Can providing a morning healthy snack help to reduce hunger during school time? Experimental evidence from an elementary school in Connecticut.

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Introduction

Childhood obesity is becoming a public health issue in most developed countries. Obese and overweight children are more likely to stay obese in adulthood and more likely to incur non-communicable diseases like diabetes and cardiovascular disease as adults (WHO, 2012). As a result, numerous obesity prevention studies seek to find appropriate policy interventions to alleviate behavioral and environmental factors positively related to obesity.

As school-age children spend a large share of their day in school, adapting the school food environment may be an ideal way to help promote healthful behavioral such as selecting healthful food choices. To this end, the federal government has taken several steps over the last fifteen years to help improve the school food environment. In 2001, the US Department of Agriculture (USDA) shared with Congress concerns regarding the poor nutritional value of the snacks provided in many schools. This was followed in 2004 with the reauthorization of the Child Nutrition Act which requires school districts to develop a local wellness policy imposing nutritional standards for a la carte foods, snacks and beverages. There are concerns, however, that these nutritional standards are not effective (The Pew Charitable Trusts, 2012).

Prior to school, children have the opportunity to eat breakfast at home, although some do not do so. At public schools, children also have the opportunity (but not the obligation) to eat breakfast at school, with some children receiving free or subsidized breakfasts. Then children have lunch where they obtain their meals from two primary sources: from the school or from their own home. In most schools, it is not school's responsibility to provide a snack between breakfast and lunch. As a result, some students may not eat their first meal until lunch time if they fail to bring a snack. Further, the quality and quantity of food a child brings is determined by their parents. The quality and quantity of food available to students throughout the day might be not ideal. In fact, these food choices might affect both academic performance (Taras, 2005) and appetite (Rinku et al., 2010). Moreover, the eating frequency has been associated with lower body weight status in children and adolescents (Kaisari et al., 2013).

Previous research suggests young children are naturally able to self-regulate caloric intakes (Birch et al, 1987). Consequently, providing the opportunity for a healthful snack between breakfast and lunch time may be beneficial for reducing students hunger status and helping them to make more healthful choice during lunch time. This might have a direct impact on eating consumption habits during school time while being indirectly beneficial on school performance as well.

The main objective of this study is to analyze what effect a child's level of hunger has on their lunch-time choices and if providing children a healthful, nutritious snack prior to lunch has an influence on their lunch-time consumption. To this end, we conducted a field experiment with fourth grade children at a public elementary school in Eastern Connecticut. For one week, we recorded what the children in the classes consumed for snack and lunch. We also measured whether they consumed breakfast at school, their level of hunger before and after the snack and the quantity of snack they consumed. In the second week, we provided one class of students with a healthy, nutritious snack approximately one hour before lunch time. We compare the lunch-time decisions of the class provided a healthy, nutritious snack to the classes that are not provided a snack using a Difference-in-Differences (DiD) approach. In particular, we evaluate each students snack and lunch consumption based on calories, sugar, fiber, protein and sodium intakes. One challenge in using the DiD approach is that not all students participate in the treatment. That is, they don't consume the snack. To control for potential bias resulting from an endogenous treatment, we also estimate the effect of snack using an instrumental variable approach.

Based on a simple rating scale, we find that offering a healthy, nutritious snack reduces the children's level of hunger immediately after it is consumed. This is relevant as students may make more healthful decisions if they are not driven by hunger. We next find that students increase their consumption of fat and sugar during snack, but reduce their consumption of carbohydrates and sugar during lunch. While this seems to suggest a zero-sum substitution in nutrient consumption from one time period to another, the sugar consumed at snack comes from milk—a natural source of lactose. As such, students might be trading off processed sugars for natural sugars. This last finding is of particular relevance since we know how an excess of added sugar consumption is strongly related to obesity. Further, between 2005 and 2008, calorie intake from added sugar accounted for an average of 16.3 percent and 15.5 percent of calories for boys and girls respectively (Ervin et. al., 2012).

Our results suggest that schools could pursue several low-cost options to help improve students' dietary habits during lunch. First, schools could make healthful snacks, such as provided in our study, more readily available during snack time. In our study schools, students had to rely on their own snacks which were often less healthful. Schools might also consider the snack-lunch schedule. By allowing kids more frequent consumption periods, such as providing milk one to two hours prior to lunch, they may be able to regulate their hunger better. This might have a double benefit: first it might induce more healthful consumption and second it might have an influence on the students' school performance.

Motivation

Food insufficiency has been found to be significantly associated with poorer cognitive functioning, academic achievement and school attendance (Taras, 2005). Kleinman (1998) found food depravation to be related to psychosocial dysfunctions among poor children. Beyond academic performance, lower eating frequency is associated with higher body weight status in children and adolescents, especially in boys (Kaisari et al., 2013). This is relevant in the US given alarming rates of childhood obesity. Hunger has clear and important implications for the health and school performance of children. Yet, in a survey of public schoolteachers, 80 percent declared students come to school hungry one or more times each week and most of them rely on school meals as their primary source of nutrition (No Kid Hungry Share our Strength, 2012).

Children demonstrate a natural ability to self-regulate food intake in response to caloric density cues (Birch et al, 1987). At the same time, however, adult verbal communication may override response to such cues (Ramsay et al, 2010). The eating schedule and food availability in schools might also affect children's natural response to hunger. While children may be naturally inclined to regulate their hunger, they are also guided by adults and influenced by environmental constrains regarding what, when and how much to eat at school.

Certain children may not have breakfast prior to school and may only have their first meal at lunch. Further, while children are in school, they have to follow a prescribed schedule of eating which does not allow them to self-regulate their hunger. They may or may not consume a snack which may be unsatiating or insufficient.Similarly, they may consume an unsatiating or insufficient lunch. Even if children are provided access to more healthful foods, such as through the NSLP, they may still be hungry by the time it is provided and make poor food choices as a result. Consequently, due to environmental factors, children transition from naturally regulating food intake to making more hunger driven choices. An important question is how these factors together affect children's decision making ability regarding their lunch. Specifically, do children's hunger cues influence their food choices and consumption decisions?

Previous research on school lunch programs has suggested that changing the food environment can have an impact on what children choose to eat (Hanks et al., 2013; Wansink, 2011). In this paper we evaluate if having a healthy snack available prior to lunch can have an effect on student's hunger level and if this has an impact on their nutrients consumption during lunch. We expect that providing a snack might reduce students hunger level. This may help students to control for possible hunger driven consumption behavior during lunch time. In particular, students may consume more healthful food items while at school.

Data Collection

We observed students over two school weeks (10 days) at a public elementary school in Eastern Connecticut in the Fall of 2012. Given limited resources, we were able to work with three fourth grade classes. School administrators helped select these classes based on their ability to participate in the experiment with respect to time constraints and academic ability[1]. We obtained IRB approval for our study in the summer of 2012 and parental permission to actively observe 24 students (10 boys and 14 girls) prior to implementing our experiment. In addition, we passively observed the behavior of the remaining students in the classes, for a total of 44 students. We compare the distribution of students with parental permission among classes and treatment and control group in Table 1.

Table 1. Sample composition by gender and class distribution

Gender	Class 1 *	Class 2*	Class 3	Overall Sample
Participants by class	8	9	7	24
Male	4	2	4	10
Female	4	7	3	14
Total class size	15	15	14	44
Share of participation	53%	60%	50%	55%

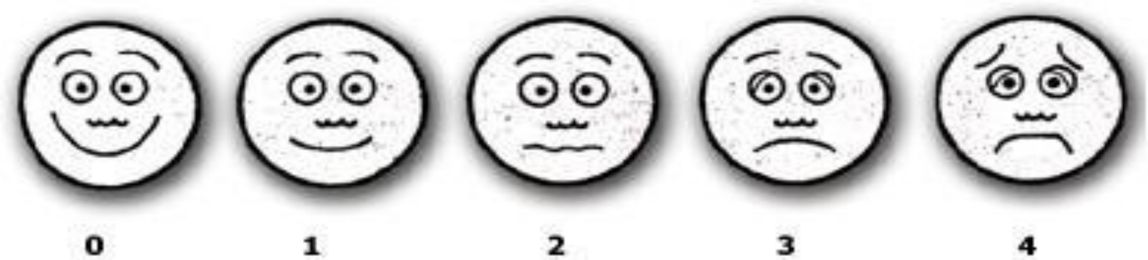
*treated classes

[1] A primary concern was that the students were independent readers so that they could participate in the survey without assistance. Another concern was the maturity level of the participating students given the added distraction of the experiment. We met with the school Principal and Nurse to discuss class options prior to the study.

Over the entire study period, we observed the children during snack and lunch time and used nametags to track participating students. Each day prior to snack, all the children were provided with a brief survey asking whether they ate breakfast that day. In the morning before snack and after snack, the children were asked to rate their level of hunger using a simple 5-point rating scale (Figure 1). The responses are used to control for child hunger levels from day to day.

Figure 1. 5-point hunger rating scale administered with survey.

How hungry are you from 0 (not hungry) to 4 (starving)?



I don't want to eat	I can eat something	I'm Hungry	I'm very hungry	I'm starving

Around 15 percent of the data sample did not have breakfast, with a slight decrease from the first to the second week (Table 2). Around 85 percent of the sample had breakfast and 75 percent consumed breakfast at home. We see about an 11 percent increase in the percentage of students who bring snack from home between the two weeks. Before the experiment, we expected that the number of students that brought their own snack from home would decline once the class started receiving the snack we provided, but this was not the case. When students are asked to state their hunger level before eating snack, more than 42 percent of the sample report not being hungry at all, while the rest of the sample report being "a little hungry" (40.8%), "hungry" (10.5%) or "very hungry" (6.1%). After eating their snacks, roughly 5 percent more report not being hungry at all during the first week (45.87%), while during the second week around 23 percent more report not being hungry (66.39%) after consuming the snack.

Based on Table 2, it appears that the second week treatment may have helped to reduce the percentage of the sample that report being "really hungry". For instance, while around 6 % of the students report being "really hungry" after snack time the first week, less than 1% of the sample report being "really hungry" after snack during the second week.

Table 2. Summary of the morning and after snack survey responses

Question	Answer	Both weeks (%)	First week (%)	Second week (%)
Morning survey				
Did you have breakfast this morning?	No	**14.91**	16.51	13.45
	Yes	**85.09**	83.49	86.55
Did you have breakfast at home?	No	**24.12**	20.18	27.73
	Yes	**75.88**	79.82	72.27
Do you have any snack to eat during the morning?	No	**25**	31.19	19.33
	Yes	**75**	68.81	80.67
How hungry are you from 0(not hungry) to 4 (starving)?	0	**42.54**	41.28	43.7
	1	**40.79**	42.2	39.5
	2	**10.53**	8.26	12.61
	3	**6.14**	8.26	4.2
	4	**0**	0	0
After snack survey				
How hungry are you from 0(not hungry) to 4 (starving)?	0	**56.58**	45.87	66.39
	1	**33.33**	41.28	26.05
	2	**6.58**	6.42	6.72
	3	**3.51**	6.42	0.84
	4	**0**	0	0

Source: Own elaboration

Each day, we visually recorded what the children brought for snack and estimated what they ate by taking a digital picture before and after they consumed their snack. Snack time was roughly 2 hours after the children arrived at school and 1 hour prior to lunch. During lunch, we also observed what the children brought from home or bought at school and what they ate. Children who buy lunch at school are able to choose among a hot lunch served at the lunch line or an alternative such as cereal lunch, peanut butter and jelly sandwich lunch, or salad lunch. For children who bought a school lunch, we took a picture of the items they selected in the lunch line and a picture of how much of their lunch they ate and specifically what they ate. For children who brought their lunch, we recorded what they brought and measured how much they ate and what they ate of their homemade lunch.

During the second week of the study, we provided Classes 1 and 2 with a snack around one hour prior to their lunch time during their normal snack time. The snack came in a snack bag and consisted of pre-sliced apple (58 grams), a snack bag of carrots (45 grams), a cheese stick and half pint of 1 percent low fat milk. Children continued to bring in their own snack if they wanted and were not required to eat the snack we provided. We continued to measure what the children brought and ate for snack and lunch using the same procedures. We continued to track the control class that did not receive the snack during the second week.

After the two week period, we used the digital pictures we collected to build a dataset identifying the nutritional content (calories fat, carbohydrates, fiber, sugar and proteins) of the foods students brought and ate during snack and lunch time for each of the subjects along the two weeks. Some students were absent from school or left after snack and prior to lunch. If the student left early, we eliminate their entire day observation.

To determine nutritional content of food items brought from home we use various online databases and product websites. Many of the foods students brought were in product packaging so it was relatively simple to identify nutritional content. For non-packaged items, we relied on the USDAs National Nutrient Database which provides nutritional information for over 8 thousand foods. In some cases, it was difficult to determine the content of homemade food items such as sandwiches. In that case, we would compile the nutritional content based on the observed product characteristics. For example, for a peanut butter sandwich, we would include the nutritional content of two pieces of white (or wheat) bread and a serving of peanut butter.

The school provided us the standard size of the portions served for the school lunches. We would then determine the nutritional content using online sources and referencing the nutrition labels in the kitchen. While there is clearly room for measurement error, we attempt to be as consistent as possible. In some cases, students often brought repeat meals, e.g. a peanut butter sandwich every day. To some extent, this helps to minimize the effect of measurement error for a specific student.

To estimate how much each student eats during lunch and snack, we used the digital pictures to estimate the percentage of each item eaten. We then calculate the amount of nutrients and calories eaten by each subject during a given meal and day by multiplying the total nutritional content of each food item by the percentage eaten[2]. We show an example of before and after pictures taken during the experiment (Figure 2).

Figure 2. Picture of lunch before (left) and after (right) and Calories and nutrients eaten for each type of food (below).

Food	% eaten	Calories	Sugar	Carbs	Fat	Protein	Fiber	Sodium
Pizza	20	41.71	0.57	4.57	1.57	2.43	0.29	127.14
Lettuce	0	0	0	0	0	0	0	0
Watermelon	100	46	10	12	0	1	1	2

Source: own elaboration

Our final dataset is an unbalanced panel containing nutrients and calories consumed over ten school days by the 24 students during snack and lunch time for a total of 458 observations after removing missing observations. For each student, we also have survey response data before and after the snack each day.

Looking at the data we compiled (Table 3), some differences emerge in average calorie and nutrient consumption between the treatment and control classes from the first to the second week. The treated classes consume more calories during snack in the second week; however, the increase in consumption during snack is partially compensated by a decrease in calorie intake during lunch. This exchange in calories between snack and lunch can be driven by different sources of nutrition. For instance, for the treatment group we notice an increase in the average sugar, fat, sodium protein and fiber consumption during snack time and a decrease of the same

[2] For consistency, we estimate the percentage of food eaten using multiples of 5 between 0-100.

nutrients, except for carbs, during lunch time. With Carbs, we observe an increase with the treated class during snack which is not balanced by a further reduction during lunch.

Table 3. Average consumption of nutrients and calories by group and week. Total number of observations by group and week. Average hunger levels before and after snack using the 5 point scale.

Variable	**Meals**	1st Week		2nd Week		Differences between weeks	
		(a) Control	**(b) Treatment**	**(c) Control**	**(d) Treatment**	**(c-a) Control**	**(d-b) Treatment**
Number of observations		70	148	68	170	-	-
Hunger before snack		1.49	2	1.18	1.98	-0.31	-0.02
Hunger after snack		1.2	1.99	1.26	1.52	0.06	-0.47
Frequency to not have Snack from home		0.06	0.19	0	0.17	-0.06	-0.02
Calories	*snack*	*254.91*	*177.2*	*212.88*	*264.37*	*-42.03*	*87.17*
	Lunch	*517.12*	*731.72*	*612.05*	*687.29*	*94.93*	*-44.43*
	Total	772.03	908.92	824.93	951.66	52.9	42.74
Sugar *(grams)*	*snack*	*22.89*	*14.06*	*19.68*	*20.27*	*-3.21*	*6.21*
	Lunch	*34.7*	*44.21*	*50.16*	*43.2*	*15.46*	*-1.01*
	Total	57.59	58.27	69.84	63.47	12.25	5.2
Carbs (grams)	*snack*	*42.65*	*29.07*	*39.25*	*36.07*	*-3.4*	*7*
	Lunch	*63.66*	*76.09*	*85.95*	*76.92*	*22.29*	*0.83*
	Total	106.31	105.16	125.2	112.99	18.89	7.83
Fat (grams)	*snack*	*4.59*	*4.91*	*2.24*	*9.38*	*-2.35*	*4.47*
	Lunch	*14.61*	*25.31*	*13.94*	*23.65*	*-0.67*	*-1.66*
	Total	19.2	30.22	16.18	33.03	-3.02	2.81
Sodium (milligrams)	*snack*	*342.62*	*200.02*	*347.01*	*368.42*	*4.39*	*168.4*
	Lunch	*813.79*	*881.05*	*778.72*	*800.1*	*-35.07*	*-80.95*
	Total	1156.41	1081.07	1125.73	1168.52	-30.68	87.45
Protein (grams)	*snack*	*7.19*	*3.65*	*5.68*	*9.97*	*-1.51*	*6.32*
	Lunch	*26.85*	*36.48*	*26.93*	*30.99*	*0.08*	*-5.49*
	Total	34.04	40.13	32.61	40.96	-1.43	0.83
Fiber (grams)	*snack*	*3.3*	*2.03*	*2.27*	*2.45*	*-1.03*	*0.42*
	Lunch	*6.82*	*8.01*	*9.01*	*7.9*	*2.19*	*-0.11*
	Total	10.12	10.04	11.28	10.35	1.16	0.31

Source: Own Elaboration

Empirical specification

The primary purpose of this research is to examine how providing a nutritious snack impacts students' consumption of snack and lunch and the effect of their hunger status during morning school. Given the numerous ways to examine consumption by students, we explore the effect of the snack treatment on several different dependent variables (Table 4). For model 1, we examine if the provision of the snack significantly impacts the percentage change in the level of the reported hunger before and immediately after the snack.

Table4. Description of the dependent variables used on testing model 1 to 6 in equation (1).

	$y_{i,t}$	***Variable description***
Model 1	$\% \; Hunger \; reduction_{i,t}$	% change of the level of hunger, measure in a scale of 1-5, registered prior and post snack for subject $i = 1 \ldots 15$ during day $t = 1 \ldots 10$.
Model 2	$Hunger \; Reduction_{i,t}$	Difference between the hunger status prior and post snack for subject $i = 1 \ldots 15$ during day $t = 1 \ldots 10$.
Model 3	$Probability \; to \; eat \; F - V_{i,t}$	Binary variable equals to one if subject $i = 1 \ldots 24$ during snack at day $t = 1 \ldots 10$ ate fruit or vegetables, equals to zero otherwise.
Model 4	$Snack \; intake_{i,t}$	Amount of calories, sugar (grams), carbohydrate (grams), fiber (grams), fat (grams), proteins (grams) or sodium (mg) consumed during snack time by subject $i = 1 \ldots 24$ during day $t = 1 \ldots 10$.
Model 5	$Lunch \; intake_{i,t}$	Amount of calories, sugar (grams), carbohydrate (grams), fiber (grams), fat (grams), proteins (grams) or sodium (mg) consumed during lunch time by subject $i = 1 \ldots 24$ during day $t = 1 \ldots 10$.
Model 6	$Snack \; and \; lunch \; intake_{i,t}$	Amount of calories, sugar (grams), carbohydrate (grams), fiber (grams), fat (grams), proteins (grams) or sodium (mg) consumed during snack or lunch time by subject $i = 1 \ldots 24$ during day $t = 1 \ldots 10$.

For model 2, we examine if the snack reduces reported hunger from before to immediately after snack. The variable in model 2 can be considered as a measure of the satiating effect of the snack. If a child eats a more satiating snack, this should result in a higher reduction in the hunger status from pre to post snack. For example, assume a child is "really hungry" pre-snack so his reported level of hunger is a 4 according to Figure 1. If the student eats an unsatiating snack, this may only decrease their level of hunger to a 3 after snack. In this case the huger reduction will be 1. If the student eats a more satiating snack however, their hunger may decrease more, i.e. to a 2 or 1 after snack. We expect the supplementary snack we provided to make students more satiated and reduce their level of hunger immediately after the snack consumption and eventually have an impact on huger cues behavior which might impact lunch time consumption.

For models 1 and 2, we use data collected in only one of our treatment classes reducing our subjects from 24 to 15. We drop one class because we found they did not consistently record the post snack hunger survey during the two week period. Including this class in our data set, however, has no impact on the primary results.

Since we offer fruits and vegetables (FV) with our snack, we explore if providing FV can have an effect on the probability of their consumption during the day (Model 3). The results from this model can be informative if the probability of school children eating FV is related to their availability. Previous studies show different results on the relationship of FV availability and their consumption. Some authors have found higher FV availability on the lunch line or at home are associated with higher consumption among children (Hearn et al., 1998; Rasmussen, 2006). Other studies found FV availability has a more effective impact on consumption if it is associated with strategies to promote their acceptance and make their consumption habitual (Reinaerts et al. 2007, Perry et al. 2014). Further, only offering healthy food might not be effective and may result in reactance and avoidance behavior which might lead to students leaving healthy options uneaten (Hanks, 2013). Since providing FV is costly, this is an important consideration.

In Models 4 and 5 we investigate if the provision of the snack has any impact on the consumption of nutrients during snack time (Model 4) and lunch time (Model 5). Specifically, we consider the total grams of proteins, fat, carbs and fiber consumed, the mg of sodium and the caloric content of the overall consumption. We expect that by providing the snack, students will shift some of their nutrient consumption to snack time and this will help students to have less hunger going forward. Ultimately, we expect that this will impact students' consumption during lunch time. Although we are not experts in nutrition, we anticipate that students will make fewer hunger-driven lunch choices. In particular, they will choose fewer items with high sugar and fat content, both of which people often consume in response to hunger cues.

Finally, we estimate the effect of the snack on total nutrient and caloric consumption, which includes both snack and lunch (Model 6).

We first test the effect of the snack using a Difference-in-Differences (DiD) estimation approachwith the following model specification:

$$y_{i,t} = \beta_0 + \beta_1 T + \beta_2 S + \beta_3\, T \times S + \beta_4\, X + \varphi_i + \omega_t + u_{i,t} \qquad (1)$$

where $y_{i,t}$ is the dependent variable corresponding to the previously described models from subject $i = 1 \ldots 24$ during days $t = 1 \ldots 10$. We identify the treatment group using the dummy variable T (control group = 0, treatment group =1), the treatment week with S ($S = 0$ during the first week before the snack has been offered and $S = 1$ during the second week). The difference-in-differences estimator which captures the effect of the snack introduction on the dependent variable is then β_3. We include a set of control variables (X) which contain a gender dummy variable (one if female, zero otherwise), a dummy to control if the subject did not have snack in the morning (1 if the subject did not eat snack, 0 otherwise) and the 1-5 hunger level rating in the morning before the snack had been consumed for subject i at time t. We use a fixed effect panel data estimator to control for heterogeneity due to day and subject: φ_i is the subject specific effect, ω_t is the day specific effect, $u_{i,t}$ is a normally distributed error term. Since in model 3 the dependent variable is discrete, we estimate equation (1) using a probit model.

Given the structure of our experiment we were not able to randomize the experimental sample leading to potential self-selection problem. In particular, even though all students are provided a snack, not all students actually consumed the snack we provided. As such, we next examine the average effect of the treatment on the treated (ATT) for all the models. We use a two stage instrumental variable approach to take into account the possible bias due to self-selection. In the first stage we estimate the probability that a student i in day t ate the snack we provided as:

$$\mathrm{ATT}_{i,t} = \alpha_0 + \alpha_1\, \mathrm{SNACK}_{i,t} + \alpha_2\, \mathrm{NO\_snack}_{i,t} + \varepsilon_{i,t} \qquad (2)$$

where ATT is a dummy variable indicating if subject i ate the snack we provided, SNACK equals to one if the snack was provided and zero otherwise, and NO_snack indicates if student i in day t did not have any snack other than the one we provided. In the next stage we estimate:

$$y_{i,t} = \gamma_0 + \gamma_1\, \widehat{\mathrm{ATT}_{i,t}} + \varphi_i + \omega_t + u_{i,t} \qquad (3)$$

where $y_{i,t}$ is the calories and nutrients lunch intake for subject i in day t.

We estimate equation (2) and (3) using a panel fixed effects estimator, in which we also control for heterogeneity due to day (ω_t) and subject (φ_i), while $u_{i,t}$ is the normal distributed reminder error.

Since sugar consumption is associated with obesity and other health-related issues, we further explore the source of sugar intake during lunch and snack time. As added sugar are differently than naturally occurring sugars provided by fruits, vegetables and milk, the real nutritional effect of our treatment may be masked by grouping all sugars together. It may be preferred if children reduce sugar consumption from processed foods rather than sugar from, for example, apples and carrots. To examine this, we further investigate the source of sugar intake during snack and lunch time by considering three possible source of sugar intake: fruit and vegetables, milk and all other sources. The sugar present in the last category is generally derived from added sugar sources like processed foods and sweetened beverages. We then estimate the DiD and ATT models using the three different types of sugar as dependent variables.

Results

Results from models 1-3: The effect of the snack on hunger, hunger reduction and on the probability of eating fruit and vegetables.

We find that providing the snack helps to reduce student hunger (Table 5, model 1 and 2). Our results indicate a 42 % decrease in hunger, or approximately a 0.64 step based on our hunger scale (Figure 1). This finding is important because it suggests that student snacks brought from home may be insufficient in our sample for satiating hunger. This could be due to students having insufficient quantity for their snack or because the type of snack they typically bring to school is not satiating because of its nutritional content. Anecdotally, it seems that the latter is the case. Most students were already bringing their own snack prior to our treatment. When our treatment began, students didn’t always finish the snack we provided. This suggests sufficient quantity, but lacking nutritional characteristics that might promote satiety.

Our results are similar using the DID estimator or the ATT estimator. However, the coefficient estimate for the ATT model is larger suggesting potential bias in the DiD model due to sample selection. In particular, by estimating the treatment effect for all students, we tend to underestimate the effect of snack because not all students consumed the snack. When we account for those students who actually ate the snack (ATT), we obtain a less biased estimated effect of the snack. These results have relevant educational implications considering the negative effect hunger can have on academic performances (Kleinman, 1998). Further the frequency of eating is being found on being correlated to lower body mass index in children and teenagers (Kaisari et al., 2013).

Results, from both DID and ATT model, show that providing the snack does not significantly impact the students' consumption of fruit and vegetables during snack (model 3 in Table 5). This suggests that increasing the availability of fruit and vegetables in school for different occasions, besides lunch, does not necessarily lead children to consume more. This result supports previous finding suggesting that increasing availability of fruit and vegetables might not be sufficient to increase consumptions among teenagers as individual preferences and education can be critical for increasing their acceptance and consumption (Hanks, 2013).

Table 5. Results of DID (equation 1) and ATT (equation 2). Effects of eating the snack we provided on hunger and F/V probabilities.

VARIABLES	**%Hunger Reduction** *(model 1)*	**Hunger Reduction** *(model 2)*	**F/V Probabilities** *(model 3)*
DID	0.420***	0.644***	1.011
	(0.111)	(0.140)	(0.655)
R-squared	0.129	0.0703	0.222
ATT	0.547***	0.838***	1.344
	(0.139)	(0.139)	(0.937)
R-squared	0.067	0.0252	0.2889
P-val. J-test	0.550	0.7291	
First stage F-stat	45.20	45.20	246.06
Subject dummy	yes	yes	yes
Day dummy	yes	yes	yes
Cluster error	Subjects	Subjects	Subjects
Observations	228	228	228
Number of Subject	24	24	24

Errors are clustered at subject level

**** p<0.01, ** p<0.05, * p<0.1*

Models 4- 6: The effect of the snack on calories and nutrients consumption during snack time, lunch time and overall

We explore the effect of the snack on calorie and nutrient consumption using the DiD (Table 6) and the ATT (Table 7) specifications. We repeat the analysis considering consumption of snack (model 4), lunch (model 5) and overall consumption (model 6). We find that the snack leads students to increase their caloric intake during snack time. In particular, the increase in caloric intake is mostly due to the higher consumption of proteins, sugar and fat. As, in the previous models, we find the ATT specification leads to coefficients with higher magnitude. Specifically, using the DiD specification, we estimate the snack provision leads to an increase in consumption of 117 calories during snack time, with an increase of almost 7 grams of sugar, fat and proteins. Controlling for gender, hunger status before snack, and bringing their own snack (model (b) in Table 6), reduces the estimated effect for calories, fat and proteins, while the coefficient on sugar is insignificant. The ATT estimates a larger increase in caloric consumption (135 calories) mainly from an increase in sugar and proteins (around 9 grams) and an increase of fat consumption of around 8 grams. Since the ATT measures the effect of the snack on those that eat the snack, we expect the increased magnitude of the coefficient may be due to higher nutritional content from milk consumption.

During lunch time, we find the snack leads students to reduce their caloric intake due to a reduction in sugar and carbohydrates eaten. The DiD model estimates, both with and without control variables, a decrease of around 75 calories consumed, mainly due to a reduction of sugar (7 grams) and carbohydrates (15 grams) eaten. The ATT estimates slightly higher reduction of calories (86 calories), sugar (9 grams) and carbohydrates (18 grams).

In general, these results indicate a shift in caloric consumption from lunch to snack time. If children have a natural ability to self-regulate food intake in response to caloric density cues (Birch et al, 1987), these results suggest that the morning food environment is constraining students' "natural" consumption patterns. In particular, once we provide the snack to students, they shift their consumption to a diet that is higher in protein and fats and lower in carbohydrates and sugar consumed during lunch time. Typically, protein and fats provide more long-term satiety than carbohydrates and sugar.

We find a significant increase in sodium consumption during snack, which is likely due to the milk and cheese we provided, both of which are high in sodium. Interestingly, we find that overall consumption of sodium doesn't change. Similarly, there is a slight reduction in fiber consumption during lunch, but that does not translate to an overall effect.

Overall, we do not find a significant change in consumption of calories, carbohydrates or sugar consumed. We do find a higher amount of fat and proteins consumed.

Table 6. : Did results of equation (1). Effects of eating the snack we provided on calories and nutrient consumption during snack (model 4) lunch time (model 5) and overall (model 6) consumption.

	Models	Calories	Sugar	Carbs	Fat	Proteins	Sodium	Fiber
Snack	(a)	117.227***	7.643*	8.718	6.731***	7.288***	164.496**	1.014
		(34.020)	(4.026)	(5.361)	(1.754)	(1.385)	(74.369)	(0.645)
	(b)	95.607***	6.496	5.034	6.196***	6.829***	127.624*	0.885
		(30.416)	(4.017)	(5.014)	(1.639)	(1.326)	(65.147)	(0.579)
Lunch	(a)	-74.581*	-8.624**	-15.302**	0.603	-2.594	-36.554	-1.891**
		(37.480)	(4.086)	(5.464)	(2.328)	(1.853)	(131.803)	(0.727)
	(b)	-75.678**	-7.732*	-15.297**	0.276	-2.318	-33.950	-1.793**
		(35.589)	(4.065)	(5.472)	(2.200)	(1.862)	(132.605)	(0.735)
Overall	(a)	42.646	-0.981	-6.583	7.333**	4.694*	127.942	-0.878
		(61.775)	(6.024)	(8.397)	(3.361)	(2.567)	(182.953)	(1.137)
	(b)	19.930	-1.236	-10.263	6.472*	4.512*	74.646	-0.908
		(55.923)	(5.928)	(7.826)	(3.151)	(2.532)	(166.530)	(1.087)
Gender=1 if Female		(b)	(b)	(b)	(b)	(b)	(b)	(b)
No-snack=1 if no snack		(b)	(b)	(b)	(b)	(b)	(b)	(b)
Hunger before snack		(b)	(b)	(b)	(b)	(b)	(b)	(b)
Subject dummy		(a) ; (b)	(a) ; (b)	(a) ; (b)	(a) ; (b)	(a) ; (b)	(a) ; (b)	(a) ; (b)
Day dummy		(a) ; (b)	(a) ; (b)	(a) ; (b)	(a) ; (b)	(a) ; (b)	(a) ; (b)	(a) ; (b)
Observations		228	228	228	228	228	228	228

Errors are clustered at subject level

**** p<0.01, ** p<0.05, * p<0.1*

***Other findings*: *The sources of changes on sugar consumption during snack and lunch time*.**

Since we find a shift in sugar consumption from lunch to snack time, we further investigate if any particular source of sugar was responsible for the change in consumption during snack and lunch time. We investigate the source of sugar (FV, milk, all other sources) during snack and lunch time implementing DiD and ATT estimators (Table 8). We find the increase in sugar during snack is mainly due to increased milk consumption; about 50% of the total consumption increase. Our results don't reveal any particular sources responsible for the sugar reduction during lunch time, however. At the same time, we know that at least some of the sugar reduction during lunch is coming from other sources and being replaced by sugar from milk. This can be a potential benefit of providing a more healthful snack.

Table 8: Sugar sources intake from fruit and vegetables (V\F), milk or all other sources. DID and ATT estimates for lunch and snack time.

	Lunch			**Snack**		
	Sugar V/F	**Sugar milk**	**Sugar all others**	**Sugar V/F**	**Sugar milk**	**Sugar all others**
DID	-3.009	-2.354	-3.261	0.799	4.047***	2.798
	(2.764)	(2.520)	(2.207)	(2.869)	(1.022)	(2.639)
R-squared	0.157	0.103	0.357	0.039	0.198	0.060
ATT	-3.831	-3.061	-4.234	1.248	5.968***	1.328
	(3.523)	(3.140)	(2.806)	(3.298)	(1.322)	(3.632)
R-squared	0.139	0.096	0.352	0.046	0.283	0.051
P-val. J-test	0.0878	0.538	0.826	0.185	0.443	0.0748
Subject dummy	yes	yes	yes	yes	yes	yes
Day dummy	yes	yes	yes	yes	yes	yes
Number of Subject	24	24	24	24	24	24
Observations	228	228	228	228	228	228
First stage F-stat	43.12	43.12	43.12	43.12	43.12	43.12

Errors are clustered at subject level
**** p<0.01, ** p<0.05, * p<0.1*

Conclusion

In this study we analyze the effect of providing children a healthy, nutritious snack prior to lunch has an influence on their lunch-time consumption. To this end, we conducted a field experiment with 3 fourth grade classes at a public elementary school in Eastern Connecticut. For one week, we recorded what the children in the classes consumed for snack and lunch. We also measured whether they consumed breakfast at school, their level of hunger before and after the snack and the quantity of snack they consumed. In the second week, we provided one class of students with a healthy, nutritious snack approximately one hour before lunch time. We compare the lunch-time decisions of the class provided a healthy, nutritious snack to the classes that are not provided a snack. In particular, we evaluate each students snack and lunch consumption based on calories, sugar, fiber, protein and sodium intakes. Based on a simple rating scale, we find that offering a healthy, nutritious snack reduces the children's level of hunger and increase the reduction of hunger immediately after it is consumed. This is relevant as students may make more healthful decisions if they are not driven by hunger. Moreover, the reduction of hunger might have positive effect on academic performance. We next find that students increase their consumption of fat, proteins and sugar during snack, but reduce their consumption of carbohydrates and sugar during lunch. While this seems to suggest a zero-sum substitution in nutrient consumption from one time period to another, the sugar consumed at snack comes from milk, a natural source of lactose. As such, students might be trading off processed sugars for natural sugars.

Overall, the analysis suggests the availability of food during the school time might not be optimal to let student regulate their level of hunger. For instance, the snack provision has an influence on student's consumption during snack and lunch and has led them towards a more intake richer of proteins and fat and poorer in sugar and carbohydrates.

The results from this study motivate important food policy considerations. First, is whether there is an opportunity to reshape current food distribution systems during the school time. In particular, it may be valuable to consider the overall well-being of the student during school time, rather than just imposing restriction on the "nutrients" component of the diet. That is, it may be just as important to consider when students eat as it is to consider what they eat. A more ideal snack and lunch schedule might help students to self-regulate their food intake therefore, their hunger level. The promotion of an environment where children can self-regulate their needs might have potentially higher benefits than imposing strict rules which can lead to avoidance behavior.

Another important consideration is the provision of healthful snacks. Based on our limited observations, students did not always bring the most healthful or satiating snacks. Providing students with more healthful options, such as milk, could be an important way to help regulate their food intake as well. Still, more work is needed to understand these benefits.

There are some limitations to this study which highlight the need for future studies. First, given the small resources implemented in the study and the difficulties of the process, our sample is small, both in the number of subjects and the time length, making it hard to generalize the findings. Second, we don’t observe student consumption outside of the school environment and we don’t have any additional information on their demographics and school performance. Investing more resources and measuring both the educational and nutritional outcome due to the snack provision might give more insights on the policies to be implemented to reduce hunger during school time.

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