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Sebastian Romano Date

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By

Sebastian Romano

Master of Public Health

Department of Global Epidemiology

____ [Faculty Thesis Advisor's signature]

Dr. William McClellan

Faculty Thesis Advisor

____ [Field Advisor's signature]

Dr. Solveig Argeseanu Cunningham

Thesis Field Advisor

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Sebastian Romano

B.S., University of Georgia, 2008

Faculty Thesis Advisors:

Solveig Argeseanu Cunningham PhD, MA, MSc

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An abstract of

A thesis submitted to the Faculty of the
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Abstract

Associations Between School Breakfasts and Weight Gain Among American Middle School Children

By Sebastian Romano

Obesity has become a major public health problem in America. In 2012 roughly 16.9% of children and adolescents ages 2-19 were at or above the 97th percentile of the 2000 BMI-for-age growth curves, more than double the prevalence of 7% in 1980. Recently, school meals have been given much attention because of their ubiquity and potential to give children well-balanced and healthy meals. This analysis will present attempt to determine whether there is a relationship between school breakfast participation and child weight status in fifth to eighth grade children. Using the nationally representative Early Childhood Longitudinal Study (ECLS-K) data set, initial multivariable cross-sectional models were conducted to test for associations between school breakfast participation and linear BMI z-score outcomes as well as logistic binary obese/ not obese outcomes. Prospective models were then used to test for associations between school breakfast participation and these outcomes over the three year study period. This analysis provides evidence that school breakfast participation was significantly associated to higher BMI z-scores. However no association was found between school breakfast participation and obesity. Results from the longitudinal analysis also found a positive association between school breakfast participation in the fifth grade and BMI z-scores in the eighth grade. Overall this analysis found evidence that school breakfasts are positively associated with BMI z-scores over time. However, there was no apparent association between school breakfast participation and the incidence of obesity. A longitudinal analysis of children at earlier developmental stages may provide differing results on the effects of school breakfasts. Also, an analysis of inter-school district policies for school breakfast may provide a more nuanced depiction the effects of the school breakfast program.

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INTRODUCTION

School meals have been widely studied in the literature due to their ubiquity in American schools. In 2010, 31 million children were given school lunches every day (1). As of 2009, over 11 million children participate in the School Breakfast Program across the United States, a majority of which are eligible for reduced price meals due to financial constraints (2).

The size of the school lunch program has led to more of a focus on its effects on weight gain compared to less common school breakfast programs. This, despite evidence that consuming breakfast is associated with improved weight status (3). There have been cross-sectional analyses conducted on school breakfasts; however it is not possible to take temporality into account with this study design. A longitudinal analysis of the effects of school breakfasts on weight status would provide stronger evidence for the positive or negative benefits associated with the school breakfast meal environment.

This study attempted to discern whether participation in school breakfast programs was associated with a change in obesity risk. It is unclear whether the quality of school meals may serve as an obesogenic factor for children or whether just eating breakfast can serve as a deterrent of obesity incidence. In order to examine the relationship between school breakfasts and obesity we used the Early Childhood Longitudinal Study (ECLS-K), a nationally representative longitudinal cohort study of over 6000 children. This analysis focused on children from the 5th and 8th grade data collection points to determine whether school breakfast participation was associated to obesity over time. Using an initial cross sectional model we determined whether there is an association between school breakfast consumption and weight gain present during the fifth and eighth grade years. This was followed by a longitudinal analysis in order to better understand the temporal relationship of these factors.

BACKGROUND

Obesity as a health problem

Childhood obesity has become a paramount concern for America over the past decade. The estimated prevalence of obesity among American children is 16.9% (4) according to data from 2010. This is more than twice the prevalence of obesity estimated in 1980 of 7% (5) and it is only recently that there has been evidence that the prevalence of obesity has begun to level off among children (4).

Obesity has been linked to numerous chronic diseases such as diabetes, cardiovascular disease, and osteoarthritis among others(6). Furthermore, children who are obese are at higher risk of being obese as adults thereby increasing their risk for non-communicable chronic diseases (7).

Along with the increased risk of physical ailments, obesity has been associated with higher levels of social marginalization (8). It has been shown that obese children were more likely to have fewer friends and be less involved in social activities such as sports and clubs (8). This lack of social support and activity opportunities can further exacerbate weight problems in children that, in turn, could lead to deleterious health outcomes.

Skipping breakfast and obesity

It has been postulated that breakfast consumption plays a protective role in the incidence of obesity. In a study using 24 dietary recalls, it was shown that individuals that did not consume breakfast for 75% of the days observed had significantly higher odds of obesity (OR=4.5 (1.57, 12.9)) compared to regular breakfast eaters (3). However this study used a small sample and the measurements made are subject to potential bias due to recall errors. In a cross-sectional analysis, by Timlin et al, there was a significant association between breakfast skipping and obesity (9). Furthermore, when examined prospectively, the authors found that breakfast skipping was associated with obesity in a dose-response manner (9). In a longitudinal study of pre-school aged children, Dubois found that the odds of being obese among breakfast skippers was 1.93 (1.16, 3.19) compared to breakfast eaters, controlling for a variety of social and economic confounding factors (10). Using a four-year prospective analysis of self-reported meal consumption habits it was found that regular breakfast consumption was associated with a statistically significant reduction in BMI z-scores compared to breakfast skippers (11).

As we have begun to understand breakfast's associations to obesity data has shown that breakfast consumption is declining for children of all ages. In 1965 89.7% of children ages 1-10 consumed breakfast; by 1991 the prevalence of breakfast consumption had lowered to 74.9% for this same age group (12). In 1965 84.4% of children aged 11-18 years consumed breakfasts, in 1991 the prevalence of breakfast consumption among this age group had lowered to 64.7% (12). Therefore the rate of breakfast consumption decreased even more rapidly among adolescents over time showing that this is a persistent trend and not an isolated occurrence particular to a certain phase of development (12). Further analysis showed that this trend was found to be predominantly due to behavioral changes rather than changing socio-demographic patterns (12). In a recent cross-sectional study of girls between the ages of nine and ten, it was found that there was a significant decrease in breakfast consumption as they grew older.

Approximately 77% and 57% of white and African American girls, respectively, at age 9 consumed breakfasts on each of the three days that 24-hour dietary recalls were conducted (13). By age 19 the prevalence of breakfast consumption during all three dietary recall days had lowered to 32% and 22% respectively (13). This strong effect on adolescent girls seems to suggest that skipping breakfast may be a form of dieting in this population. There is data supporting this theory with breakfast skipping girls more likely to be dissatisfied with their body shapes (14). However when asked directly through telephone follow-up interviews as to why they did not eat breakfast, these girls almost uniformly stated that they did not eat because they were not hungry or were in a rush (14). Though it appears that there is an association between breakfast and obesity, the temporality of this association must be examined further. Put more succinctly, are individuals skipping breakfast and then becoming overweight or are they skipping breakfast to alleviate their weight problem?

Indeed, other data examining the association between breakfast and obesity are less clear. In another cross-sectional analysis of breakfast consumption it was found that there was a significant relationship between breakfast consumption and BMI, with those that ate breakfast more frequently having a lower BMI compared to those who did not eat breakfast (15). However when this analysis was conducted in a longitudinal manner no significant association was seen between breakfast consumption and lower BMI (15). The authors believed that the inconsistent associations seen in their study could be due to reverse causality (obese individuals skip breakfast because they are overweight) or a lack of effective cohort data that is independent of physical activity measures (15).

Though there is evidence of a protective effect of breakfast on obesity, there are questions about how this effect can be explained. Some analyses have attempted to understand how this mechanism could work by comparing the eating habits of children who ate breakfast compared to those who skipped breakfast. Those who skipped breakfast were more likely to eat larger lunches and to eat more snacks in the afternoon and evening compared to breakfast eaters (16). Interestingly, breakfast skippers' mean BMI increased as energy intake increased, however this pattern was not apparent among breakfast eaters (16). This result shows that breakfast may play a role in preventing obesity through some hunger control mechanism. Alternatively, another possible way to explain these observations is that those who ate breakfast consumed less food later in the day when physical activity is less common (16).

Using a randomized clinical trial design, it was shown that adult women who ate breakfasts as part of the intervention had higher weight loss averages compared to women who did not eat breakfast while controlling for overall caloric intake (17). Both of the trial populations received the same amount of calories per day, however women who ate breakfast lost, on average, 2.7 kg more than breakfast skippers over a twelve-week period (17). Upon further examination of the dietary habit differences between the two groups, it was shown that those who ate breakfast had a lower average consumption of calories during lunch and dinner compared to breakfast skippers (17). Also of note, women who were breakfast skippers prior to the intervention and who were placed in the breakfast eating group during the intervention saw a significant decrease in implsive eating compared to those who skipped breakfast at baseline and during the randomized trial (17). Despite the promising results seen in this randomized control trial it is unclear whether the same outcomes would be seen in younger populations.

The school meal environment: regulation and practice

Current dietary regulations for schools are based on the *Dietary Guidelines for Americans* (DGA) (18). Developed by the USDA, the DGA provides the guidelines for how these regulations are to be followed. According to the DGA, meals must not contain more than 30% of their calories from fat, and no more than 10% of their calories are from saturated fats (18). School breakfasts must provide a fourth of the Recommended Dietary Allowance (RDA) for protein, calcium, iron, vitamin A, vitamin C, and calories (18). The DGA also has recommendations for sodium, cholesterol, Trans fats, and added sugars intake however there is no specific regulations for these nutrients (18). DGA guidelines also recommend that the consumption of refined grains be limited, though, again, no specific cutoffs are made. The federal standards set forth by the DGA are the minimum requirements that must be followed in order to be eligible for federal funding as part of the national school meal program. However, individual School Food Authorities (SFA) can develop more stringent nutritional standards if they wish. This school meal food quality regulatory process was not always in place; it is actually the end result of analyses into the nutritional content of school meals.

Though originally enacted in 1946, requirements for national school meal program have changed as our understanding and needs for nutrition have shifted. The first examination of school meal’s nutritional content was the School Nutrition Dietary Assessment (SNDA I). This report was published by Mathematica Policy Research Inc. under contract by the USDA in 1993 with the goal of determining whether children were receiving healthy meals in the school environment (19). This first school nutrition assessment had strong implications for school food policy due to its findings. It was found that schools met a variety of nutritional goals such as overall calorie intake and certain nutrient levels; however it was also found that 38% of the calories from school meals were derived from fat (19). This was in violation of the DGA recommendations established in 1990 and, as a result, congress passed the Healthy Meals for Healthy Americans Act in 1994. This law required schools to provide meals that were consistent with the DGA in order to be eligible for federal school meal funding. To aid in the process of reaching these dietary goals, the government set up the School Meal Initiative (SMI) to aid schools in the development of nutritious meal programs.

After the implementation of the DGA and SMI guidelines, a second nutritional survey was completed in 1999 that showed an improvement towards meeting the DGA guidelines (20). Among their findings, it was shown that there was a statistically significant shift towards lower levels of calories from fat in school meals (20). However, at 34% of calories from fat, more improvement was needed to reach the DGA mandated levels of 30% (20). Overall, it was found that one in six schools were compliant with DGA regulations at the time of the second study (20).

Results from the most recent SNDA study (SNDA III) found that, much like in SNDA II, a large proportion of school lunches offered (>85%) met dietary guidelines for protein, vitamin A, vitamin C, calcium, and iron (21) . However, only roughly 20% of schools met fat guidelines with an average of 34% of calories coming from fat (21). The data on overall fat levels are quite similar to results seen in SNDA II. Despite the minimal change in overall fat served in school lunches, the percentage of schools that met the saturated fat guidelines more than doubled (from 15% to 34% in elementary schools) compared to SNDA II (21).

Analyses of the SBP program shows that it is more in line with DGA and SMI regulations compared to the NSLP. According to SNDA III more than 90% of schools met nutritional standards for their breakfast program showing no significant changes from SNDA II (21). However only 23% of school breakfasts met the caloric requirement of a fourth of the recommended daily intake for breakfast offered (21). However, when looking directly at children's eating habits through 24 hour dietary recalls, 31% of them met the caloric recommendation showing that children were eating more energy dense foods as part of their SBP meal (21). According to the SNDA III, 88% of schools offered breakfasts that met the total fat benchmark, while 75% met the saturated fat benchmark (21). When taking actual child consumption into account, it was shown that 81% and 69% of schools met the benchmark for total fat and saturated fats respectively. Both of these macronutrient consumption characteristics were significantly higher than SNDA II levels (21).

The School Meal Environment: Associations to Weight Status

In a study funded by the Department of Agriculture after SNDA I was completed, it was shown that the percentage of energy from total fats in the SBP program was below the SMI threshold of less than 30% of calories from fat. However it was marginally higher than the SMI recommended threshold of 10% (11%) for saturated fats (22). The total food energy percentage for the SBP fit the 25% RDA recommendation also set by the SMI and it was shown that over a 24-hour period, there was no significant difference in total energy consumed when comparing SBP participants and non-participants (22).

Using data collected from the most recent SNDA III, Gleason et al., 2009 tried to further explain the effects of school meal programs on daily dietary consumption and their associations to weight status. Using 24-hour dietary recall data, the authors showed that SBP participants consumed significantly more calories at breakfast compared to non-participants. However, this did not translate to higher overall caloric consumption over the course of the day (23). The data also showed that children in the SBP were spreading out their caloric consumption more evenly throughout the day compared to non-participants (23). This pattern of consumption may have led to the significant association between lower BMI and SBP participation (23). The association between school breakfast and BMI was modest, with participants having an average BMI 0.75 points lower than non-participants. However the association found between school breakfast participation and BMI was only significant among white students and not among other subgroups of children (23). The protective association that school breakfast provided was examined further and it could not be explained by lowered consumption of low-nutrient energy dense (LNED) foods. When breakfast consumption was compared to no breakfast consumption the protective association of the SBP was lost (23). Therefore, it appears that it is breakfast consumption has a significant negative association to BMI rather than school breakfasts in particular (23).

Bhattachara used a differences-in-differences methodology to examine the particular effects of school breakfasts. Using the differences-in-differences approach, the author was able to account for unobserved differences between SBP participants and non-participants (24). It was shown that participants in the SBP ate healthier meals (as measured by a composite healthy eating index) and a lower percentage of calories from fat compared to their non-participant comparison group (24). In terms of overall energy consumption, SBP participation was not associated with higher caloric intake when compared to non-participants, showing that school breakfasts were associated with improved dietary quality (24). Though this study showed that school breakfasts may improve nutritional intakes of children, the short follow-up period used did not allow for the examination of longer term effects on weight status of school breakfast participants was conducted.

The NSLP program has quite different associations to dietary intake among participants. This porgram was associated with a higher percentage of food energy from fat and saturated fat that were both above the recommended guidelines set forth by the DGA (25) . Furthermore, it was shown that, over 24-hours, NLSP participants consumed significantly more calories than non-participants, though both participant and non-participant groups were above the recommended daily allowance of energy for their lunch meals (21).

Using white children from the kindergarten and first grade waves of the ECLS-K dataset, it was shown that those who participate in the NSLP were 2% more likely to be overweight compared to those who ate homemade lunches (26). To further examine the possible effects of the NSLP, the authors used a regression discontinuity model to compare whether children barely eligible for reduced price lunches (and more likely to receive it) had different weight outcomes when compared to those who were just above the reduced price threshold (and less likely to eat school meals). Children barely eligible for the subsidized food were significantly more likely to eat school lunches indicating that the regression discontinuity approach would be effective (26). Using this approach, it was shown that those just eligible for free lunches (and more likely to eat school lunch) were almost a third more likely to be obese compared to the group just above the reduced price lunch threshold (26). To examine how this discrepancy could occur, the authors used dietary recall data from the NHANES study. The recall data showed that this higher likelihood of overweight was likely due to NSLP meals since participants consumed 46 more calories on average at lunch compared to their non-participating counterparts (26). Furthermore, it appeared that the higher caloric consumption was due primarily to differences in lunch since both breakfast and dinner consumption were not significantly different between the groups (26). Overall, NSLP participants were shown to consume 40-120 calories per day more than non-participants (26). While this study shows that NSLP participation is associated with deleterious weight statuses, the relationship between SBPs and weight status was not examined. This is significant since school breakfasts have been consistently shown to provide nutrition that meets DGA guidelines in a much more consistent manner than school lunches.

In another study using data collected in 1997, it was shown that the NSLP was associated with a higher prevalence of overweight among school children, though it was only significant at the <0.1 level(27). Unfortunately, despite being a nationally representative cohort, not enough data was collected to determine if there was an association between school breakfast participation and weight status (27). However, when examined together, joint NSLP and SBP participation showed no significant change in the probability of being overweight or having higher BMI scores compared to NLSP-only participants (27). Interestingly, when comparing the effects of school meal programs across income groups a different association is seen (27). Stratified on socioeconomic (SES) status, the average BMI for low SES children was 17.8 (27). Children in this group who were not participants in the NSLP had a BMI of 16.5 compared to an average of 18.2 for those who participated in both breakfast and lunch programs (27). Therefore, in the case of economically disadvantaged children, school meal programs appear to bring participant's weight closer to the average for their entire age group (BMI=18.4)(27). Keeping in mind the result of this study, it should be noted that parents were asked to report on their child's weight and height. This could have led to noisy results given that self-reported weight and height tends to be skewed in the direction of lower BMI scores for those who have higher actual BMIs while being skewed to higher BMI scores for those with actual low BMI scores (28).

Despite Gordon et al's data on excess calorie consumption over a 24-hour period in their school-based study, there are studies showing that there may be no relationship between the school meal environment and weight gain (29). Using prospective data, it was shown that children gained weight at a faster pace during the summer months when children are away from the school environment (29). This summer weight gain was more pronounced in children who ended their kindergarten year overweight. This could show that schools may actually play a role in preventing weight gain among children(29). Minority Black and Hispanic children experienced more pronounced weight gains during these months, which widened the racial gap between them and their White counterparts. This racial-based diversion pattern continued to become wider into their first grade year (29). It should be noted that participation in summer meal programs were not taken into account. Despite this limitation, this study appears to show that the school meal environments could play a complex role in the determination of weight status for children.

Other factors affecting weight status in the school setting

Besides the effects of food access in schools, physical activity plays a vital role in the proper development of children. In a logistic analysis using the ECLS-K data set it was shown that children with less activity were significantly more likely to be overweight compared to their more active counterparts (30). Another study using ECLS-K data showed that one additional hour of physical education in schools reduces BMI scores by 0.31 points for overweight girls (31). The problem of inactivity is widespread as it is potent, an estimated 10% of children are completely inactive and another third of the population is not getting the recommended levels of moderate or vigorous physical activity (32). More worrisome, this trend may be worse than the data shows since it has been shown that electronic physical activity monitors tend to report significantly lower levels of activity compared to self-reported surveys (33). The results of these studies show that individual factors in the school environment must be controlled for when assessing the effects of particular programs on weight status.

American family meal trends

American dietary habits have changed greatly over time. As America has become a modern industrialized country there has been a gradual shift of food consumption away from the home. In the mid-1990s 57% of Americans consumed at least one food item away from home on a given day compared to 43% in the late 1970s (37). It is estimated that adolescents consume 30% of their meals away from home, with half of these meals coming from fast food restaurants (37). While this trend alone may not have health impacts, assuming that these meal environments are equivalent, there is evidence that meals consumed outside of the home are higher in fats while lower in nutrients such as calcium and iron (38). In a recent study, it was found that the calories consumed by children and adolescents at restaurants and fast food establishments has more than tripled from 6% to 19% in an analysis of the dietary intakes from 1977 to 1996 (39). In addition to being energy dense and lower in nutrients, meals families that eat meals outside the home are generally consuming portions that exceed the recommended sizes laid out by the FDA and USDA (40). Particularly egregious in this regard were energy dense foods like cookies and pasta that were over 400% larger than the USDA recommended portion sizes for each (40).

The increase in prevalence of eating out among American families is often believed to occur out of convenience due to parental work hours. Data has shown that easy meals are important for families that are seeing increased workforce participation by parents. In 1900 only 21% of women were in the workforce (45). By the year 1999 the portion of women who worked increased to 60% (45). This increase in maternal work hours has led to families spending less time cooking, eating, and playing with their children (46). More directly, maternal employment has been associated with the purchasing of prepared foods (46).

Qualitative associations to meal locations

Away-from-home meals can be a significant factor to be controlled for when trying to examine the associations of school breakfast and weight status. In examining the health outcomes associated with away-from-home meals, it was shown that purchasing at least one family dinner from an outside source over a week period significantly increased the odds of being obese compared to families who did not eat any meal away from home (41). Furthermore, biomarker analyses of the study population found that eating out at least weekly significantly increased insulin and cholesterol levels which can have major implications for future chronic disease progression, especially in young individuals (41).

However, there are questions as to whether all away-from-home meal environments have equivalent obesity risks potentials. For example, a cross-sectional study found an association with obesity only among children who ate at fast-food restaurants. This association to obesity was not found among those children who ate at full-service restaurants (42). Ultimately this result may be the result of confounding by SES and not an entirely accurate reflection of the effects of different away-from-home meals. Whether eating at certain restaurants is more likely to result in obesity is something that is currently being debated, however, it is apparent that meal environments play a role in the incidence of obesity.

Despite the evidence that eating out is a risk factor for obesity and its related diseases, there is conflicting data that home meals are a protective factor against obesity. On the one hand, there is evidence that family meals are significantly associated with the quality of adolescent's diets (43). Adolescents who reported seven family meals in the past week had an average of one serving more of fruits and vegetables per day compared to those who reported no family meals in the past week (43). Despite this association to healthy eating, there was no data presented showing an effect on overall weight status among this adolescent population (43). Other studies have shown that family meals have differing effects across different racial groups (44). One of these studies found that non-

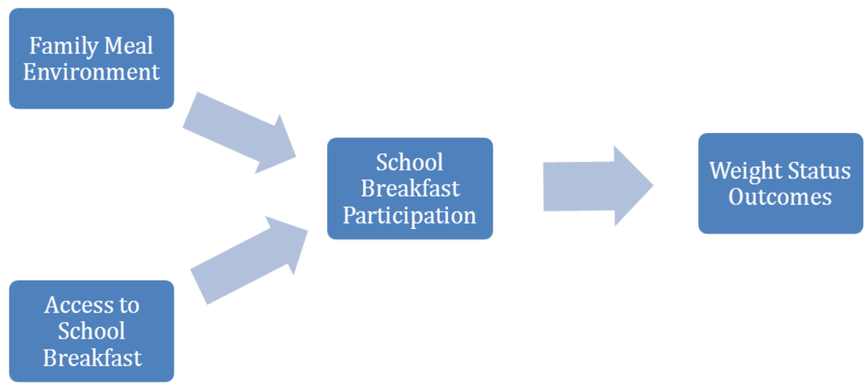
Hispanic white children who ate at home were less likely to be obese compared to those who did not eat at home. However, the protective effect of home meals was not as clear for other racial groups (44). For example, higher family meal frequency was a marginal risk factor for low SES Hispanic boys but protective for girls of the same social category (44). In the African American population examined in this study, it was found that family meals were protective for boys but this meal environment was found to be a risk factor for girls of this racial group (44). It is possible that these differences in race may be due to the qualitative differences of the meals eaten at home between different racial groups.

Controlling for away from home meals

The link between maternal employment and increased eating out may lead to negative weight outcomes. In a longitudinal study of British families, there was a statistically significant positive relationship between overweight and maternal employment seen among families above a predefined income group (>$57,000 per year) (47). However this association between maternal employment and overweight was not seen in lower income groups (47).

The link between maternal employment and child overweight is believed to run through family mealtime changes. In theory, mothers have less time to cook, which, in turn, has led to a reliance on quick, easy meals that are often low in nutrients, energy dense, and larger than meals made at home. Indeed it does appear that families are devoting less time to meals than in the past. Mothers in 1900 devoted roughly 44 hours to meal preparation and cleaning (48). In 1999 mothers were devoting less than 20 hours per week to these tasks (48). Together, the importance of convenience and commercial pressure to keep market share by providing quantitative “value” has created an environment where out-of-home meals are more popular than ever while at the same time significantly less healthy and larger than meals made at home.

CONCEPTUAL FRAMEWORK



Significant attention has been given to the factors inducing the rise in prevalence of childhood obesity in America. There are a variety of influences, ranging from the school environment to the home environment that can have an influence on weight and development. The present analysis focuses on the school meal environment, in particular, school breakfast participation and how it relates to weight status. This study attempted to determine whether school breakfast programs were associated to weight status outcomes while also taking into account other environmental factors, such as the home meal environment, that have been shown to play a significant role in childhood weight status.

Based on the current literature it is unclear whether school breakfasts are protective against deleterious weight gain. On the one hand, breakfast has been shown to be negatively associated to obesity (9). On the other, school meals, lunch in particular, have been shown to increase the odds of being obese by one third (26). Other studies on school breakfasts have mainly focused on the nutritional content of these meals with no analysis of the weight outcomes related to school breakfast consumption. This analysis focused on whether weight outcomes are associated with school breakfast participation.

In examining the relationship between weight status and school breakfast participation, certain external factors must be taken into account. A particular challenge in this analysis is the effects of family meals, and their correlation to out-of-home meals, on both school breakfast participation and weight status. This analysis controlled for the home meal environment by entering home meal frequency for both breakfast and dinner. Home breakfast was used to examine whether the association between school breakfast and weight status is in some way affected by family breakfast consumption. Does entering home breakfast environment into our model change the associations seen between school breakfast and weight status? If so, how does this association change? Family dinner was also added to the conceptual framework since it is a more accurate measure of family meal environments compared to breakfast. By entering family dinner frequency in the model we are controlling for overall family meal environments and parental care more fully and with less confounding due to school and work related habits.

Children can only be exposed to school breakfasts if they are available in their particular school. However this study did not examine differences between students who had or did not have exposure to school breakfast programs. Students were divided into groups based on whether they ate a school breakfast or not, regardless of their schools policy. The differences between schools that offer school breakfast and those that do not is another area of school food policy that must be examined further.

In order to get an accurate estimate of the association between school breakfast and weight status socioeconomic status had to be accounted for in our models. SES has been shown to be associated with obesity in children (49). Additionally, over 80% of the school breakfasts served by the School Breakfast Program were served to children eligible for free or reduced-price meals (2).

Physical activity has been strongly linked to the incidence of obesity among children (31) and therefore it was included in the model. Based on the literature, it was expected that physical activity would have a strong association to our outcome. It is also possible that physical activity would be associated to our exposure of interest since children who eat breakfast are often more active throughout the day.

Family structure was also taken into account since these factors have an association to whether a child receives school meals and is an indicator of overall household environment (50). Marital status was added to the model since it is associated with increased risk for obesity (51), while also being associated to the home meal environment (50). Maternal employment is assumed to be indicator of parental supervision and care. The literature also has shown that maternal employment is associated with increased risk for obesity among children (47).

METHODS

ECLS-K data set

The data used for this analysis was obtained from the Early Childhood Longitudinal Study – Kindergarten cohort (ECLS-K). The ECLS-K is a data set that has been compiled by the National Center for Education Statistics (NCES) and is a nationally representative of American 5th and 8th grade populations (52). Data was collected from children, their parents, and school administrators starting in the kindergarten class of 1998 and follows them until their eighth grade year (52). The ECLS-K employed a multistage probability sample design with the primary sampling units (PSUs) consisting of counties or groups of counties, the second stage units were schools within the PSUs and the final stage unit was children within those schools (52). Weight, strata, and PSU parameters had to be used in all of the analyses presented to adjust for the sampling technique and the unequal probability of being selected for the sample (52). The ECLS-K oversampled certain groups including, Asians and Pacific Islanders, children that learned English as a second language, and private school children to ensure precision goals were met for the sample (52).

Predictors

School breakfast environment exposure variable was converted to a binary variable for school breakfast consumption. Originally, the interviewer asked the following question: “During the last five days child was in school, how many school breakfasts did (he/she) receive?” Acceptable responses varied from 0-5 days of school breakfast consumption as well as -1 which coded for not applicable (child did not receive school breakfast). In the created binary variable, a value of 0 meant that the child received no school breakfast (originally coded as -1). A value of 1 for the binary variable coded for any school breakfast consumption in the last five school days.

Home breakfast and dinner environments were also taken into account in the models presented. For the home breakfast question, the interviewer originally asked: "In a typical week, please tell me the number of days at least some of the family eats breakfast together." This question had valid responses ranging from 0-7. The interviewer also asked the parent about the home dinner environment with the following question: "In a typical week, please tell me the number of days the family ate dinner together." This question also had valid responses ranging from 0-7. Both of these family meal environment questions were left as continuous variables and are both present in the models presented.

This analysis will focus on the sixth and seventh waves of data which provide a nationally representative sample of American middle school children. The sixth wave consists primarily of American fifth grade students while the seventh wave consists primarily of eighth grade students and is the last wave of data collected by the ECLS-K. Wave six had a total sample size of 10,996 observations and wave seven had a total sample size of 8,809 observations. This sample was reduced to ensure that only observations with a full collection of relevant data were used. A list-wise deletion method was used; therefore, any observation that had any missing variable of interest was deleted so as to create a data set that was comparable to itself. The final sample used in this analysis contained 6,641 observations or 60.4% of the sixth wave sample and 75.4% of the seventh wave sample.

Outcome Variables

One of the main advantages of using the ECLS-K for this type of analysis is that it directly measures children's height and weight and does not rely on self-report. BMI is recorded in this data set; however this measure does not take adolescent growth into account (52). Since the sample consists of a growing adolescent population child growth curves based on a reference population was used. To get these growth curve BMI scores we used a CDC-developed SAS macro to calculate age and sex adjusted BMI z-scores based on height, weight, age, sex, and measurement technique (53). Height was converted from inches to centimeters (inches*2.54), and weight was converted from pounds to kilograms (pounds*0.45359237). Age was originally coded into quintiles in the ECLS-K with no exact age only available in the restricted access data set. Therefore each quintile value was averaged and this value was used to estimate age as closely as possible (For example: the first quintile in the seventh wave was ages 148 months to 163 months. These values were averaged to give a value of 155.5 months. In this example, each person who had a value of 1 for their wave seven age were given an age of 155.5 months for the SAS macro, this process was repeated for each of the other quintiles). All children were measured while standing, therefore the recumbent value was the same for each participant in the CDC developed macro. Using the CDC age-adjusted BMI macro, we obtained age-adjusted BMI z-scores for each individual (54). Using these BMI z-scores, a weight status variable was then created to account for obese and not obese individuals. Observations with a BMI z-score $\geq$1.96 ($\geq 95^{th}$ percentile) were coded as obese while individuals with a BMI z-score less than 1.96 and greater than or equal to 1.4395 were considered overweight ($\geq$85th percentile) (55). Individuals with a BMI z-score less than 1.4395 were considered normal-weight (55). Normal-weight and overweight individuals were grouped together for most of the stratified and binary logistic analyses. One exception to this was the fourth prospective model which will be explained later in the methods.

Control variables

Physical activity was taken into consideration for each of the models presented. In wave six parents were asked, "…how many days their child got exercise that caused rapid breathing, perspiration, and a rapid heartbeat for 20 continuous minutes or more." This question had valid values of 0-7. Though parents were not asked this question in the seventh wave of data collection, it was asked to the children in the seventh wave. Therefore these physical activity variables were treated as equivalent despite the difference in responder.

Control variables were modified as needed to provide analyzable categories for the analysis. Race was originally coded into eight categories which produced several small sample groups. To make larger sample subgroups this race was reduced to five variables: White, African-American, Hispanic, Asian, and other (Reference category: White). Parental education was also modified; originally an eight level variable, it was reduced to four levels: Did not complete high school, high school graduate (or equivalent), completed some college (including associate degrees), and college graduates (Reference category: college graduate). Parental marital status was originally divided into five categories; this was reduced to two categories: married and not married (separated, divorced, widowed and single parents) (Reference category: married). Mother's employment status was originally a five category variable that was reduced to three levels: full-time and no mother in household, part-time, unemployed (Reference category: Full time/no mother in household). No mother in household was added to the employed mothers category however it should be noted that this was a small portion of the sample (<3%) and its effects will were negligible when treated as a separate category.

Also included in this model are ECLS-K-based SES quintile measurements. This variable takes parental education, occupation, income, and occupational prestige into account to produce a measure of SES than income alone could produce. The SES variable was left as an ordinal categorical variable with values from 1-5. Gender was coded 1 for males and 0 for females.

Descriptive Methods

Initial descriptive statistics were collected for each of the variables of interest. Tests for associations between the independent and dependent variables were conducted to examine differences between obese and not-obese for both the fifth and eighth grade data waves. To test for an association between independent and dependent variables at each time point, a Rao-Scott chi square test was done for each variable. The Rao-Scott chi square test was used because it is a survey adjusted equivalent to the Pearson chi square test.

Analytic Methods

To test for an association between obesity and school breakfast and family breakfast and dinner meal environments, two initial cross- sectional models were conducted for each wave of data. A multivariable cross-sectional linear regression was done with BMI z-scores at fifth grade and eighth grade being the outcome variable of interest. Included in each model were school breakfast participation, family breakfast and dinner environments, physical activity, gender, race, parental education, parental marital status, SES quintiles, and maternal employment status for their respective outcome variable wave. Another cross-sectional model was conducted using logistic regression with the binary obese variable as the outcome. The logistic models contained the same variables as the linear models and they were also conducted for both the fifth and eighth grade waves of data. For each of these models, cross-sectional PSU, strata, and weight variables were used. Therefore, wave six cross-sectional models contained wave six PSU, strata, and weight variables while wave seven cross-sectional models contained wave seven PSU, strata, and weight variables.

Longitudinal analyses were conducted to test for the temporality of the exposure of interest (school breakfast participation) and outcomes (BMI z-score and obese/not obese) of interest. Each model is explained in detail below.

Model 1: **BMI z-score$_{(7)}$ regressed on fifth grade$_{(6)}$ predictor variables.**

The first model consisted of the eighth grade wave BMI z-score linearly regressed on all the fifth grade wave independent variables.

Model 2: **Obese/ Not obese$_{(7)}$ regressed on fifth grade$_{(6)}$ predictor variables**

The second model was a logistic model using the binary obese and not-obese eighth grade wave variable with the fifth grade wave explanatory independent variables used.

Model 3: **BMI z-score change regressed on fifth grade$_{(6)}$ predictor variables**

The third longitudinal model used BMI z-score changes over time as the outcome variable which was equal to BMI z-score from eighth grade minus the BMI z-score from fifth grade. This outcome was regressed on fifth grade independent variables.

Model 4: **Weight status increase regressed on fifth grade$_{(6)}$ predictor variables**

The fourth prospective model was a logistic model that gave an outcome variable value of 1 for anyone who went from a lower weight category to a higher category. Therefore any individual who went from normal-weight to overweight, normal-weight to obese or overweight to obese from fifth to eighth grade received a value of 1. Individuals that had no change in weight status or went down in weight status from fifth to eighth grade received a value of 0 in this model. This dependent variable was regressed on the same independent fifth grade variables.

The data analysis for this paper was generated using SAS software, Version 9.3 of the SAS System for Windows, Copyright 2011. SAS Institute Inc., Cary, NC, USA.

RESULTS

Descriptive Statistics

Obesity prevalence was 11.79% in the fifth grade (Table 1) and increased slightly by eighth grade to reach 11.94%. 20.79% of kids participated in a school breakfast program at both time points, with a slight decrease to 19.61% seen in the eighth grade sample. Meal consumption at home and with family members showed a downward trend from fifth to eighth grade. The number of days the child and their family ate dinner together dropped from an average of 5.45 days per week, to 5.19 days between the two samples. There was also a downward trend in breakfast consumption with the sample eating an average of 3.57 family breakfasts per week in fifth grade and 3.15 breakfasts in eighth grade.

In the fifth grade sample, parents said their children exercised 3.79 days per week. In eighth grade physical activity reporting by the children increased to an average of 4.58 days per week. All of the statistics stated above are survey adjusted. 52.39% of mothers worked full time in the fifth grade, this proportion went up by eighth grade to 57.37% of (this also includes a portion of households that had no mother present; which contributed to less than 3% of the total population). The increase in full time working mothers was mostly due to a loss of unemployed mothers over time. In fifth grade 24.66% of mothers were unemployed; this proportion went down to 20.02% by eighth grade.

When the sample was stratified according to weight status (obese/not obese) significant differences in the sub-populations were found using the Rao-Scott chi square test of association. Among the fifth grade population, obese children were statistically more likely to receive a school breakfast (Table 2). They also tended to have fewer family breakfast meals and exercise fewer days than non-obese individuals. Boys had a higher proportion of obese individuals compared to females in the fifth grade as well. Obese children were more likely to be minorities, specifically, Hispanics, who made up over a quarter of the entire obese population in the fifth grade sample while only being roughly 16% of the overall sample population. Children whose parents were less educated and of lower socioeconomic status were found to have a statistically higher prevalence of obesity. Interestingly, children who were obese were more likely to have mothers that were employed full time (62.47% for obese compared to 56.67% in non-obese). These same significant associations were seen in the eighth grade of data, though it should be noted that marital status was also found to be significantly associated to obesity (Table 3). Those children who had parents who were not married were more likely to be obese.

Analytic Results

Unadjusted models regressing BMI z-scores on school breakfast participation outcomes for both fifth and eighth grades were conducted. These unadjusted models showed that those who participate in the breakfast programs were significantly more likely to have higher BMI z-scores compared to non-participating individuals (Table 4). However, when a multivariable linear cross-sectional model was used for both time points, there was only a significant association between school breakfast participation and higher BMI z-scores in the eighth grade. No positive association between school breakfast participation and BMI z-score was also seen in the fifth grade but this was not found to be significant.

Using an unadjusted logistic regression analysis of school breakfast participation on the obese binary outcome variable at both fifth and eighth grades, it was shown that school breakfast participants were significantly more likely to be obese. However in a multivariable logistic regression at both time points there was no significant association between school breakfast participation and obesity prevalence (Table 5).

The unadjusted linear longitudinal analysis showed that children who received school breakfasts in the fifth grade had significantly higher BMI z-scores compared to non-participants in eighth grade (Table 6). When this linear model was fully parameterized, school breakfast participation in fifth grade was still found to be significantly associated to higher eighth grade BMI z-scores. This shows that the association between school breakfast and increased BMI z-scores was significant over time.

In an unadjusted logistic model regressing school breakfast participation on the obese binary outcome variable, children who participated in school breakfast programs were significantly more likely to be obese compared to non-participants (Table 6). When control variables were added to this model a positive association was still present however it was not found to be statistically significant.

In the linear model, where the outcome of interest was change in BMI z-score from fifth to eighth grade a significant association to change in BMI z-score was found (Table 7). The unadjusted analysis again found that school breakfast participants were significantly more likely to have higher BMI z-scores compared to non-participants.

However when the control variables were added to this model the effect of school breakfast participation was almost completely gone and not discernable.

A final longitudinal analysis compared those who went to a higher weight status category (5.7% of the sample population) to those that stayed in the same weight category or went to a lower weight status category was first conducted. In an unadjusted model it was shown that school breakfast participation was significantly associated to an increase in weight status. However when this model was fully parameterized the association of school breakfast participation to increased weight status was not found to be statistically significant.

Other determinants of obesity

The association of school breakfast participation to our weight status outcomes was not significantly affected by the presence or absence of a regular home meal environment. None of the models presented showed any significant effect of home breakfast or home dinners on either BMI z-scores or the obese binary variable.

Among all the models presented there were certain control variables that had consistent associations to our main outcome variables. Higher reported physical activity was found to be associated to lower BMI z-scores and decreased likelihood of obesity in each of the logistic cross-sectional models. Interestingly, this association was found in the linear cross-sectional model for fifth grade, however this association was not found in the eighth grade model. In the longitudinal analyses there was an association between fifth grade physical activity and lower eighth grade BMI z-scores and probability of obesity. However no association was seen between physical activity and the change in weight status models.

Higher socioeconomic status was consistently associated to lower BMI z-scores and a decreased probability of being obese. This association was even found to be significant in the change in weight status model (Table 7), where no other significant variables were found.

Identifying as racially Hispanic was also found to be associated to increased BMI z-scores and probability of obesity across each of the cross-sectional and longitudinal models. However this positive association was not found in either of the change in weight models in table 7.

Maternal employment status was found to be associated to weight status in most of the models presented. Children whose mother was working part-time were found to have significantly lower BMI z-scores and probabilities of being obese in both the fifth and eighth grade cross-sectional models. Longitudinally, it was found that maternal part-time employment was associated with significantly lower BMI z-scores and probabilities of being obese. However no association was found between fifth grade maternal working status and in the change in weight status models.

DISCUSSION

The purpose of this study was to determine whether there was an association between school breakfast participation and weight status among middle school students. The results of this study showed that there is limited evidence of an association between school breakfast participation and weight. Though children who were obese were significantly more likely to participate in school breakfast programs, this apparent association did not stay consistent in most of the multivariable cross-sectional models. The one exception in this regard was the eighth grade linear cross sectional model which showed that students who participated in school breakfasts in eighth grade had significantly higher BMI z-scores in the eighth grade. The logistic cross-sectional models showed no association between school breakfast participation and obesity prevalence. Therefore it appears that school breakfasts were associated in a cross-sectional manner to overall BMI z-scores but not associated to obesity odds.

When looking at school breakfast participation in a prospective manner, it was found that school breakfast participation in the fifth grade was significantly associated with higher BMI z-scores in the eighth grade. No association was found between school breakfast participation and obesity in our logistic model. It appears that while school breakfast participation may be linked to increases in BMI z-scores, there is little evidence to show that participation leads to deleterious weight statuses. Alternatively, it is possible that a longer study time frame is needed to capture the long-term effects of school breakfast participation. For the logistic change in weight status model (Table 7, 2nd Model) there were only 379 participants that changed weight status which is 5.7% of the overall sample. The small sample size for individuals who changed weight status from fifth to eighth grade may have led to an unstable model with volatile point estimates and standard errors.

When taken together, the cross-sectional models show a possible effect of school breakfasts on BMI z-scores with little effect seen in overall obesity prevalence. The prospective models also indicated an association between BMI z-score increases and school breakfast participation, however, like the cross-sectional models; there is little evidence of school breakfast participation affecting obesity prevalence. These results indicate that while a positive association between school breakfast participation and BMI z-scores is present, there is no evidence that school breakfast participation leads to a higher probability of becoming obese.

The home meal environment has received attention for its possible role in regulating meal consumption and quality (56). However none of the models used in this analysis found that family breakfast or dinner significantly changed the association of school breakfast to weight status. While some studies have found cross-sectional associations to these factors to weight status alone (56), none were found in this study and the theory that inclusive family home meals may provide a protective factor against obesity will need to be further examined. It is possible that the protective associations of home meals is dependent upon the quality of the meals served as postulated in several articles (44).

Overall, there was limited evidence showing that school breakfasts had a strong effect on the weight status of middle school children. There was evidence that school meals increased BMI z-scores without affecting obesity levels. However this conclusion is based on a limited time frame which may limit the true effects of school breakfast over time. Like this analysis, another study has shown that school breakfast participation can increase BMI, however this increase in weight did not automatically indicate an increase in negative weight outcomes and may actually bring about more equitable weight statuses across the population of students (27).

It is possible that no strong school breakfast participation effect was seen because this analysis examined children's weight status after their dietary habits had been formed. Studies have shown that food preferences are formed much earlier in life (57) and these overriding factors can limit the effects of dietary programs in schools. Family meals did not modify the association between school breakfast participation and weight status. This may indicate that, indeed, dietary habits had already been formed by fifth grade and therefore the family meal effect that has been examined in the literature (43) was missed in this study.

Another avenue by which to improve weight status in the school setting is through policy. There is evidence that limiting competitive food access may have beneficial impacts on the consumption sugar sweetened beverages (SSB), especially among minority groups (34). Despite this significant decrease in SSB consumption no direct association was found to decreased BMI scores in the study population (34).

Despite the utility of policy in improving dietary behaviors at schools there are often conflicting interests that restrict schools and their actions. In a time of financial constraints for schools, many are looking for new ways to generate funds and this can force schools to serve poor quality foods (35). Indeed, competitive foods such as snacks, cookies, and cakes are sold in more than 50% of elementary schools and are a large source of LNED foods (35). In one study it was shown that a 10% increase in the probability of access to junk foods in schools leads to a 1% increase in BMI among students (36). Together, these studies show that though school meals are an important factor in the overall dietary environment in schools, physical activity, competitive foods, and policies affecting their access, are another area of the school environment that must be examined further for their associations to obesity.

Strengths and Weaknesses

The ECLS-K is an ideal data set to examine the long-term effects of various school-based exposures on obesity. This data set uses direct measurements of participant's height and weight to limit recall bias.

Despite this, modified questions would have led to a more direct examination of the association between school breakfast and weight status. First, parents were asked how many school meals their child ate in the past five school days. Parental recall of their children's dietary habits while they are not under their supervision is probably not as accurate as if the question was asked directly to the student. The question asking about family breakfast was also somewhat limited. Originally, this question asked on how many days in the past week did any family members eat breakfast together. This question does not automatically include the child that was surveyed in this question and there is no guarantee that the child participated in each of those family breakfasts. Another more direct way to measure the family home meal environment would have been to ask the away-from-home meal consumption frequency. As noted in the literature review, away from home meals have been associated with higher levels of consumption and energy dense foods (40).

Finally, the questions regarding physical activity frequency were asked to the parent in the fifth grade sample, and were asked to the child in the eighth grade sample. These questions may be biased in both instances; however there must be some systematic bias between the child's recall and parent's recall. Despite this most of the limitations likely only increased random error in the sample and did not create a systematic error that would lead to biased results.

IMPLICATIONS AND FUTURE DIRECTIONS

School breakfasts have become an important safety net for families that are unable to afford money or time to feed their children breakfasts before going to school (2). In this analysis we find evidence that suggests that while school breakfast may be associated with increased BMI z-scores, there is little evidence that school breakfast programs are creating increasing the probability of being obese among participants. That being said, a longitudinal analysis conducted from kindergarten to eighth grade would be able to examine the long-term associations of school breakfast participation to weight status at a developmental period closer to dietary habit formation. Due to the district-centric regulatory structure of school meal program it would be beneficial to understand the effects of school breakfast and how these effects vary depending on the various state policies regarding this program. Since schools districts are able to plan their meal programs there is opportunity for significant differences in meal content. This inter-district variation may provide further insights into what meal programs are associated with beneficial nutritional and weight outcomes. For example, schools have the option to fulfill SMI guidelines by providing a fixed amount of various food components in each meal or they can voluntarily make more stringent choices limiting access to unhealthy foods at meal times. The effects that these local policy differences produce must be examined further.

REFERENCES

1. USDA. National School Lunch Program Fact Sheet [electronic article].

2. USDA. The School Breakfast Program Fact Sheet [electronic article].

3. Ma Y, Bertone ER, Stanek EJ, 3rd, et al. Association between eating patterns and obesity in a free-living US adult population. *Am J Epidemiol* 2003;158(1):85-92.

4. Ogden CL, Carroll MD, Kit BK, et al. Prevalence of obesity and trends in body mass index among US children and adolescents, 1999-2010. *Jama* 2012;307(5):483-90.

5. CDC. NCHS Fact Sheet. Atlanta, GA; 2012. (http://www.cdc.gov/nchs/data/factsheets/factsheet_obesity.htm#overview). (Accessed).

6. The Surgeon General's Vision for a Healthy and Fit Nation. Rockville, MD: U.S. Department of Health and Human Services, 2010, (General OotS

7. Freedman DS, Khan LK, Serdula MK, et al. The relation of childhood BMI to adult adiposity: the Bogalusa Heart Study. *Pediatrics* 2005;115(1):22-7.

8. Strauss RS, Pollack HA. Social marginalization of overweight children. *Arch Pediatr Adolesc Med* 2003;157(8):746-52.

9. Timlin MT, Pereira MA, Story M, et al. Breakfast eating and weight change in a 5-year prospective analysis of adolescents: Project EAT (Eating Among Teens). *Pediatrics* 2008;121(3):e638-45.

10. Dubois L, Girard M, Potvin Kent M. Breakfast eating and overweight in a pre-school population: is there a link? *Public Health Nutr* 2006;9(4):436-42.

11. Haerens L, Vereecken C, Maes L, et al. Relationship of physical activity and dietary habits with body mass index in the transition from childhood to adolescence: a 4-year longitudinal study. *Public Health Nutr* 2010;13(10A):1722-8.

12. Siega-Riz AM, Popkin BM, Carson T. Trends in breakfast consumption for children in the United States from 1965-1991. *Am J Clin Nutr* 1998;67(4):748S-56S.

13. Affenito SG, Thompson DR, Barton BA, et al. Breakfast consumption by African-American and white adolescent girls correlates positively with calcium and fiber intake and negatively with body mass index. *J Am Diet Assoc* 2005;105(6):938-45.

14. Shaw ME. Adolescent breakfast skipping: an Australian study. *Adolescence* 1998;33(132):851-61.

15. Laska MN, Murray DM, Lytle LA, et al. Longitudinal Associations Between Key Dietary Behaviors and Weight Gain Over Time: Transitions Through the Adolescent Years. *Obesity (Silver Spring)* 2011.

16. Dubois L, Girard M, Potvin Kent M, et al. Breakfast skipping is associated with differences in meal patterns, macronutrient intakes and overweight among pre-school children. *Public Health Nutr* 2009;12(1):19-28.

17. Schlundt DG, Hill JO, Sbrocco T, et al. The role of breakfast in the treatment of obesity: a randomized clinical trial. *Am J Clin Nutr* 1992;55(3):645-51.

18. Dietary Guidelines for Americans. Washington D.C.: US Government Printing Office, 2010, (no. 7)(Agriculture UDo, Services UDoHaH

19. Burghardt J, Devaney B. The School Nutrition Dietary Assessment Study: Summary of Findings. Princeton, NJ, 1993, (USDA

20. Fox MK, Crepinsek MK, Connor P, et al. School Nutrition Dietary Assessment Study-II: Summary of Findings. Cambridge, MA, 2001, (USDA

21. Gordon AR, Crepinsek MK, Briefel RR, et al. The third School Nutrition Dietary Assessment Study: summary and implications. *J Am Diet Assoc* 2009;109(2 Suppl):S129-35.

22. Burghardt JA, Devaney BL, Gordon AR. The School Nutrition Dietary Assessment Study: summary and discussion. *Am J Clin Nutr* 1995;61(1 Suppl):252S-7S.

23. Gleason PM, Dodd AH. School breakfast program but not school lunch program participation is associated with lower body mass index. *J Am Diet Assoc* 2009;109(2 Suppl):S118-28.

24. Bhattacharya J, Currie J, Haider S. Breakfast of Champions? The School Breakfast Program and the Nutrition of Children and Families [electronic article]. *NBER WORKING PAPER SERIES.*

25. Gordon AR, Devaney BL, Burghardt JA. Dietary effects of the National School Lunch Program and the School Breakfast Program. *Am J Clin Nutr* 1995;61(1 Suppl):221S-31S.

26. Schanzenbach DW. Do School Lunches Contribute to Childhood Obesity? [electronic article].

27. Hofferth SL, Curtin S. Poverty, food programs, and childhood obesity. *J Policy Anal Manage* 2005;24(4):703-26.

28. Stommel M, Schoenborn CA. Accuracy and usefulness of BMI measures based on self-reported weight and height: findings from the NHANES & NHIS 2001-2006. *BMC public health* 2009;9:421.

29. von Hippel PT, Powell B, Downey DB, et al. The effect of school on overweight in childhood: gain in body mass index during the school year and during summer vacation. *Am J Public Health* 2007;97(4):696-702.

30. Rose D, Bodor JN. Household food insecurity and overweight status in young school children: results from the Early Childhood Longitudinal Study. *Pediatrics* 2006;117(2):464-73.

31. Datar A, Sturm R. Physical education in elementary school and body mass index: evidence from the early childhood longitudinal study. *Am J Public Health* 2004;94(9):1501-6.

32. Koplan JP, Liverman CT, Kraak VI. Preventing childhood obesity: health in the balance: executive summary. *J Am Diet Assoc* 2005;105(1):131-8.

33. Pate RR, Freedson PS, Sallis JF, et al. Compliance with physical activity guidelines: prevalence in a population of children and youth. *Ann Epidemiol* 2002;12(5):303-8.

34. Taber DR, Stevens J, Evenson KR, et al. State policies targeting junk food in schools: racial/ethnic differences in the effect of policy change on soda consumption. *Am J Public Health* 2011;101(9):1769-75.

35. Anderson PM, Butcher KE. Childhood obesity: trends and potential causes. *Future Child* 2006;16(1):19-45.

36. Anderson PM, Butcher, K. F. Reading, Writing and Raisinets: Are School Finances Contributing to Children's Obesity? [electronic article]. *NBER Working Paper Series.*

37. Lin B, Guthrie, J., Frazao, E. America's Eating Habits: Changes and Consequences. USDA, 1999, (Department of Agriculture ERS, Food and Rural Economics Division

38. Lin B-H, Frazão E. Away-From-Home Foods Increasingly Important to Quality of American Diet. Washington DC: USDA, 1999, (Food and Rural Economics Division ERS

39. Nielsen SJ, Siega-Riz AM, Popkin BM. Trends in food locations and sources among adolescents and young adults. *Prev Med* 2002;35(2):107-13.

40. Young LR, Nestle M. The contribution of expanding portion sizes to the US obesity epidemic. *Am J Public Health* 2002;92(2):246-9.

41. Fulkerson JA, Farbakhsh K, Lytle L, et al. Away-from-home family dinner sources and associations with weight status, body composition, and related biomarkers of chronic disease among adolescents and their parents. *J Am Diet Assoc* 2011;111(12):1892-7.

42. Larson N, Neumark-Sztainer D, Laska MN, et al. Young adults and eating away from home: associations with dietary intake patterns and weight status differ by choice of restaurant. *J Am Diet Assoc* 2011;111(11):1696-703.

43. Neumark-Sztainer D. Eating among teens: do family mealtimes make a difference for adolescents' nutrition? *New Dir Child Adolesc Dev* 2006(111):91-105.

44. Rollins BY, Belue RZ, Francis LA. The beneficial effect of family meals on obesity differs by race, sex, and household education: the national survey of children's health, 2003-2004. *J Am Diet Assoc* 2010;110(9):1335-9.

45. French SA, Story M, Jeffery RW. Environmental influences on eating and physical activity. *Annu Rev Public Health* 2001;22:309-35.

46. Cawley J, Liu F. Maternal Employment and Childhood Obesity: A Search for Mechanisms in Time Use Data [electronic article]. *NBER Working Paper Series.*

47. Hawkins SS, Cole TJ, Law C. Maternal employment and early childhood overweight: findings from the UK Millennium Cohort Study. *Int J Obes (Lond)* 2008;32(1):30-8.

48. Bowers DE. Cooking Trends Echo Changing Roles of Women. *Food Review* 2000;23:23-9.

49. Lawman HG, Wilson DK. A Review of Family and Environmental Correlates of Health Behaviors in High-Risk Youth. *Obesity (Silver Spring)* 2012.

50. Stewart SD, Menning CL. Family structure, nonresident father involvement, and adolescent eating patterns. *J Adolesc Health* 2009;45(2):193-201.

51. Yannakoulia M, Papanikolaou K, Hatzopoulou I, et al. Association between family divorce and children's BMI and meal patterns: the GENDAI Study. *Obesity (Silver Spring)* 2008;16(6):1382-7.

52. Tourangeau K, Nord C, Lê T, et al. Early Childhood Longitudinal Study, Kindergarten Class of 1998–99 (ECLS-K), Combined User’s Manual for the ECLS-K Eighth-Grade and K–8 Full Sample Data Files and Electronic Codebooks (NCES 2009–004). Washington DC: National Center for Education Statistics, Institute of Education Sciences, 2009, (Education USDo

53. Kuczmarski R, Ogden C, Guo S. 2000 CDC growth charts for the United States: Methods and development. Washington DC: National Center for Health Statistics 2002, (Statistics VH

54. Prevention CfDCa. A SAS Program for the CDC Growth Charts. Atlanta, GA: Division of Nutrition, Physical Activity, and Obesity, National Center for Chronic Disease Prevention and Health Promotion; 2011. (Accessed).

55. Must A, Anderson SE. Body mass index in children and adolescents: considerations for population-based applications. *Int J Obes (Lond)* 2006;30(4):590-4.

56. Anderson SE, Whitaker RC. Household routines and obesity in US preschool-aged children. *Pediatrics* 2010;125(3):420-8.

57. Birch LL, Fisher JO. Development of eating behaviors among children and adolescents. *Pediatrics* 1998;101(3 Pt 2):539-49.

TABLES

Table 1:

Univariate Analysis of Fifth and Eighth-grade students (n= 6,641)

Table1: Descriptive statistics of school breakfast participation, home meal environment, physical activity, and weight status in the United States by grade

	Fifth Grade		Eighth grade	
	Mean/ %	**SE**	**Mean/ %**	**SE**
Child receives school breakfasts				
Any	20.79	1.34	19.61	1.24
None	79.21	1.34	80.39	1.24
Average number of days family eats breakfast together	3.57	0.06	3.15	0.05
Average number of days family eats dinner together	5.45	0.04	5.19	0.04
Average number of days child exercised at least 20 minutes	3.79	0.04	4.58	0.05
Gender				
Male	49.73	0.99	50.46	0.91
Female	50.27	0.99	49.54	0.91
Race				
White	64.43	1.76	61.20	1.62
Black	12.57	1.06	15.32	1.04
Hispanic	16.79	1.50	17.13	1.43
Asian	2.41	0.27	3.02	0.32
Other	3.80	0.87	3.32	0.79
Parents highest educational level				
Did not complete HS	8.41	0.80	9.11	0.82
HS Grad	23.86	1.08	23.59	1.05
Some College	33.42	1.02	33.07	0.95
College Graduate	34.31	1.36	34.23	1.23
Marital Status				
Married	70.64	1.26	70.66	1.10
Not married	29.36	1.26	29.34	1.10
SES Quintiles				
1st Quintile	16.21	1.22	17.00	1.14
2nd	18.36	0.83	17.48	0.75
3rd	19.41	0.93	19.22	0.84
4th	21.80	0.86	22.12	0.86
5th	24.23	1.22	24.18	1.12
Mother's Employment Status				
Full-time, no mother in HH	52.39	1.09	57.37	1.15
Part-time	22.95	1.01	22.62	0.91
Unemployed	24.66	0.99	20.02	0.92
Obese				
Yes	11.79	0.62	11.94	0.60
No	88.21	0.62	88.06	0.60
BMI Z-score	0.63	0.02	0.64	0.02
BMI (kg/m^2)	20.50	0.85	22.98	0.10

Note: Sample means and standard errors are weighted, and controlled for strata and PSUs. Children were reported as receiving breakfast if parent reported at least one school breakfast was received in past 5 school days. 5th grade corresponds to wave 6 of the ECLS-K and 8th grade to wave 7; a small number of children are in other grades.

Table 2:

Stratified Analysis of obese and non-obese Fifth-grade students

Table 2: Descriptive bivariate statistics comparing obese and non-obese individuals

	Obese (n=777)		Non-obese (n=5864)		
	Mean/ %	SE	Mean/ %	SE	P-value
Child receives school breakfasts					<0.0001**
Any	31.14	2.99	19.41	1.42	
None	68.86	2.99	80.59	1.42	
Average number of days family eats breakfast together	3.11	0.13	3.63	0.06	0.0002**
Average number of days family eats dinner together	5.42	0.12	5.45	0.04	0.8478
Average number of days child exercised at least 20 minutes	3.25	0.12	3.86	0.04	<0.0001**
Gender					0.0290*
Male	55.19	2.63	49.00	1.08	
Female	44.81	2.63	51.00	1.08	
Race					<0.0001**
White	50.67	3.45	66.27	1.76	
Black	15.55	2.35	12.17	1.05	
Hispanic	26.65	2.73	15.47	1.49	
Asian	3.17	0.72	2.31	0.28	
Other	3.96	1.60	3.78	0.83	
Parents highest educational level					<0.0001**
Did not complete HS	13.56	2.22	7.73	0.80	
HS Grad	28.23	2.55	23.28	1.12	
Some College	35.21	2.70	33.18	1.09	
College Graduate	23.00	2.49	35.82	1.47	
Marital Status					0.0507
Married	65.11	3.29	71.39	1.32	
Not married	34.89	3.29	28.62	1.32	
SES Quintiles					<0.0001**
1st Quintile	25.50	3.34	14.97	1.27	
2nd	23.02	2.38	17.73	0.85	
3rd	18.30	2.05	19.55	1.00	
4th	19.64	2.35	22.09	0.92	
5th	13.54	2.23	25.66	1.29	
Mother's Employment Status					<0.0034**
Full-time, no mother in HH	57.16	2.55	51.75	1.22	
Part-time	15.62	1.92	23.93	1.11	
Unemployed	27.22	2.39	24.32	1.04	
BMI Z-score	2.23	0.01	0.41	0.02	<0.0001**
BMI (kg/m^2)	29.64	0.18	19.28	0.07	<0.0001**

*p<0.05; **p<0.01. Note: Sample means and standard errors are weighted. Children were reported as receiving breakfast if parent reported at least one school breakfast was received in past 5 school days. 5th grade corresponds to wave 6 of the ECLS-K and 8th grade to wave 7; a small number of children are in other grades.

Table 3:

Stratified Analysis of obese and non-obese Eighth-grade students

Table 3: Descriptive bivariate statistics comparing obese and non-obese individuals

	Obese (n=694)		Non-obese (n=5947)		
	Mean/ %	**SE**	**Mean/ %**	**SE**	**P-value**
Child receives school breakfasts					<0.0001**
Any	29.93	2.93	18.21	1.32	
None	70.07	2.93	81.79	1.32	
Average number of days family eats breakfast together	2.90	0.13	3.18	0.05	0.0380*
Average number of days family eats dinner together	5.26	0.11	5.18	0.04	0.5083
Average number of days child exercised at least 20 minutes	4.25	0.12	4.63	0.05	0.0026**
Gender					0.0184*
Male	56.81	2.68	49.59	1.00	
Female	43.19	2.68	50.41	1.00	
Race					<0.0001**
White	47.03	3.13	63.13	1.65	
Black	21.00	3.01	14.55	1.05	
Hispanic	25.02	2.14	16.06	1.46	
Asian	3.36	0.97	2.97	0.34	
Other	3.59	1.42	3.29	0.76	
Parents highest educational level					<0.0001**
Did not complete HS	12.33	1.73	8.67	0.85	
HS Grad	29.47	2.30	22.79	1.08	
Some College	35.61	2.77	32.72	0.98	
College Graduate	22.58	2.24	35.81	1.34	
Marital Status					0.0223*
Married	65.09	2.81	71.42	1.13	
Not married	34.91	2.81	28.58	1.13	
SES Quintiles					<0.0001**
1st Quintile	25.75	3.02	15.82	1.15	
2nd	23.35	2.34	16.68	0.72	
3rd	17.81	2.24	19.41	0.91	
4th	21.19	2.57	22.24	0.88	
5th	11.90	1.47	25.85	1.22	
Mother's Employment Status					0.0055**
Full-time, no mother in HH	62.47	2.46	56.67	1.23	
Part-time	15.24	2.03	23.62	0.97	
Unemployed	22.29	2.34	19.71	0.98	
BMI Z-score	2.28	0.01	0.41	0.02	<0.0001**
BMI (kg/m^2)	34.05	0.22	21.48	0.08	<0.0001**

*p<0.05; **p<0.01. Note: Sample means and standard errors are weighted. Children were reported as receiving breakfast if parent reported at least one school breakfast was received in past 5 school days. 5th grade corresponds to wave 6 of the ECLS-K and 8th grade to wave 7; a small number of children are in other grades.

Table 4:

Linear cross-sectional analysis of BMI z-scores based on school breakfast participation and home meal environments for fifth and eighth grade students(n=6,641)

Table 4:Estimated relationships between school breakfast participation and BMI Z-scores

	Outcome variable: BMI z-score			
	5th grade		**8th grade**	
	Unadjusted point estimate (SE)	Fully parameterized point estimates (SE)	Unadjusted point estimate (SE)	Fully parameterized point estimates (SE)
Child receives school breakfasts	0.31(0.07)**	0.10 (0.07)	0.41 (0.05)**	0.16 (0.07)*
Family eating breakfast together		-0.004 (0.01)		-0.01 (0.01)
Family eating dinner together		-0.004 (0.01)		-0.01 (0.01)
Child's physical activity		-0.04 (0.01)**		-0.001 (0.01)
Male		0.15 (0.04)**		-0.04 (0.04)
Race				
White		--		--
Black		0.02 (0.08)		0.17 (0.08)*
Hispanic		0.22 (0.07)**		0.16 (0.06)**
Asian		-0.02 (0.11)		0.02 (0.10)
Other		0.06 (0.12)		-0.08 (0.15)
Parents highest educational level				
College Graduate		--		--
Did not complete HS		-0.03 (0.14)		-0.03 (0.12)
HS Grad		-0.02 (0.09)		0.03 (0.09)
Some College		-0.03 (0.06)		0.07 (0.05)
Marital Status				
Married		--		--
Not married		-0.01 (0.06)		0.04 (0.04)
SES Quintiles		-0.09 (0.03)**		-0.10 (0.03)**
Mother's Employment Status				
Full-time, no mother in HH		--		--
Part-time		-0.21 (0.06)**		-0.20 (0.05)**
Unemployed		-0.12 (0.06)*		0.04 (0.05)

*p<0.05; **p<0.01. Shown are the estimated coefficients and standard errors of linear models as indicated. Models 1 and 3 control for family breakfast and dinner meal environments, while models 2 and 4 are unadjusted. Children were reported as receiving school breakfast if parent reported that the child received a school breakfast in past 5 school days. Breakfast and dinner together models were treated as continuous variables with values ranging from 0-7 days. The estimates are for fifth grade (wave 6) and eighth grade (wave 7) children; a small number of children are in other grades.

Table 5:

Logistic cross-sectional analysis of binary obesity outcomes based on school breakfast participation and home meal environments for fifth and eighth grade students(n=6,641)

Table 5:Estimated odds ratios between school breakfast participation and obese/ not obese binary variable

	Outcome variable: Obese Binary			
	5th grade		**8th grade**	
	Unadjusted point estimate (SE)	Fully parameterized point estimates (SE)	Unadjusted point estimate (SE)	Fully parameterized point estimates (SE)
Child receives school breakfasts	1.88(1.38, 2.55)**	1.20(0.83,0.172)	1.91(1.39, 2.64)**	1.21(0.79,1.85)
Family eating breakfast together		0.96(0.92,1.01)		0.98(0.93,1.04)
Family eating dinner together		0.99(0.92,1.07)		1.01(0.93,1.09)
Child's physical activity		0.84(0.78,0.89)**		0.92(0.87,0.98) **
Male		1.41(1.13,1.77)**		1.43(1.11,1.85) **
Race				
White		--		--
Black		1.15(0.72,1.85)		1.36(0.83,2.22)
Hispanic		1.62(1.12,2.36)*		1.57(1.12,2.19)*
Asian		1.70(0.90,3.19)		1.39(0.68,2.83)
Other		1.25(0.68,2.29)		1.12(0.59,2.13)
Parents highest educational level				
College Graduate		--		--
Did not complete HS		0.78(0.38,1.59)		0.45(0.24,0.83)*
HS Grad		0.75(0.40,1.43)		0.62(0.36,1.06)
Some College		1.06(0.71,1.58)		0.96(0.65,1.40)
Marital Status				
Married		--		--
Not married		0.96(0.70,1.32)		0.92(0.69,1.23)
SES Quintiles		0.79(0.63,0.99)*		0.72(0.59,0.87)**
Mother's Employment Status				
Full-time, no mother in HH		--		--
Part-time		0.64(0.46,0.90)*		0.61(0.43,0.88)*
Unemployed		0.86(0.64,1.15)		0.94(0.70,1.25)

*p<0.05; **p<0.01. Shown are the estimated coefficients and standard errors of logistic models as indicated. Models 1 and 3 control for family breakfast and dinner meal environments, while models 2 and 4 are unadjusted. Children were reported as receiving school breakfast if parent reported that the child received a school breakfast in past 5 school days. Breakfast and dinner together models were treated as continuous variables with values ranging from 0-7 days. The estimates are for fifth grade (wave 6) and eighth grade (wave 7) children; a small number of children are in other grades.

Table 6:

Prospective analysis of eighth grade weight status based on fifth grade school breakfast participation and home meal environment (n=6,641)

Table 6:Estimated relationships between 5th grade meal characteristics and 8th grade weight status outcomes

	Outcome variable: BMI z-score		*Outcome variable: Obese Binary*	
	Unadjusted point estimate (SE)	Fully parameterized point estimates (SE)	Unadjusted point estimate: OR (SE)	Fully parameterized point estimates: OR (SE)
Child receives school breakfasts	0.39 (0.5)**	0.15 (0.06)*	1.91(1.44,2.54)**	1.31 (0.90,1.90)
Family eating breakfast together		-0.003 (0.01)		1.03 (0.98,1.08)
Family eating dinner together		-0.001 (0.01)		0.99 (0.93,1.07)
Child's physical activity		-0.02 (0.01) *		0.86 (0.82,0.91)**
Male		-0.01 (0.04)		1.46 (1.14,1.89)**
Race				
White		--		--
Black		0.17 (0.07) *		1.36 (0.85,2.20)
Hispanic		0.17 (0.06) *		1.61 (1.13,2.29)**
Asian		0.004 (0.10)		1.26 (0.62,2.55)
Other		-0.03 (0.15)		1.17 (0.62,2.22)
Parents highest educational level				
College Graduate		--		--
Did not complete HS		0.01 (0.11)		0.47 (0.26,0.86)*
HS Grad		0.04 (0.08)		0.64 (0.38,1.06)
Some College		0.08 (0.05)		0.95 (0.67,1.34)
Marital Status				
Married		--		--
Not married		0.03 (0.04)		0.88 (0.66,1.19)
SES Quintiles		-0.09 (0.03)*		0.72 (0.59,0.89)**
Mother's Employment Status				
Full-time, no mother in HH		--		--
Part-time		-0.17 (0.04)*		0.52 (0.36,0.75)**
Unemployed		-0.05 (0.04)		0.76 (0.56,1.04)

*p<0.05; **p<0.01. Shown are the estimated coefficients and standard errors of linear and logistic models as indicated. Model 1's outcome variable is BMI z-score in 8th grade, while model 2's outcome variable is the binary obese/ not obese variable in 8th grade. Independent variables are from the sixth wave (fifth grade) data set. Children were reported as receiving school breakfast if parent reported that the child received a school breakfast in past 5 school days. Breakfast and dinner together models were treated as continuous variables with values ranging from 0-7 days. A small number of children are in other grades.

Table 7:

Prospective analysis of changes in weight status based on school breakfast participation and home meal environment (n=6,641)

Table 7: Estimated relationships between 5th grade characteristics and 8th grade changes in BMI z-scores.

	Outcome variable: BMI z-score		*Outcome variable: Obese Binary*	
	Unadjusted point estimate (SE)	Fully parameterized point estimates (SE)	Unadjusted point estimate: OR (SE)	Fully parameterized point estimates OR (SE)
Child receives school breakfasts	0.07 (0.03)*	0.03 (0.03)	1.51(1.06,2.16)*	1.02 (0.69,1.52)
Family eating breakfast together		0.00004 (0.01)		1.04 (0.98,1.10)
Family eating dinner together		0.004 (0.01)		0.98 (0.90,1.08)
Child's physical activity		0.01 (0.01)		0.97 (0.90,1.05)
Male		-0.14 (0.02)**		1.19 (0.84,1.68)
Race				
White		--		--
Black		0.07 (0.05)		1.37 (0.76,2.47)
Hispanic		-0.06 (0.03)		1.06 (0.71,1.58)
Asian		-0.01 (0.04)		0.53 (0.27,1.05)
Other		-0.08 (0.12)		1.32 (0.60,2.94)
Parents highest educational level				
College Graduate		--		--
Did not complete HS		0.06 (0.08)		0.41 (0.15,1.11)
HS Grad		0.04 (0.04)		0.48 (0.21,1.07)
Some College		0.07 (0.03)*		0.71 (0.44,1.15)
Marital Status				
Married		--		--
Not married		0.03 (0.03)		1.25 (0.87,1.81)
SES Quintiles		-0.01 (0.01)		0.71(0.54,0.92)**
Mother's Employment Status				
Full-time, no mother in HH		--		--
Part-time		0.01 (0.03)		0.84 (0.50,1.40)
Unemployed		0.07 (0.03)*		1.23 (0.86,1.77)

*p<0.05; **p<0.01. Shown are the estimated coefficients and standard errors of linear and logistic prospective models as indicated. Model 1's outcome of interest was measured as BMI z-score at eighth grade minus BMI z-score at fifth grade. Model 2's outcome variable was coded as 1 if there was a positive change in weight status and 0 if there was no change or a negative change in weight status. Independent variables were measured at wave 6 (fifth grade). Children were reported as receiving school breakfast if parent reported that the child received a school breakfast in past 5 school days. Breakfast and dinner together models were treated as continuous variables with values ranging from 0-7 days. A small number of children are in other grades.