0.64 more breakfasts per week in the 5th grade, 0.70 more breakfasts per week in the 8th grade, and 0.68 more breakfasts per week in the longitudinal fixed effects model).

Table 3 shows the results of bivariate logistic regression models that estimate the effect of school breakfast consumption and availability on children's obesity. In the 5th grade, 8th grade, and 5th grade predicting 8th grade bivariate models, we find significant evidence that school breakfast consumption increases the likelihood of obesity in children. The effect of a one-breakfast increase in school breakfast consumption was fairly consistent across the model specifications: we estimated that consuming one additional breakfast was associated with a 10-15% point increase in the probability that the child was obese (in the 5th grade model, a one-breakfast increase in the number of school breakfasts consumed per week was associated with a 10% point increase in the probability that a child was obese; in the 8th grade model a one-breakfast increase in the number of school breakfasts consumed per week was associated with a 15% point increase in the probability that a child was obese; finally, a one-breakfast increase in the number of school breakfasts consumed per week in the 5th grade was associated with a 10% point increase in the probability that a child is obese in the 8th grade). The bivariate relationship between school breakfast consumption and obesity persisted when comparing children who consumed at least 1 breakfast in the past week to those who consumed none. Children who consumed any school breakfast had a far greater probability of being obese compared to children who did not consume any school breakfast (46% point higher likelihood of being obese in the 5th grade; 68% point higher likelihood of being obese in the 8th grade; 49% point higher likelihood of being obese in the 5th grade predicting 8th grade longitudinal model). The marginal effect of consuming any school breakfast compared to consuming no breakfast was much higher than the linear effect of one additional breakfast consumed per week.

Table 3 also shows the results of bivariate logistic regression models estimating the effect of school breakfast availability on whether a child was obese—showing strong evidence that children who attend schools where breakfast is available have a higher likelihood of being obese (67% point higher likelihood in the 5th grade, 68% point higher likelihood in the 8th grade, and 68% point higher likelihood in the longitudinal 5th grade predicting 8th grade model). Significant coefficients were not estimated for any of the bivariate fixed effects regressions, which may reflect a combination of fixed effects sample restrictions and bias from unobserved time-invariant differences between children.

Although significant positive results were estimated in the bivariate models, these results, with the exception of some school breakfast availability effects, were not significant after the inclusion of child, household, and school control variables (Table 4). Furthermore, after including the control variables, the effect of the school breakfast variables on obesity attenuated. For example, in the 5th grade sample, the effect of a one breakfast increase in the number of school breakfasts consumed per week went down to a 2% point increase in the likelihood that the child was obese, with a similar trend in the 8th grade. The effect of any school breakfast consumption also attenuated substantially: in the 5th grade sample, children who consumed any school breakfast in the past week had am only 6% point increase in the likelihood of being obese compared to children who did not consume any school breakfast.

To investigate whether the effect of school breakfast consumption was only detectable for children who attended schools that served breakfast, we estimated regression models only children who attended schools where school breakfast was available (Table 5). After controlling for child, school, and household variables no significant effects were estimated for school breakfast consumption in any of the model specifications. Comparing this subsample to the overall sample of children, the effect of school breakfast consumption further attenuated. The effects of both a one-breakfast increase in the number of school breakfasts consumed per week and any school breakfast consumption were smaller than the effect in the overall sample.

The only statistically significant association in the multivariable models was between school breakfast availability and obesity for the full 5th grade sample, where children who attended a school that served breakfast were 54% points more likely to be obese compared to children that attended a school that did not serve breakfast. However, this estimate was not significant in the 8th grade. All estimates from both longitudinal specifications were not significant in the multivariable models. To see if alternate specifications of the outcome variable changed the effect of school breakfast, we estimated regression models for the effect of school breakfast on both BMI z-scores and a dichotomous indicator for whether a child was overweight or obese (See appendix). The direction of the effect of school breakfast consumption estimated in our results was robust to these alternative specifications; however, none of the effects were significant after controlling for child, household, and school variables.

Finally, we estimated a series of logistic regressions to examine whether the effect of consuming school breakfast is different for children who come from families above and below the federal poverty line. This interaction between poverty status and school breakfast consumption was first examined with simple regression models that just contained the school breakfast indicator, poverty status indicator, and interaction term (Table 6). In all the models, children below the poverty line who did not consume breakfast had a higher likelihood of being obese compared to children above the poverty line who did not consume breakfast; however, this effect was not statistically significant. We did, however, find evidence that the effect of school breakfast consumption varies by poverty status. For children above the poverty line, a one-breakfast increase in school breakfasts consumed per week was associated with a 16% point increase in the likelihood that the child was obese in the 5th grade, and a 20% point increase in the 8th grade. Furthermore, consumption of any breakfast was associated with a 75% point increase in the likelihood that the child was obese in the 5th grade, and a 93% point increase in the 8th grade. For children below the poverty line, consuming school breakfast was associated with a reduction in the likelihood of obesity compared to children below the poverty line that did not consume school breakfast. In the 5th grade, a one-breakfast increase in school breakfasts consumed per week was associated with a 2% point reduction in the likelihood that the child was obese; consuming at least 1 breakfast per week was associated with a 13% reduction in likelihood that the child was obese. Although we estimated significant interaction terms for the 8th grade sample as well, the protective interaction effect was not large enough to mediate the effect of school breakfast consumption. Consuming school breakfast still increased the likelihood that the child was obese for children below the poverty line, but the magnitude of this increase was smaller compared to children above the poverty line.

Only one estimate was statistically robust to the inclusion of the child, household, and school controls: in the 5th grade, we continue to find evidence that consumption of at least one breakfast per week increases the likelihood of obesity for children above the poverty line and reduces it for children below the poverty line (41% point increase in the likelihood of obesity for children above the poverty line and a 9% point reduction for children below the poverty line) (Table 7). However, coefficients that lost significance maintained similar effect sizes and directions with p-values right outside the 5% cutoff. For such "marginally" significant results, more data might have kept the estimates robust to the inclusion of controls.

Discussion

In this analysis of the school breakfast environment, little evidence was found to indicate an association between school breakfasts and obesity. School breakfast participation by schools was shown to significantly increase the likelihood of school breakfast consumption among their student populations, as we would expect to see. This indicates that school breakfast is effective in increasing school breakfast consumption among children who participate in the program.

The linear bivariate analyses indicated a significant positive association between SBP participation and obesity (0.15 ($P>0.001$)). This positive association to obesity was also seen at the school level with breakfast availability (0.68 ($P>0.001$)). However in the multivariate analyses controlling for student characteristics, socioeconomic status, family structure, school type, and family meal environments these associations to obesity did not remain. It should be noted that the direction of the non-significant association remained positive, however these associations were much reduced compared to their bivariate counterparts. Since the school breakfast program is primarily used by those of lower socioeconomic status, it is probable that the bivariate associations between school breakfast consumption and obesity are a reflection of different populations of students both at the school and individual levels.

Interestingly, when looking at the interaction between household poverty and school breakfast participation there was evidence to indicate that participation in school breakfast decreased the odds of being obese among those children who were classified as poor. Similar coefficients for the interaction terms were found across each of the three model specifications showing that school breakfast participation and household poverty were associated with lower odds of obesity. Though statistical significance varied for these models, the similarity of the coefficients provide an intriguing case where school breakfasts have differing effects based on socioeconomic factors of the individual. Since the majority of school breakfasts participants come from families of lower socioeconomic status, this result has strong potential significance for policy makers and should be examined further.

Since the analyses above would only identify individuals who went into or out of the obese category, other analyses using BMI z-scores and an overweight binary category were conducted to look for smaller weight changes. Using a linear and logistic multivariate regression models, no significant association was found between school breakfast participation and either of these weight change outcomes (see Appendix Table 2).

Our results are robust to alternative specifications including multilevel specifications of breakfast consumption, using binary and ordinal measures of school breakfast participation. The results also remained robust even when a subsample containing only children whose school participated in the school breakfast program was used (see Appendix Table 3). Since schools that provide breakfast tend to have similar characteristics, the exposed and unexposed students in this subsample were more similar to each other than the full sample. That no significant association was found strongly promotes the idea that school breakfast consumption is not associated with deleterious weight outcomes while controlling for unanticipated confounders. We also attempted to control for differences in family meal patterns, and again, no association was found when controlling for family breakfast habits in the multivariable logistic model (See Appendix 1). These results suggest that the relationship between school breakfast consumption and weight outcomes are not significantly different between the two student groups and that school breakfast does not deleteriously affect the home meal environment.

The results of this study are based on the answers given by both school administrators (breakfast availability) and children (number of days school breakfast consumed). As a result we are basing these results on the assumption that the children understood the questions being asked in regards to frequency of school breakfast consumption as opposed to home breakfast consumption. Although this could introduce bias into the results, we do not expect it to be systematic, with children of different weights being more or less likely to misunderstand the questions in the survey. Additionally, there is the possibility that social stigma, related to undesirable foods on the menu and choosing to eat free meals (Bailey-Davis et al., 2013) led to an underreporting of school breakfast consumption. If this were the case, it is possible that we are underestimating the association between school breakfast consumption and obesity. However the robustness of each of our models shows that this is not likely since the bivariate school breakfast consumption variable (any consumption/ no consumption) showed no significant changes in the multivariate models compared to the ordinal multivariate model. We also think that it is unlikely that school administrators misunderstood the question and answered correctly.

The study's strengths include the dataset which provided this analysis with a nationally representative longitudinal population with a large sample size. The ECLS-K is the only nationally representative dataset to include direct measures of weight and height for participating children. Finally, being a longitudinal dataset we include individual fixed effects, which can control for unobserved heterogeneity that can confound cross- sectional analyses. Additionally, the ECLS-K is the only study of its size to collect detailed information on frequency of school breakfast consumption for the children surveyed.

The results of the cross-sectional and longitudinal multivariate analyses done here foun no evidence of an association between school breakfast participation and obesity among American middle school children. This is a crucial finding since the published literature is quite clear that breakfast consumption leads to improved weight outcomes and improved scholastic performance (Dubois et al., 2009; Haerens et al., 2010; Mahoney et al., 2005; G. Rampersaud, 2005; Timlin et al., 2008). However we also found evidence that school breakfast participation has different effects across different populations We found that school breakfast participation for children from households below the poverty line decreased the odds of being obese, though these results were marginally significant. Since a large portion of school breakfast participants come from these low socioeconomic backgrounds, these findings show that the school breakfast program could be a useful tool to provide children with a balanced and nutritious diet, especially for those who do not regularly eat a morning meal. In further analyses, it will be important to look at the effects of the school breakfast program on dietary quality. Fortunately the ECLS-K dataset is uniquely suited for this analysis since it has self-reported dietary frequency data.

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Table 1

Descriptive statistics overall and by obesity status, 5th grade children, ECLS-K Wave 6, United States.

	Not Obese (N=6394)		Obese (N=896)		Overall (N=7290)		
	Mean or %	SE	Mean or %	SE	Mean or %	SE	t test
Breakfast Variables							
Number of breakfasts eaten at school in a week	1.02	0.07	1.46	0.13	1.07	0.07	**
Child ate at least 1 breakfast at school in a week	22.6	1.5	31.7	2.71	23.7	1.45	**
School Serves Breakfast	74.8	1.41	85.3	1.58	76	1.32	***
Child Variables							
BMI Z-Score	0.42	0.02	2.24	0.01	0.65	0.02	***
Male	49.9	1.01	57	2.42	50.7	0.92	**
Age Groups							
9.2 to 10.9 years old	29.6	1.05	36.1	2.66	30.4	1.03	
11 to 11.4 years old	45	1.19	44.3	3.09	44.9	1.19	
11.5 to 13.8 years old	25.4	1.23	19.6	1.99	24.7	1.2	**
Race/Ethnicity							
White	59.4	1.72	42.6	3.25	57.3	1.73	***
Black	16.3	1.25	20.3	3	16.8	1.29	
Hispanic	17.4	1.46	28.6	2.35	18.8	1.39	***
Asian and other	6.9	0.94	8.6	1.92	7.1	0.99	***
Number of days child exercised in a week	3.81	0.04	3.24	0.09	3.74	0.04	***
Child Changed School Between 5th and 8th Grade	84	1.2	82.7	2.29	83.9	1.24	
Household Variables							
SES Quintiles							
1	17.5	1.26	26.9	2.73	18.7	1.2	**
2	17.7	0.79	23	1.81	18.3	0.75	**
3	19.4	0.8	18.5	1.9	19.3	0.7	

		6		1		7	
4	21.8	0.88	18.9	2.07	21.4	0.8	
5	23.7	1.07	12.7	1.88	22.3	1	***
Parents are Married	69.7	1.34	64.5	2.88	69	1.33	
Number of breakfasts family ate together in a week	3.56	0.05	3.14	0.13	3.50	0.05	**
Number of dinners family ate together in a week	5.46	0.04	5.41	0.09	5.46	0.03	
Mother's Employment Status							
Unemployed	25.8	1.05	26.8	2.15	25.9	0.97	
Part Time	23.3	0.9	17.1	1.97	22.6	0.84	***
Full Time	50.9	1.11	56.1	2.33	51.6	1.01	*
School Variables							
Public School	88.0	0.88	93.2	1.07	88.6	0.80	
Census Region							
Northeast	18.5	1.05	19.3	2.2	18.6	1.02	
Midwest	25.4	1.9	18.1	2.06	24.5	1.81	**
South	37.3	1.69	42.7	2.49	37.9	1.61	*
West	18.9	1.02	19.9	1.91	19	0.96	
Urban Status							
Large and Mid-Size City	34.9	1.74	38.9	2.92	35.4	1.65	
Large and Mid-Size Suburb and Large Town	42.3	2.96	35.6	4.71	41.5	3.02	
Small Town and Rural	22.8	2.8	25.6	4.4	23.1	2.9	

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

Notes: Sample means and standard errors are survey adjusted. 5th grade corresponds to wave 6 of the ECLS-K.

Table 2

Estimated relationships between school breakfast availability and the number of school breakfasts consumed per week, ECLS-K Waves 6 and 7, 5th and 8th grade children, United States.

Variable (Reference Group)	5th Grade	8th Grade	Fixed Effects
School Serves Breakfast	0.64*** (0.09)	0.70*** (0.09)	0.68*** (0.12)
Child Variables			
Male (Female)	0.13 (0.08)	0.17** (0.07)	
Age (9.2 to 10.9 years old)			
11 to 11.4 years old	0.06 (0.09)	0.09 (0.08)	0.25* (0.11)
11.5 to 13.8 years old	0.11 (0.11)	0.33*** (0.10)	0.31* (0.15)
Race/Ethnicity (White)			
Black	0.95*** (0.18)	0.83*** (0.17)	
Hispanic	0.52*** (0.11)	0.49*** (0.10)	
Asian or other	0.45 (0.25)	0.77** (0.29)	
Number of days child exercised in a week	0.01 (0.02)	0.03 (0.02)	
Child Changed School Between 5th and 8th Grade	-0.02 (0.10)	-0.17 (0.09)	
Household Variables			
SES Quintiles (1)			
2	-1.07*** (0.15)	-0.89*** (0.16)	
3	-1.23*** (0.15)	-1.06*** (0.14)	
4	-1.59*** (0.14)	-1.27*** (0.14)	
5	-1.52*** (0.13)	-1.36*** (0.13)	
Parents are Married	-0.50*** (0.10)	-0.52*** (0.12)	-0.40*** (0.11)
Number of breakfasts family ate together in a week	-0.09*** (0.01)	-0.08*** (0.02)	-0.07*** (0.02)
Number of dinners family ate together in a week	0.07** (0.02)	0.07** (0.02)	0.00 (0.02)
Mother's Employment Status (Unemployed)			
Part-Time	-0.09 (0.09)	-0.40*** (0.11)	-0.17 (0.12)
Full-Time	-0.23** (0.08)	-0.44*** (0.10)	-0.08 (0.12)
School Variables			
Public School (Private School)	-0.01 (0.11)	-0.01 (0.10)	-0.25* (0.11)
Census Region (Northeast)			
Midwest	0.18 (0.13)	0.08 (0.13)	1.56* (0.77)
South	0.35** (0.13)	0.28* (0.11)	-0.24 (0.17)
West	-0.08 (0.11)	-0.08 (0.11)	1.00* (0.42)
Urban Status (Large and Mid-Size City)			
Large and Mid-Size Suburb and Large Town	-0.20 (0.13)	-0.29* (0.13)	0.19 (0.13)
Small Town and Rural	0.13 (0.16)	-0.16 (0.14)	-0.09 (0.18)
Data were dummy variable adjusted	-0.23 (0.54)	-0.08 (0.40)	-0.60* (0.26)
8th Grade Survey Wave (7th Grade Survey Wave)			-0.14** (0.05)
N	7056	6724	6890

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Standard errors in parentheses

Notes: Results were estimated using linear regression models. Cross-sectional models are survey adjusted by weight, strata, and primary sampling unit. Fixed effects models are weighted and stratified but do not account for primary sampling units. The fixed effects regressions have 2 observations per child. Covariates that are missing from the fixed effect model were automatically dropped due to colinearity. Categorical variables were entered as dummies with one factor level omitted.

Table 3

Estimated bivariate relationships between school breakfast indicators and children's obesity status, ECLS-K Waves 6 and 7, 5th and 8th grade children, United States.

	5th Grade	8th Grade	5th Predicting 8th	Fixed Effects
Number of school breakfasts consumed in the last week	0.10*** (0.03)	0.15*** (0.03)	0.10*** (0.03)	0.04 (0.05)
N	7256	7133	7256	900
Any school breakfast consumed in the last week	0.46*** (0.13)	0.68*** (0.14)	0.49*** (0.14)	0.06 (0.25)
N	7256	7133	7256	900
School breakfast available	0.67*** (0.12)	0.68*** (0.17)	0.66*** (0.15)	0.16 (0.28)
N	7160	6852	7160	858

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Standard errors are shown in parentheses.

Notes: Results were estimated using logistic regression models. Coefficients are presented as marginal effects. Cross-sectional models are survey adjusted by weight, strata, and primary sampling unit. Fixed effects models are not survey adjusted. Each coefficient and standard error pair is from 1 regression, for a total of 12 regressions in the table. The fixed effects regressions have 2 observations per child.

Table 4

Estimated multivariable relationships between school breakfast indicators and children's dichotomous obesity status, ECLS-K Waves 6 and 7, 5th and 8th grade children, United States.

	5th Grade	8th Grade	5th Predicting 8th	Fixed Effects
Number of school breakfasts consumed in the last week	0.02 (0.04)	0.07 (0.04)	0.03 (0.04)	-0.02 (0.06)
N	7236	7099	7236	898
Any school breakfast consumed in the last week	0.06 (0.19)	0.31 (0.18)	0.13 (0.19)	-0.17 (0.28)
N	7236	7099	7236	898
School breakfast available	0.54** (0.20)	0.31 (0.20)	0.36 (0.21)	0.23 (0.32)
N	7141	6820	7141	856

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Standard errors are shown in parentheses.

Notes: Results were estimated using logistic regression models. Coefficients are presented as marginal effects. Models control for sex, age, socioeconomic status quintiles, race/ethnicity, parental marital status, children who changed schools between waves, school type, number of breakfasts family ate together, number of dinners family ate together, 5th grade child exercise level, maternal employment, census region, and urban status. Fixed effects model additionally control for survey wave. Cross-sectional models are survey adjusted by weight, strata, and primary sampling unit. Fixed effects models are not survey adjusted. Each coefficient and standard error pair is from 1 regression, for a total of 12 regressions in the table. The fixed effects regressions have 2 observations per child.

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Table 5

Estimated relationships between school breakfast consumption and children's obesity among children attending schools where breakfast is available, ECLS-K Waves 6 and 7, 5th and 8th grade children, United States.

	5th Grade	8th Grade	5th Predicting 8th	Fixed Effects
Number of school breakfasts consumed in the last week	0.01 (0.04)	0.06 (0.04)	0.02 (0.04)	-0.04 (0.07)
N	4837	4824	4837	602
Any school breakfast consumed in the last week	0.01 (0.19)	0.29 (0.19)	0.11 (0.20)	-0.25 (0.30)
N	4837	4824	4837	602

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$; Standard errors are shown in parentheses.

Notes: Results were estimated using logistic regression models. Coefficients are presented as marginal effects. Models control for sex, age, socioeconomic status quintiles, race/ethnicity, parental marital status, children who changed schools between waves, school type, number of breakfasts family ate together, number of dinners family ate together, 5th grade child exercise level, maternal employment, census region, and urban status. Fixed effects model additionally control for survey wave. Cross-sectional models are survey adjusted by weight, strata, and primary sampling unit. Fixed effects models are not survey. Each coefficient and standard error pair is from 1 regression, for a total of 8 regressions in the table. The fixed effects regressions have 2 observations per child.

Table 6

Estimated interaction effect between school breakfast indicators and poverty status on children's obesity status, ECLS-K Waves 6 and 7, 5th and 8th grade children, United States.

	5th Grade	8th Grade	5th Predicting 8th
Number of school breakfasts consumed in the last week	0.16^{***} (0.04)	0.20^{***} (0.04)	0.13^{***} (0.04)
Child is below the poverty line	0.38 (0.21)	0.32 (0.20)	0.35 (0.25)
Number of school breakfasts consumed in the last week*Below the poverty line	-0.18^{**} (0.07)	-0.15^{*} (0.06)	-0.12 (0.07)
N	7256	7133	7256
Any school breakfast consumed in the last week	0.75^{***} (0.18)	0.93^{***} (0.20)	0.66^{***} (0.18)
Child is below the poverty line	0.41 (0.21)	0.34 (0.20)	0.37 (0.26)
Any school breakfast consumed in the last week*Below the poverty line	-0.88^{**} (0.32)	-0.73^{*} (0.29)	-0.61 (0.35)
N	7256	7133	7256
School breakfast available	0.66^{***} (0.13)	0.65^{***} (0.18)	0.63^{***} (0.16)
Child is below the poverty line	0.21 (0.39)	0.21 (0.42)	0.30 (0.42)
School breakfast available*Below the poverty line	-0.12 (0.42)	-0.03 (0.47)	-0.11 (0.44)
N	7160	6852	7160

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$; Standard errors are shown in parentheses.

Notes: Results were estimated using logistic regression models. Models included school breakfast indicator, poverty status indicator, and the interaction term. Coefficients are presented as marginal effects. Cross-sectional models are survey adjusted by weight, strata, and primary sampling unit. The coefficients for each cluster of school breakfast indicator, poverty status indicator, and interaction term is from 1 regression, for a total of 9 regressions in the table.

Table 7

Estimated interaction effect between school breakfast indicators and poverty status on children's obesity status controlling for relevant covariates, ECLS-K Waves 6 and 7, 5th and 8th grade children, United States.

	5th Grade		8th Grade		5th Predicting 8th	
Number of school breakfasts consumed in the last week	0.09	(0.05)	0.13**	(0.05)	0.06	(0.05)
Child is below the poverty line	0.14	(0.22)	0.06	(0.22)	0.05	(0.22)
Number of school breakfasts consumed in the last week*Below the poverty line	-0.13	(0.07)	-0.11	(0.07)	-0.05	(0.07)
N	7236		7099		7236	
Any school breakfast consumed in the last week	0.41	(0.22)	0.59**	(0.21)	0.34	(0.23)
Child is below the poverty line	0.18	(0.22)	0.07	(0.22)	0.09	(0.22)
Any school breakfast consumed in the last week*Below the poverty line	-0.68*	(0.34)	-0.51	(0.31)	-0.31	(0.35)
N	7236		7099		7236	
School breakfast available	0.64**	(0.20)	0.39	(0.22)	0.48*	(0.21)
Child is below the poverty line	0.11	(0.40)	-0.11	(0.39)	0.25	(0.45)
School breakfast available*Below the poverty line	-0.25	(0.43)	0.02	(0.44)	-0.29	(0.47)
N	7141		6820		7141	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Standard errors are shown in parentheses.

Notes: Results were estimated using logistic regression models. Models included school breakfast indicator, poverty status indicator, the interaction term, sex, age, race/ethnicity, parental marital status, children who changed schools between waves, school type, number of breakfasts family ate together, number of dinners family ate together, 5th grade child exercise level, maternal employment, census region, and urban status. Coefficients are presented as marginal effects. Cross-sectional models are survey adjusted by weight, strata, and primary sampling unit. The coefficients for each cluster of school breakfast indicator, poverty status indicator, and interaction term is from 1 regression, for a total of 9 regressions in the table.