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Timing is Everything: The Impact of School Lunch Length on Children's Body Weight

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Abstract: The large number of overweight children in the United States has prompted school administrators and policy makers to identify practices in schools that contribute to unhealthy weight outcomes for children and develop strategies to prevent further increases. Advocates for school nutrition reform have suggested that it is important for children to have an adequate amount of time to eat meals in school in order to maintain a healthy weight. This article examines whether the length of time children are given to eat lunch in school has an impact on their weight. I find evidence that an increase in lunch length reduces the probability a child is overweight, and this finding is robust across various econometric specifications, including a two-sample instrumental variable model and difference-in-differences model that account for the potential endogeneity of lunch length [PUBLICATION ABSTRACT].

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1. Introduction

The connection between the food children eat in school and their body weight has been the topic of much discussion among public health officials (U.S. Department of Health and Human Services 2001). Children eat close to 180 lunch meals in school each year, in addition to snacks, and, for some students, breakfast. As a result, emphasis has been placed on identifying practices in schools that contribute to children's excess weight, and on developing strategies to reduce further gains. Past research has examined the link between weight and the availability of junk food in schools, school lunches, and participation in the National School Lunch Program and School Breakfast Program (Anderson and Butcher 2006; Schanzenbach 2009; Millimet, Tchernis, and Husain 2010; Gundersen, Kreider, and Pepper 2012). [1]

One aspect of the eating environment at school that has received attention among advocates for school nutrition reform, but less so in research, is the length of time children are given to eat lunch. For instance, both the National Association of State Boards of Education (NASBE) and the School Nutrition Association (SNA) have recommended that schools provide students with at least 20 minutes to eat lunch once they are seated (NASBE 2000; SNA 2005).

Two questions arise in light of this recommendation. First, what is the typical amount of time students are given to eat lunch, and second, how might lunch length impact weight? Data from the School Nutrition Dietary Assessment-III (SNDA), a survey of students in first-twelfth grade, indicate that the average lunch length is 32.7 minutes, with some children receiving as little as 10 minutes and some receiving as much as 60 minutes. During this time, children must travel to and from the cafeteria, wait in line to obtain their food (if applicable), and clean

up. As a result, the amount of time actually available for eating could be substantially lower. For instance, a report by the National Food Service Management Institute indicates that in order for children to have 20 minutes of eating and socializing, an additional three to eight minutes are necessary for service and cleaning, and four minutes for travel (Conklin, Lambert, and Anderson 2002).

There are a few ways that lunch (or any meal) length may affect weight. First, short lunch periods may lead students to skip lunch, and this can result in overeating later. Second, short lunches may affect students' food choices and lead them to substitute away from healthy food items to quicker, less healthy alternatives. Finally, there is a medical literature that suggests that there is a delay between eating and satiation (Hayes and Landan 2009; Rolfes, Pinna, and Whitney 2009), and as a result, eating at a slow pace can lead to lower calorie intake relative to eating at a fast pace (Martin et al. 2007; Andrade, Greene, and Melanson 2008). If children that have short lunches eat quickly, this could translate to greater calorie consumption during lunch.

This article examines whether the length of time children are assigned to eat lunch in school has an impact on their body mass index (BMI). Ordinary least squares (OLS) estimates indicate a negative relationship between lunch length and BMI; however, these estimates may be biased due to the potential endogeneity of school lunch length. To overcome this, I estimate a two-sample instrumental variables (IV) model, where the instrument is each state's law regulating lunch lengths in school. I find a 10 minute increase in predicted lunch length is predicted to reduce BMI by 1.2% and the probability of being overweight by 2.5 percentage points. These findings are also upheld in a difference-in-differences (DD) model, where I estimate the reduced form effect of the state laws on BMI.

To understand the mechanism(s) behind the BMI and lunch length relationship, I analyze calorie intake data. I find that students with shorter lunches consume fewer calories during lunch, but more during dinner, compared to their counterparts with longer lunches. This suggests the negative relationship between BMI and lunch length may be due to longer lunches shifting consumption toward times of the day when there are more opportunities to expend calories.

2. Background and Related Literature

School Meals and Children's Body Weight

This article contributes to the literature on eating at school and weight. Schanzenbach (2009) finds that students in kindergarten and first grade who eat school lunches are more likely to be obese than their classmates who bring their lunch from home. Anderson and Butcher (2006) find that increased access to junk food at schools results in higher BMI. Gundersen, Kreider, and Pepper (2012) find that children who receive free/reduced-price lunches have higher self-reported health outcomes compared to income-eligible children that do not participate. Millimet, Tchernis, and Husain (2010) find that children who receive free/reduced-price breakfasts (lunches) are less (more) likely to be obese compared to all other students. Finally, a series of studies examine the effect of other factors in school such as physical education, recess, and the structure of the school day/year on weight (Getlinger et al. 1996; Cawley, Meyerhoefer, and Newhouse 2007; von Hippel et al. 2007; Frisvold and Lumeng 2011).

To the best of my knowledge, only one other study, by Bergman et al. (2003), examines the relationship between lunch length and consumption. The authors compare food intake among children that receive 20 minutes for lunch versus 30 minutes and find that plate waste is higher among children with the shorter lunch, but the nutritional content of food consumed by students with 30 minutes for lunch is higher. This suggests that longer lunches may lead to better food choices, although a caveat to this study is that it is based on a sample size of four schools.

Meal Length and Weight: Potential Mechanisms

Meal length and food consumption can be related in a variety of ways. First, meal length may affect the food choices children make. Short lunches may encourage students to substitute towards quicker-to-eat, less healthy foods, such as choosing apple sauce (194 calories if sweetened) over a raw apple (81 calories). These foods

can be brought from home or bought at school from vending machines, where the nutritional quality of food has typically been found to be low (Center for Science in the Public Interest 2013). In addition, short lunches may affect purchases of school meals, since this requires spending time in the service line, and the nutritional content of these meals could have an impact on weight (Schanzenbach 2009).

A second way that meal length may affect weight is if short lunches lead children to skip lunch or eat less than is nutritionally necessary because they lack time. Research has found that kids who skip meals are more likely to be obese due to unhealthy snacking and overeating at other meals (Lafay et al. 2001; Leidy et al. 2001; Deshmukh-Taskar et al. 2010). Longer lunches could lead to lower BMI by shifting consumption towards times of the day when there are more opportunities to expend calories (i.e., after lunch) compared to later in the day (i.e., after dinner).

The third link is based on the physiology of appetite. When an individual eats, signals are sent from the stomach to the brain to indicate that the individual is getting full and should stop eating. These signals take 10 to 20 minutes to reach the brain once eating starts (Hayes and Landan 2009; Rolfes, Pinna, and Whitney 2009), and it is under this setting that individuals are recommended to eat slowly, so that they do not overeat. [2] If children with short lunches eat quickly, then these students may consume more calories than students who eat slowly (by virtue of having a long lunch). Although there is no direct evidence that children eat quicker when they have a short time to eat, this seems plausible. For instance, in the SNDA-III, a higher proportion of students with short lunches report being dissatisfied with their lunch length: 32% of students with less than 30 minutes are dissatisfied, compared to 25% of students with 40-plus minutes.

Finally, it is important to note that while the mechanisms described herein provide motivation for why longer lunches may lead to lower weight, it is possible that longer lunches actually increase weight. Very long lunches may simply provide children with too much time to eat, so that, for instance, they purchase extra food and consume more than if they were time constrained. More generally, the effect of lunch length could be nonlinear: Both short and long lunches could induce poor eating behavior and result in more overweight children. I investigate evidence for this in section 4, but ultimately find no evidence of nonlinear effects.

Meal Length and Weight: Potential Biases

An issue with estimating the effect of meal length on weight is that lunch length may be correlated with unobserved factors that directly influence weight. For instance, parents that otherwise encourage healthy nutrition habits may send their children to schools with longer lunches, and it is these habits that affect weight gain. Similarly, schools facing accountability pressures may reduce the time allocated for lunch as well as physical education to increase instructional time, and it could be the reduced exercise time that ultimately impacts weight.

While some of these issues are more plausible than others, I cannot ignore the potential endogeneity of lunch length. As a result, I estimate the impact of lunch length using a variety of methods. First, I estimate an OLS model where I condition on a rich set of controls for children's eating behavior and nutrition practices at school. Second, I estimate a two-sample IV (TSIV) model where I instrument for lunch length using state laws regarding the minimum amount of time schools should allocate for lunch. I then use the exogenous portion of lunch length that is uncorrelated with unobservables to identify the impact on children's weight. The TSIV model exploits variation in lunch laws across states, which may be confounded with other unobserved state characteristics. As a result, I also estimate a difference-in-differences (DD) model where I utilize variation over time within a state by comparing the weight outcomes of students from the same state that face different state lunch laws. Together, the results from these models offer useful insight into the relationship between weight and lunch length.

3. Data and Descriptive Statistics

School Nutrition Dietary Assessment-III

The SNDA-III is a nationally representative survey of children in grades 1 through 12 at schools in the United

States conducted in 2005. The survey covers 2314 students at 285 schools. Children, their parents, principals, and school food service managers are surveyed regarding the diet and exercise behaviors of kids and the nutrition environment at schools. In addition, survey administrators measure each child's height and weight, providing a measure of BMI. This data are used for the OLS analysis, and one important limitation of this data is that it does not contain state identifiers.

Children are not asked how long their lunch periods are, and so I constructed lunch length using principals' reports of the start and stop time of each lunch period and the grades that eat in each period. I combined this with each child's grade to construct lunch length for each child. Missing information on lunch length, BMI, and key demographic characteristics reduces the final sample size to 1287 students from 179 schools. [3] Appendix A provides descriptive statistics for all the variables in the SNDA-III that are included in the OLS model. Although the average lunch length is over 30 minutes, children likely have less than this to eat--for instance, school food service managers report that children spend an average of 5.5 minutes waiting in line to purchase food. Finally, note that a child is defined as overweight (obese) if he/she has a BMI above the 85th (95th) percentile of a historic baseline for their age and sex.

School Health Policies and Programs Study

The School Health Policies and Programs Study (SHPPS) is a survey of schools and states conducted in 2006, and I used data from it for the TSIV and DD analyses. In the survey, state school food administrators from all 50 states and the District of Columbia are asked about state laws governing school nutrition practices. In a subset of these states, school administrators were also surveyed regarding policies at their school. Overall, 944 schools from 41 states (state identities are known) were selected to participate in both the state and school survey, but missing information on key variables reduces the sample to 916 schools.

I obtained information on lunch length from the school administrator survey. Administrators are asked how much time (on average) students in their school have to eat lunch once they are seated. The average is 22.7 minutes, with some schools providing as little as 10 minutes and some as much as 60 minutes. Comparing the average lunch length in the SHPPS to the SNDA-III suggests that a nontrivial amount of a child's lunch can be spent on noneating activities. [4]

I obtained information on each state's minimum lunch length law from the state food service administrator questionnaire. Administrators were asked if their state required or recommended schools to provide a minimum time for lunch once students were seated. Administrators answered whether they had a requirement (six states), recommendation (26 states), or no policy (18 states plus D.C.). [5]

The SHPPS does not contain information about the required or recommended times. In conversations with state food service agencies, the requirements were determined to be: Delaware, N/A; Kansas, 20 minutes once students are seated with food; New Mexico, 30 minutes for the entire lunch period; Nevada, 20 minutes once seated; South Carolina, 20 minutes once seated for grades K-5, a recommendation for all other grades; and West Virginia, 20 minutes once seated. States with recommendations do not provide a numerical time; rather, they suggest that schools provide "enough" time for children to enjoy and consume their food. I constructed the instrument as a set of two dummy variables equal to one if the state has a recommendation or no policy, respectively (the omitted category is having a requirement).

There are three aspects of the state laws that are important to note. First, the exact year that states adopted their law is not known, although there is evidence to suggest it occurred between 2000 and 2006. In 2000, an SHPPS survey was also conducted, and in this survey, state food administrators were asked about their lunch policies. At the time, zero states had a requirement, two had recommendations, and the remaining had no policy. [6] Finally, in conversations with state food service agencies, it was determined that the 2006 laws were still in place by 2010.[7]

Second, although the motivation for adopting these laws is not known, anecdotal evidence suggests it may have been driven by federal pressure that affected all states at once, rather than in response to a state-specific event

or trend. In June of 2004, the U.S. Congress passed the Child Nutrition and WIC Reauthorization Act, which required educational agencies to develop and implement a wellness policy by the 2006 school year. The wellness policy should highlight goals and practices for nutrition, physical/health education, and food provision; the latter could include minimum lunch length. These wellness policies were constructed in consultation with states, and as a result states themselves may have identified a set of "best practices," such as a minimum lunch length, to implement at the state level (Council of State Governments 2007).

A third and related point is that in order for state lunch length laws to be a valid instrument in the TSIV model and exogenous regressors in the DD model, they must be uncorrelated with unobserved characteristics that can directly influence children's health outcomes. Although this cannot be tested directly, in section 5, I present a series of falsification tests and empirical evidence suggesting the state laws are plausibly exogenous.

I obtained information on other state-level school nutrition policies (i.e., physical education standards, bans on vending machines, etc.) from the state food administrator questionnaire in the SHPPS. These are listed in the upper half of Appendix B. Administrators reported whether there was a requirement, recommendation, or no policy, and I formatted their responses as a series of dummy variables (requirement is always the omitted category). The lower half of Appendix B details descriptive statistics for a series of state-level variables that I appended to the SHPPS from various auxiliary data sources. This includes socioeconomic characteristics from the U.S. Census such as age and race breakdowns, the percentage of free/reduced-price lunch recipients, and characteristics of schools from the National Center for Education Statistics such as average pupil-teacher ratio and achievement on the National Assessment of Educational Progress mathematics exam. I use these variables to control for school environmental factors that could affect lunch length and weight outcomes. Finally, adult obesity rates were obtained from the Centers for Disease Control and Prevention (2010) to control for state-level health conditions.

Youth Risk Behavior Surveillance System

The YRBSS is conducted every two years, starting in 1991 and most recently in 2009. The YRBSS is a cross-sectional survey of ninth- through twelfth-grade students, and it collects information on students' eating habits. Students self-report their weight and height, providing a measure of BMI. The YRBSS does not contain information on lunch length, but students' state of residence is known, and consequently all the state-level information from the SHPPS and auxiliary data sets can be merged to the YRBSS. These data are used for the TSIV and DD analysis.

For the analysis, I pooled the 2007 and 2009 YRBSS surveys. Waves prior to 2007 were not used to ensure that all students were exposed to the laws that existed as of 2006.[8] The data were pooled across years to increase sample size, and the final sample consists of over 180,000 students from 41 states. Appendix C displays summary statistics for these students.

Unlike in the SNDA-III, BMI in the YRBSS is constructed from self-reported height and weight, which can be reported with error. While the correlation between self-reported and actual BMI is high, the former is generally underestimated (Morrissey et al. 2006). In fact, there is evidence of this in the data--among high school students, there is a lower proportion of overweight and obese students in the YRBSS compared to the SNDA-III. If the measurement error is classical, this will not bias the estimates, but it does reduce precision. In the TSIV analysis, measurement error in BMI will not result in biased estimates so long as the measurement error is uncorrelated with the instrument. While it seems unlikely that the misreporting is correlated with state laws, this cannot be ruled out, and the results should be considered with this caveat. Prior research has faced similar issues with self-reported measures (Anderson and Butcher 2006; Cawley, Meyerhoefer, and Newhouse 2007).

4. OLS Estimation and Results

I estimate the following model using the SNDA-III data:

(Formula omitted. See article image.)

Here, $health_{is}$ represents one of three health outcomes for child i in school s : the natural log of BMI, and two

binary indicators for being overweight and obese. I use a linear probability model; results (available upon request) are similar using probit. The variable $lunchlength_{is}$ is the length of a child's lunch period in minutes. X_{is} is a vector of child and parent characteristics, and S_s is a vector of school characteristics. All the variables in X_{is} and S_s are listed in Appendix A. Standard errors are clustered at the school level, and SNDA-III sample weights are used.

In columns 1 and 2 of Table 1, I display the OLS results for the three outcomes. For brevity, only the coefficient on lunch length is shown. Column 1 shows the results when I condition on basic characteristics of children (age, sex, race, family income), schools (attendance rate, grade span, whether children receive recess), and dummies for region of residence. The estimates indicate that a 10 minute increase in lunch length is predicted to decrease BMI by 1.1% and lower the probability of being overweight by 3.7 percentage points (a 9.5% change from the mean), and there is a negative but insignificant effect on obesity. Column 2 provides the results when I include a richer set of covariates in the model. This includes whether there are vending machines or fast food restaurants at schools, whether children can leave campus for lunch, time spent in service line waiting for food, whether the child participates in sports, and whether the child buys lunch at school (for a full description of the controls, see Table 1 and Appendix A). In spite of these additional controls, the estimated effect is similar: A 10 minute increase in lunch length is predicted to decrease BMI by 1.3% and reduce the likelihood of being overweight by 3.9 percentage points. [9] I continue to find no effect on obesity; one explanation is that there can be different effects of lunch length across the BMI distribution.

Table 1. OLS Estimates: Effect of Lunch Length on Body Mass Index (SNDA-III)

(Table omitted. See article image.)

As discussed earlier, the effect of lunch length could be nonlinear if, for instance, very long lunches lead children to eat more. To test this, I created indicators for four categories of lunch length (10-29 minutes [omitted], 30, 31-40, and 41-plus minutes; bin sizes were chosen to equate observations across groups) and regressed the natural log of BMI on these indicators and all the covariates in Appendix A. None of the results is significant (omitted for brevity, but available upon request), but I do observe negative and nonzero point estimates for the two highest lunch categories relative to the omitted category. Overall then, I find no evidence that longer lunches lead to increases in weight for children.

In summary, the OLS estimates suggest that there is a negative relationship between lunch length and BMI. In an omitted analysis (available upon request), I show these results are robust to the inclusion of additional controls and alternative specifications. [10] That said, there may be unobserved factors that bias the OLS results, and so I turn to the TSIV and DD models.

5. TSIV and DD Estimation

First Stage

In the first stage, I use the SHPPS to estimate the relationship between lunch length and each state's laws on lunch length. Formally, I estimate:

(Formula omitted. See article image.)

Here, $lunchlength_{sm}$ denotes lunch length in school s and state m , and Z_m is a set of dummy variables for if a state recommends or has no policy on lunch length (recall the omitted category is require). M_m is a vector of state-level school nutrition and physical education policies, financial characteristics, and socioeconomics, and R_m is a set of region dummies. All control variables included in the first and second stage of the TSIV model are listed in Appendix B. Finally, standard errors are clustered by state, and SHPPS sample weights are used throughout.

The set of conditioning variables was purposefully chosen to be large and exhaustive in an attempt to control for state characteristics that may be correlated with weight and lunch length. This includes whether students can purchase junk foods at school, must meet state physical education standards, and whether schools have serving size limits. Teacher salary and pupil-to-teacher ratios are intended to proxy for overcrowding and

financial conditions of schools. Adult obesity rates capture variation in health across states, and math proficiency rates are meant to reflect performance accountability pressures. It should be noted that no school-level covariates can be included in the model since the estimates from this regression are used to predict lunch length in the YRBSS, where there are no data about schools. As a result, the state-level school variables are also intended to control for practices at the school level that could affect children's weight (i.e., a state ban on vending machines will affect their prevalence at schools).

The first-stage results are displayed in Table 2. Focusing first on the instrument, the results indicate that schools in states with a recommendation have lunches that are, on average, 5.7 minutes shorter compared to schools in states with a requirement. An even stronger effect is found at schools where there is no policy: Lunch lengths are about 6.6 minutes shorter. The F-statistic testing the joint significance of the instrument is 30.62 (p -value = 0.0000). In addition, I test whether the coefficient estimates on the indicators for recommendations and no policy are statistically different from one another and find that they are at the 5% level. This indicates that the identifying variation is not only based on a comparison of states with and without a requirement, but also across states with no policy versus a recommendation. [11]

Table 2. TSIV First-Stage Estimates: Effect of State Lunch Laws on Lunch Length (SHPPS + Auxiliary Data)

(Table omitted. See article image.)

Second Stage

For the second stage, I use the YRBSS data with the merged SHPPS and auxiliary data. Using the estimates from Equation 2, I constructed predicted lunch length (denoted, $predlunch_m$) for each student in the YRBSS and estimated:

(Formula omitted. See article image.)

Here, $health_{im}$ refers to any one of three outcomes for student i in state m (natural log of BMI, overweight, obese). M_m and R_m are defined as in Equation 2 (described in Appendix B), and B_{im} is a vector of student characteristics from the YRBSS that are listed in Appendix C. Standard errors are clustered at the state level, and YRBSS sample weights are used. Standard errors are adjusted to correct for the fact that lunch length is predicted (Murphy and Topel 1985).

The second-stage results are displayed in Table 3. For each dependent variable, Equation 3 is estimated with and without B_{im} , and for brevity, only the coefficients on these variables and predicted lunch length are reported. For the outcome using the natural log of BMI, I find that a 10 minute increase in predicted lunch length is predicted to reduce BMI by 1.2-1.3%. Controlling for individual characteristics does not substantially change the estimate on lunch length, suggesting demographic characteristics are not correlated with the exogenous portion of lunch length that is predicted by state law. The remaining columns suggest that a 10 minute increase in predicted lunch length is predicted to reduce the probability that a child is overweight by 2.5 percentage points (9%), and there is no significant effect on obesity.

Table 3. TSIV Second-Stage Estimates: Effect of Predicted Lunch Length on Body Mass Index (YRBSS + SHPPS + Auxiliary Data)

(Table omitted. See article image.)

Difference-in-Differences

I examine the robustness of the TSIV results by estimating a simple difference-in- differences (DD) model of each state's lunch law on BMI. This is analogous to estimating the reduced form regression of the instrument on the outcome. The DD model compares BMI before and after a state switched from no policy to a recommendation or requirement, relative to the same before and after for states where the state continued to have no policy. To do this, I utilized data from the 1999, 2001, 2007, and 2009 YRBSS, and the 2000 and 2006 SHPPS.

To construct the data for the DD analysis, I first combined data from the YRBSS survey years 1999 and 2001 (this serves as the "pre" period) and data from the 2007 and 2009 surveys (the "post" period). I limited the

sample to states that were surveyed in both the 1991/2001 and 2007/2009 surveys. Next, I used data from the 2000 and 2006 SHPPS surveys to determine whether states had a requirement, recommendation, or no policy on minimum lunch length in 2000 and 2006. None of the states included in the combined 1999, 2001, 2007, and 2009 YRBSS had a policy in 2000. The final sample includes more than 230,000 students across 32 states. I estimate:

(Formula omitted. See article image.)

Here, *i* refers to the individual, *m* to the state, and *c* to the YRBSS cohort (i.e., 1999/2001 or 20007/2009). $Require_m$ is a binary variable equal to one for states where there was no policy in 2000 but by 2006 there was a requirement, and $Recommend_m$ is a binary variable equal to one for states where there was no policy in 2000 but by 2006 there was a recommendation. The omitted category is states where there was no policy in 2000 or in 2006. $C0709_{mc}$ is an indicator equal to one for observations from the 2007/2009 YRBSS and zero for the 1999/2001 YRBSS. M_{mc} is a vector of the same state-level controls that were included in the TSIV model. (For the 1999/2001 YRBSS observations, I use state-level covariates for the year 2000.) Finally, B_{imc} is a vector of individual characteristics of students in the YRBSS. The coefficients λ_4 and λ_5 provide the difference-in-difference estimates.

The results are given in Table 4. Only the estimates for λ_1 to λ_5 are presented for brevity. Column 1 (2) shows the results without (with) controls for demographic characteristics. In both specifications, the effect of the law is in the expected direction. That is, I observe a decrease in BMI by approximately 2.3-2.5% for students living in states that went from no policy to a requirement (relative to students in states where there was never a policy). There is a similar, but smaller, drop in BMI of 0.8-0.9% in states that switched to a recommendation. Moreover, the F-statistic testing the equality of the two interaction terms is sufficiently large that I can reject the null at the 1% level in both columns 1 and 2.

Table 4. Difference-in-Difference Estimates: Effect of State Lunch Laws on Body Mass Index (YRBSS + SHPPS + Auxiliary Data)

(Table omitted. See article image.)

Validity of Instrument

In order to interpret the estimates from the TSIV and DD analyses as estimating causal effects, a state's lunch law should only affect weight outcomes through lunch length. Doubts about validity can be aggregated into two broad categories. First, states' lunch length laws could reflect unobserved differences that exist across states, and it is these differences that affect outcomes, rather than lunch length. For instance, a state may adopt their lunch law in response to preexisting trends in BMI. Second, state laws may induce changes in schools with respect to other nutrition practices that can directly influence BMI, which will confound the results. Although I cannot conclusively rule out these issues, below I describe a series of falsification tests and empirical evidence that suggests these issues are unlikely to bias the results.

I tested for evidence of whether states adopted their lunch laws in response to prior trends in children's weight. If this is the case, I should observe a relationship between the lunch laws in place by 2006 and BMI in states prior to that year. To test this, I estimated the TSIV model (first and second stages are defined in Eqns. 2 and 3), where in lieu of using data from the 2007/2009 YRBSS, I used student BMI data from the 1999/2001 YRBSS. I conditioned on all the controls listed in Appendix B (in both the first and second stage). The results are omitted for brevity (available upon request). I find no significant effect of predicted lunch length on BMI, suggesting there is no relationship between prior levels of BMI and the state lunch laws. [12]

I cannot control for school-level covariates in the TSIV and DD models, since the YRBSS does not include information on schools. The lack of school controls will be problematic if a state's lunch law not only affects lunch length, but also other school practices that impact weight. I investigate this in the upper half of Table 5 using data on schools in the 2006 SHPPS. I considered four characteristics of schools that may plausibly change in response to lunch length and could affect children's weight: overcrowding of eating locations, amount

of time allocated for recess and physical education, and bans on junk foods in vending machines. In the table, I group schools by their state's law and calculate the fraction of schools with the given characteristic. Rates of overcrowding and recess time are similar across groups, but schools with lunch length requirements tend to ban junk food at a higher rate and offer more time for physical education. That said, these differences are not statistically significant once I control for observed state-level characteristics. The last column provides the F-statistic testing the joint significance of the lunch law dummies from a regression of these characteristics on the dummies and all the covariates in Appendix B, and in all cases, I fail to reject the null.

Table 5. Characteristics of Schools, by 2006 State Lunch Length Policies

(Table omitted. See article image.)

A remaining concern is whether schools changed their lunch lengths in response to their state's law, or if schools were already setting systematically different lunch lengths prior to the law. This is tested using data from the 2000 SHPPS. Schools in the 2000 SHPPS were asked to report the length of time children were given to eat lunch once seated with food. The last row of Table 5 provides average lunch time in 2000 for schools grouped by the law their state adopted by 2006. Lunches range from 22 to 24 minutes, and the differences are not statistically different, suggesting no evidence of systematic differences prior to adoption.

6. Discussion

Comparison of Results

The OLS and TSIV estimates are largely similar, indicating a 10 minute increase in lunch length is predicted to reduce BMI by 1.1-1.3% and reduce the probability of being overweight by 2-3.7 percentage points. Moreover, the difference-in-differences model produces results that are consistent with the way in which state lunch laws can affect children's weight vis-à-vis lunch length. The pattern of results across models provides fairly consistent evidence of a negative relationship between lunch length and body mass index among children in school.

Economic Significance of the Estimates

I can evaluate the magnitude of the findings by estimating the monetary and nonmonetary savings that accrue from providing longer lunches. This is done below, but it should be noted that these calculations do not factor in any of the potentially adverse consequences of or costs associated with scheduling longer lunches. For instance, increasing lunch length could come at the expense of instructional and noninstructional time, leading to potentially lower achievement and opportunity for exercise. Moreover, lengthening lunches could necessitate hiring more staff and incurring additional expenses. Any formal assessment of the welfare benefits of longer lunches should consider the potential costs and benefits, and this is out of the scope of this analysis.

Fewer overweight children would translate into lower costs of treating weight-related illnesses.[13] Transande and Chatterjee (2009) estimate that the two-year medical cost of services for treating overweight children (relative to normal weight) is close to $79 per child. Pairing this with the TSIV finding, if all students in the YRBSS were given 10 minutes more for lunch, this would reduce the share of overweight children from the current average of 27.7% to 25.2%, which represents a cost saving of nearly $33 million dollars (2005 dollars) over two years.

Additionally, I can consider the impact on academic outcomes. Several studies have examined the impact of obesity on academic outcomes (Geier et al. 2007; Sabia 2007). Taking Geier et al.'s (2007) finding that overweight children miss 1.7 more days of school per year than their normal weight classmates, the results indicate that if all students in the YRBSS were given 10 minute longer lunches, this would reduce the number of absences by close to 700 thousand days per year. This is a nontrivial amount, given that close to 60% of all 10th-grade students miss anywhere from one to six days per year (Snyder and Dillow 2011).

Calorie Consumption

As discussed already, there are (at least) three potential channels through which lunch length may affect children's weight. Shorter lunches may lead students to skip lunch, substitute towards less healthy food options, or lead students to eat at a quick pace. To gain insight on these potential mechanisms, I examine data on

calorie consumption from students in the SNDA-III. Students completed a 24 hour dietary recall diary, where they listed their food consumption over a random school day, and the calorie content of these foods was computed by survey administrators. I used these data to estimate the relationship between calorie consumption and the length of time a child is assigned to eat lunch in school using OLS. The dependent variables are the amount of calories consumed during various meals in the day. I allow for nonlinear effects by formulating lunch length as a set of binary indicators representing lunch lengths of 10-29 minutes (omitted), 30, 31-40, and 41 plus minutes. All regressions control for all the covariates in Appendix A and are estimated using SNDA-III survey weights.

The results are presented in Table 6.[14] There are no significant differences in calories consumed during breakfast or as snacks for students with different lunch lengths. In contrast, I observe that students who have 30 minutes to eat lunch consume an average of 59 more calories during that time than students who eat for less than 30 minutes, and those with 40 or more minutes eat close to 100 calories more. Looking at dinner, I find a similar but opposite-signed pattern: Students with 30 minutes to eat lunch consume 90 fewer calories during dinner, and students with 40 or more minutes consume 120 fewer calories compared to the omitted category. When I look at all the calories consumed over a day, however, there are no significant differences in calories consumed across students with different lunch lengths.

Table 6. OLS Estimates: Effect of Lunch Length on Calorie Intake (SNDA-III)

(Table omitted. See article image.)

These results suggest that timing of consumption can have important implications for weight gain. Students arguably have more time to burn off any calories consumed during the day with exercise and play, whereas there are fewer opportunities for exercise after dinner. Although I find no evidence that lunch length affects the total amount of calories consumed, the results in Table 6 indicate that longer lunches may shift consumption towards times of the day where students have more opportunities to expend calorie intake, thus leading to reductions in BMI.

7. Conclusion

The consequences of childhood obesity are considerable. Overweight children are at risk for having high blood pressure and elevated levels of cholesterol, are more prone to asthma, sleep apnea and Type 2 diabetes, and experience psychosocial problems, which can lead to risky behavior and depression (Mallory, Fiser, and Jackson 1989; Serdula et al. 1993; Dietz 1998; Freedman et al. 1999; Farhat, Iannotti, and Simmons-Morton 2010). Such illnesses can lead to poor academic performance, which has implications for human capital accumulation and skill formation (Geier et al. 2007; Sabia 2007).

The severity of childhood obesity has prompted interest at the national and local level for developing strategies to reduce obesity and prevent further increases from occurring (U.S. Department of Health and Human Services 2001; NASBE 2010). At the forefront of this discussion are schools, and of particular interest is the role of meals and food eaten at school. Proposed school-based methods to achieve reductions in obesity include, among other things, increasing the availability of fresh fruits and vegetables, reducing the availability of calorie sweetened beverages (U.S. Department of Health and Human Services 2001), and, as argued by some advocates for nutrition reform, scheduling lunch periods of sufficient length so that children have time to consume and enjoy their food (NASBE 2000; SNA 2005).

To date, there has been no evidence about the impact of lunch period length on children's weight. This article is the first to provide evidence on this link. The TSIV results indicate that extending lunch length by 10 minutes is associated with a 1.2% reduction in BMI, and it reduces the probability a child is considered overweight for his/her age and gender by 2.5 percentage points. These magnitudes are economically meaningful when translated into potential cost savings that could result from a reduction in treating weight-related illness among children.

Although the results indicate that allocating more time for school meals has potential benefits for lowering

children's weight, there are many practical considerations that limit the extent to which schools can offer longer lunches. If the school day is held constant, longer lunches would presumably come at the expense of other noninstructional/noncore activities (physical education, art) or instructional activities (math, reading), and there are drawbacks to this. While increasing the length of the school day is one possibility, this is likely to meet resistance unless sufficient compensation can be given to staff and administrators. Given the already strained budgets of schools and districts, this seems difficult to manage. The tension between finances and practices that can affect weight is not unique to this study. For instance, Anderson and Butcher's (2006) study highlights the tradeoff between allowing junk food sales on school property and increased revenue to schools from these sales.

This analysis underscores the need for further research to be conducted not only on the food students eat in school, but also the environment in which they eat it. For instance, it may be of interest to examine whether the spacing of lunch between the beginning and end of the school day, or eating location (supervised cafeteria space versus unsupervised locations such as hallways or commons) has an effect on children's weight. It would also be interesting to examine the impact of lunch length on other outcomes of children, such as their behavior in school. Given the results of such research, policy makers and educational administrators can work towards developing effective and creative solutions for bettering the outcomes of children.

Footnote

A related literature examines the impact of other food assistance programs, such as the Food Stamp Program, on obesity (see, for example, Baum 2011).

This has been tested in laboratory experiments where some participants are instructed to eat at a slow pace and others at a fast pace. The former consumed fewer calories (Martin et al. 2007; Andrade, Greene, and Melanson 2008).

The majority of missing data stems from missing information on lunch length. Questions about lunch periods were asked during an initial contact survey with principals, and no effort was made to follow up. In an omitted analysis, I compare average characteristics of schools with and without missing information on lunch length and find no systematic differences. I omit 11 students with lunch lengths of 100 minutes, since they are potential outliers, and two students who were in kindergarten and may not eat at school because they attend half-day programs. Results are similar if these observations are included. All omitted analyses are available upon request.

Schools were omitted if lunch length was not reported, and all schools in Alaska were dropped because the state questionnaire was not answered. In addition, I omitted four schools that provided eight minutes for lunch because they are potential outliers (results are similar if they are included). Nine schools (three elementary, six secondary) were interviewed in South Carolina. Unlike all other states, younger children are subject to a different minimum lunch length policy (requirement) compared to older students (recommendation). For all other schools in the first stage, variation in the independent variables occurs only at the state level, and it is not clear whether to include all schools from South Carolina, inducing variation within the state. Since the second stage utilizes data from the YRBSS (see section 3), which consists of only high school students, I omit the three elementary schools. The results do not change meaningfully if these schools are included, however. All omitted analyses are available upon request.

States with a recommendation are: Alabama, Arkansas, California, Colorado, Connecticut, Georgia, Iowa, Idaho, Louisiana, Missouri, Mississippi, Montana, North Carolina, North Dakota, Nebraska, New Jersey, Ohio, Pennsylvania, South Dakota, Texas, Utah, Virginia, Vermont, Washington, Wisconsin, and Wyoming.

In the 2000 SHPPS, state food service administrators were first asked if their state had any lunch policies. Those that said yes (22 states) were then asked if there was a minimum lunch length policy. For the purposes of this analysis, I assume that states with no lunch policies had no minimum lunch length policy either. Substantial effort was made to identify the year in which states adopted their lunch law through conversations

with administrators at state school food offices, as well as by examining state statutes. Consistent information could not be determined through either of these methods. Louisiana and D.C. had recommendations in 2000. Some states and territories (California, D.C., Minnesota, Nebraska, Oregon, Virginia, and Washington) do not conduct a state YRBSS. Among the states that do, the Centers for Disease Control and Prevention (CDC) has permission from a subset of these states to directly provide researchers with the data. For the remaining states, a private data agreement must be reached with each state's YRBSS representative. Through these two methods, state YRBSS data were obtained for all the states that conduct a survey except two (Georgia and Louisiana).

Lunch length can vary within schools; however, this occurs only for 20% of students in the SNDA-III. Due to the small sample size and somewhat limited variation, I do not include school fixed effects in Equation 1. That said, in an omitted analysis, I re-estimate the equation with fixed effects, and find no significant effects of lunch length on any of the three outcomes. The standard errors in these regressions are more than double those in Table 1, however.

If students attend schools where the same grade can eat in multiple periods, I use the average and include an indicator for average lunch length in all regressions. Results are similar if averaged observations are excluded.

The results are also robust to the inclusion of a control for whether or not a child eats within 15 minutes of midday. Both the SNA and NASBE recommend that children eat close to midday in order to avoid going long periods of time without food. The coefficient on lunch length remains similar with the addition of the time-of-day control, and I find a negative but insignificant effect of eating at midday on BMI.

Since school characteristics like average pupil-teacher-ratio are measured at the state level, they may not accurately reflect the characteristics of any individual school exactly. This leads the school characteristics to be measured with sampling error. If the mismeasured variables are correlated with state lunch laws, this will bias the coefficient estimates on the instrument in the first stage. I gauge the extent to which mismeasurement affects the results in two ways. First, I omit the school characteristics from the first stage. Doing so changes the coefficients on "recommend" and "no policy" minimally, suggesting there is little correlation between the lunch law and school characteristics, conditional on other state-level controls. Second, I re-estimate the first stage under different assumptions about the extent of measurement error in the school characteristics. Even when assuming the school characteristics are only measured with 96% reliability, I still find similar first-stage results as those presented in Table 2. Results from these analyses are available upon request.

In an analysis, omitted for brevity (available upon request), I estimate the first stage of the TSIV model, where in lieu of controlling for each state's *school* lunch length law, I include each state's *workplace* lunch length laws (some states require that employers provide employed minors and adults with minimum break times) (Department of Labor 2006). If the school lunch laws simply reflect unobserved health and behavioral characteristics of a state, the workplace laws likely reflect similar characteristics, and therefore should be correlated with school lunch length. In practice, I find no evidence of this: The F-statistic testing the joint significance of the dummies for requiring a minimum lunch length for minors and adults has a p -value of 0.7203.

Cost savings can accrue regardless of if the costs of weight-related medical care are borne by all taxpayers, or largely internalized (Bhattacharya and Sood 2011).

The sample is restricted to students who ate lunch on the diary day and those that ate fewer than 6000 calories.

Appendix

(Table omitted. See article image.)

(Table omitted. See article image.)

(Table omitted. See article image.)

(Table omitted. See article image.)

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