Hunger-driven food choices: An experiment to test the effect of providing pre-lunch snacks on school lunch choices

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Introduction

Obesity among children is becoming a public health issue in most of the 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 (World Health Organization). As a result, social scientists have been increasingly involved in obesity prevention studies with the role of finding appropriate policy interventions to alleviate behavioral and environmental factors positively related to obesity.

Adapting the school environment is seen as having the potential to reduce the risk of obesity in children by promoting behavioral changes such as increasing more healthful food choices. In January 2012, the US Department of Agriculture (USDA) provided new guidelines for school cafeterias as part of National School Lunch Program (NSLP). The new guidelines impose more stringent rules on the type of food provided, thus minimizing the opportunity for unhealthful choices. As pointed out by Hanks et al. (2013), however, a policy of enforcement finalized to promote a healthful choice might be costly and its effectiveness might be downsized by reactance and avoidance behavior. Alternatively, proponents of "libertarian paternalism" suggest that indirect *nudges* may be more effective at changing behaviors in children (Thaler and Sunstein, 2009; Hanks et al., 2013; Gittelsohn and Lee, 2013). In general, this approach proposes that improving "the convenience, attractiveness, and normative nature of healthy foods in the lunchroom could encourage students to make healthier choices of their own volition" (Hanks et al., 2013).

To this end, several studies have engaged in examining how changing school lunchroom conditions might impact student behavior (http://ben.dyson.cornell.edu/). Less focus has been given, however, on how changes to the students' condition might impact their behavior.

A growing literature identifies a physiological response to food deprivation in adults and teenagers which can impact decision making processes and behavior (Nederkoorn et al., 2009).

That is, as people become hungry, they tend to make worse decisions. 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). So while children may be naturally inclined to regulate their hunger, they are also guided by adults regarding when and how much to eat.

While children are in school, children have to follow a prescribed schedule of eating which does not allow them to self-regulate their hunger. Further, they may not eat breakfast or have a limited breakfast. They may or may not consume a snack which may be unsatiating or insufficient. Consequently, it may be that 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?

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 healthy, nutritious snack prior to lunch has an influence on their lunch-time consumption. To this end, we conduct a field experiment with 3 fourth grade classes at a public elementary school in Eastern Connecticut. For one week, we record what the children in the classes consume for snack and lunch. We also measure whether they consume breakfast at school, their level of hunger before and after the snack and the quantity of snack they consume. In the second week, we provide one class of students with a healthy, nutritious snack approximately one hour before lunch time. We then 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.

We find that offering a healthy, nutritious snack reduces the level of hunger immediately after it is consumed. Moreover, offering the snack increases the probability subjects eat fruits and vegetables while at school. This has important policy implications as people in general consume to few servings of fruits and vegetables. We also find that when providing the snack, students tend to substitute some amount of nutrients from lunch time to snack time. In particular we have found this substitution interest mostly sugar consumption. This last finding is of particular relevance since we know how an excess of sugar consumption is strongly related to obesity.

This substitution behavior between lunch and snack time suggests in the baseline environment, where student do not receive an extra snack, the availability of food might be a

limitation on the students to consume more healthful foods. By providing the snack, we relax this constraint. Student natural response is to consume more nutrients at snack time to self-regulate their hunger level over time which might be helpful to control hunger cues behavior.

The paper proceeds as follow in the next section we describe the methodology and data. The econometric model follows in section 3. Results and policy implication are in section 4 and 5.

Methodology

a. Student Sample

We observe students over two school weeks (10 days) at a public elementary school in Eastern Connecticut. Three fourth grade classes were chosen by the researchers and school administrators due to their ability to participate in the experiment. We obtained parental permission to actively observe 24 students, 14 females and 10 male. In addition, we passively observed the behavior of the remaining students in the classes, for a total of 44 students. Table 1 shows how subjects with parental permission are distributed among classes and treatment and control group.

Table 1. Sample composition by gender and class distribution

Gender	**Class 1 ***	**Class 2***	**Class 3**	**Overall total**
Male	4	2	4	10
Female	4	7	3	14
Total	8	9	7	24

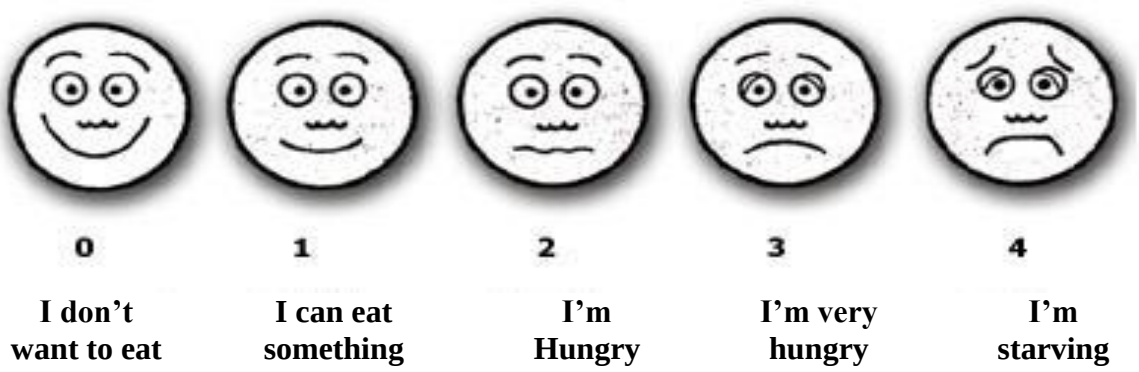
*treated classes

Over the study period, we observed the children during snack and lunch time. Using nametags, we were able to track each student from snack to lunch time along the two weeks experiment. Each day of the experiment, prior to snack, the children were provided with a brief survey asking whether the child 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 response to the hunger question is intended to provide a means to control for 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)?



Around 15 percent of the data sample did not have breakfast, with a slight increase from the first to the second week (Table 2). Around 75 percent of the students consumed breakfast at home. From the survey we notice a consistent difference on the percentage of students who bring snack from home between the two weeks. For instance, during the second week we notice an increase of 10percent of students who bring snacks from home with respect to the first week. Before the experiment, we expected that students might reduce their own snack from home once they started receiving the snack we provided, but this does not appear to be the case. Just looking at the control group, 100percent of students brought their own snack in both weeks.

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

b. Data Collection

During snack, we visually recorded what the children brought for snack and what they ate using digital cameras. This required a picture of their snack before and after consumption. Snack time was roughly 1 hour prior to lunch and 2 hours after the children arrived at school. 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 observed and measured what specific items they selected in the lunch line, how much of their lunch they ate and specifically what they ate. For other children, we recorded what they brought and measured how much they ate and what they ate of their homemade lunch.

During the second week we provided two classes 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 1percent low fat milk. Children continued to bring in their own snack if they wanted and were not required to eat the snack we provided. Again, we measured 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 subject 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 count for the nutrition 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 across students. In particular, we noticed that students often brought repeat meals, e.g. a peanut butter sandwich every day. As such, we were able to minimize the measurement error for a specific student over time.

To estimate how much each student eats during lunch and snack, we rely on the digital pictures to estimate the serving size and visually estimate the percentage eaten. Multiplying the nutritional content of each food item by the percentage eaten we calculate the amount of nutrients and calories eaten by each subject during a given meal and day. Figure 2 shows an example of before and after pictures taken during the experiment. In this example, the entire slice

of watermelon was consumed, approximately 20 percent of the slice of cheese pizza and none of the salad with dressing.

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

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	1	46	10	12	0	1	1	2

Source: Own elaboration

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 relatively more calories during snack in the second week. However, the increase in consumption during snack is balanced by a decrease in calorie intake during lunch. This exchange in calories between snack and lunch can be driven by different sources of nutrition. Sugar and carbohydrates, fat and protein show similar substitution patterns between the snack and lunch with respect to the control group. With sodium, we observe an

increase from the treated class during snack which is not balanced by a further reduction during lunch. We observe an increase in fiber consumption during snack and a relative decrease during lunch with respect to the control group.

We also notice that providing the snack might induce students to anticipate some of their consumption at snack time and to reduce their intake at lunch time. We expect substituting their consumption from two contiguous time periods students can reduce their hunger status immediately after the snack. The reduction on hunger status can help students to control for possible hunger driven consumption behavior during lunch time.

Table 3. Average value of nutrients consumed by meal, week and groups (sugar, carbohydrates, fat, protein and fiber are measured in grams and sodium is measured in *mg*).

Nutrients	**Meals**	**1st week**			**2nd week**		
		(a)	**(b)**	**(a-b)**	**(c)**	**(d)**	**(c-d)**
		Control class	**Treated classes**	**Difference**	**Control class**	**Treated classes**	**Difference**
Calories	snack	254.91	177.20	77.70	212.88	264.37	-51.49
	Lunch	517.12	731.72	-214.60	612.05	687.29	-75.24
	Total	28.79	29.13	-0.34	412.47	475.83	-63.36
Sugar	snack	22.89	14.06	8.83	19.68	20.27	-0.59
	Lunch	34.70	44.21	-9.51	50.16	43.20	6.95
	Total	28.79	29.13	-0.34	34.92	31.74	3.18
Carbs	snack	42.65	29.07	13.58	39.25	36.07	3.18
	Lunch	63.66	76.09	-12.43	85.95	76.92	9.03
	Total	53.15	52.58	0.58	62.60	56.49	6.11
Fat	snack	4.59	4.91	-0.32	2.24	9.38	-7.14
	Lunch	14.61	25.31	-10.71	13.94	23.65	-9.71
	Total	9.60	15.11	-5.51	8.09	16.52	-8.43
Sodium	snack	342.62	200.02	142.60	347.01	368.42	-21.41
	Lunch	813.79	881.05	-67.26	778.72	800.10	-21.38
	Total	578.21	540.53	37.67	562.86	584.26	-21.39
Protein	snack	7.19	3.65	3.54	5.68	9.97	-4.29
	Lunch	26.85	36.48	-9.63	26.93	30.99	-4.07
	Total	17.02	20.06	-3.04	16.30	20.48	-4.18
Fiber	snack	3.30	2.03	1.28	2.27	2.45	-0.17
	Lunch	6.82	8.01	-1.19	9.01	7.90	1.11
	Total	5.06	5.02	0.04	5.64	5.17	0.47

Source: Own elaboration

Research questions

The primary purpose of this experiment is to examine how providing a nutritious snack impacts students' consumption of snack and lunch. Given the numerous ways to examine consumption by students, we focus on several specific questions. In particular, in our econometric analysis, we want to test the following hypothesis:

H1: Providing the snack will significantly reduce the level of hunger from the morning to afternoon snack.

H2: Providing the snack will significantly reduce the level of hunger post snack consumption.

H3: Providing the snack will significantly increase the probability that students eat fruits and vegetables during snack time.

H4: The provision of the snack will have the effect of increasing some calories and nutrients intake during snack time.

H5: The provision of the snack will have the effect of reducing some calories and nutrients intake during lunch time.

H6: The overall consumption of calories and nutrients can either positively or negatively or not affect at all the overall calories and nutrients intake.

H4-H6 test the effect of the snack provision on the substitution of calories and nutrients between snack and lunch time. We expect providing the snack students will anticipate some of their nutrients' consumption at snack time (H4). This earlier change will impact students' hunger level (H1 and H2) and will help them to control hunger cues behavior. This will translate in a reduction on nutrients' consumption at lunch time (H5). The sign of the overall nutrients' intake during lunch and snack time will depends on the magnitude of the variation of snack and lunch consumption (H4 and H5).

We test our hypothesis on the effect of the snack provision using a Difference-in-Differences (DiD) estimation approach and the following econometric model:

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

where $y_{i,t}$ is the dependent variable from subject $i = 1 \dots 24$ during days $t = 1 \dots 10$. The dependent variable will have a different specification depending on the hypothesis we want to test (Table 4). T = 0 if the subject is part of the control group and T = 1 otherwise; $S = 0$ during the first week before the snack has been offered and $S = 1$ during the second week; DID $= T \times S$ is the difference-in-differences estimator which capture the effect of the snack introduction on the dependent variable. X is a set of control variables 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, zero 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 the normal distributed reminder error.

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

Hypothesis	$y_{i,t}$	***Variable description***
H1	$\Delta Level\ of\ hunger_{i,t}$	Difference between the hunger status prior and post snack for subject $i = 1 \dots 15$ during day $t = 1 \dots 10$.
H2	$Level\ of\ hunger_{i,t}$	Level of hunger on a scale of 0-4 registered with after snack survey for subject $i = 1 \dots 15$ during day $t = 1 \dots 10$.
H3	$Probability\ to\ eat\ F - V_{i,t}$	Binary variable equals to one if subject $i = 1 \dots 24$ during snack at day $t = 1 \dots 10$ ate fruit or vegetables, equals to zero otherwise.
H4	$Snack\ intake_{i,t}$	Amount of calories, sugar (grams), carbohydrate (grams), fiber (grams), fat (grams), proteins (grams) or sodium (mg) consumed during snack time by subject $i = 1 \dots 24$ during day $t = 1 \dots 10$.
H5	$Lunch\ intake_{i,t}$	Amount of calories, sugar (grams), carbohydrate (grams), fiber (grams), fat (grams), proteins (grams) or sodium (mg) consumed during lunch time by subject $i = 1 \dots 24$ during day $t = 1 \dots 10$.
H6	$Snack\ and\ lunch\ intake_{i,t}$	Amount of calories, sugar (grams), carbohydrate (grams), fiber (grams), fat (grams), proteins (grams) or sodium (mg) consumed during snack or lunch time by subject $i = 1 \dots 24$ during day $t = 1 \dots 10$.

To test H1 and H2 we use data collected in two classes reducing our subjects from 24 to 15. We drop one class because we found one of the classes didn't consistently record the post snack hunger survey during the two week period. Including the third class data, however, has no impact on the results.

As sugar from processed foods are different than sugar provided by fruits, vegetables and milk, the real nutritional effect of our treatment may be masked by grouping all sugars together. It is preferred if children reduce sugar consumption from processed foods rather than sugar from, for example, apples and carrots. To examine this in our experiment, 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 packed food and sweetened beverages. We then estimate model (1) using as dependent variable the sugar intake in grams from three different sources: fruit or vegetables, milk or all other sources.

Since students were not required to consume the snack provided by the researchers, the definition of the treatment group can vary based on the level of participation. In particular, we observe students that don't consume the snack, consume it a few times or consume it all the time. Further, we distinguish between students who ate particular components of the snack, e.g. the fruit, milk or cheese. We repeat our estimation of equation (1) keeping the control group fixed and defining the treatment group in the following ways:

- Treatment group 1: All students who ate at least one part of the snack provided[1].
- Treatment group 2: All students who ate the snack at least three days out of five.
- Treatment group 3: All students who ate the cheese snack at least once.
- Treatment group 4: All students who drank the milk snack at least once.
- Treatment group 5: All students who ate the apple snack at least once.
- Treatment group 6: All students who ate the carrot snack at least once.

Table 5 shows the summary statistics for each of the treatment groups in the two weeks period separately.

[1] This treatment is the same as all people receiving the snack, as everyone ate part of the snack at least once.

Table 5. 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	Control	Treatments					
			1	2	3	4	5	6
1st week								
Number of observations		70	148	118	130	140	108	64
Hunger before snack		1.49	2.00	2.00	2.00	2.06	2.15	2.44
Hunger after snack		1.20	1.99	2.00	1.95	2.00	2.15	2.31
Calories	*snack*	*254.91*	*177.20*	*189.63*	*183.08*	*192.78*	*187.96*	*141.03*
	Lunch	*517.12*	*731.72*	*674.21*	*757.45*	*696.83*	*691.67*	*685.83*
	Total	386.01	454.46	431.92	470.26	444.80	439.82	413.43
Sugar *(grams)*	*snack*	*22.89*	*14.06*	*14.46*	*14.91*	*15.70*	*15.23*	*13.85*
	Lunch	*34.70*	*44.21*	*43.03*	*45.67*	*43.93*	*45.54*	*48.60*
	Total	28.79	29.13	28.75	30.29	29.81	30.38	31.23
Carbs (grams)	*snack*	*42.65*	*29.07*	*30.52*	*30.12*	*31.79*	*29.92*	*25.72*
	Lunch	*63.66*	*76.09*	*71.94*	*78.36*	*72.52*	*73.06*	*75.89*
	Total	53.15	52.58	51.23	54.24	52.16	51.49	50.80
Fat (grams)	*snack*	*4.59*	*4.91*	*5.43*	*5.10*	*5.23*	*5.52*	*2.75*
	Lunch	*14.61*	*25.31*	*21.66*	*26.86*	*22.67*	*21.83*	*19.30*
	Total	9.60	15.11	13.54	15.98	13.95	13.68	11.02
Sodium (milligrams)	*snack*	*342.62*	*200.02*	*217.65*	*205.63*	*221.54*	*192.69*	*168.45*
	Lunch	*813.79*	*881.05*	*867.70*	*906.25*	*855.70*	*858.98*	*850.99*
	Total	578.21	540.53	542.68	555.94	538.62	525.84	168.45
Protein (grams)	*snack*	*7.19*	*3.65*	*3.85*	*3.68*	*3.91*	*3.83*	*2.76*
	Lunch	*26.85*	*36.48*	*35.08*	*37.24*	*36.29*	*36.24*	*37.06*
	Total	17.02	20.06	19.47	20.46	20.10	20.04	19.91
Fiber (grams)	*snack*	*3.30*	*2.03*	*2.28*	*2.05*	*2.22*	*2.31*	*1.55*
	Lunch	*6.82*	*8.01*	*7.36*	*8.22*	*7.54*	*7.60*	*7.99*
	Total	5.06	5.02	4.82	5.13	4.88	4.95	4.77
2nd week								
Number of observations		68	170	140	150	126	130	80
Hunger before snack		1.18	1.98	1.97	1.99	2.09	2.09	1.55
Hunger after snack		1.26	1.52	1.49	1.53	1.51	1.55	2.20
Calories	*snack*	*212.88*	*264.37*	*294.95*	*285.27*	*275.88*	*288.72*	*278.68*
	Lunch	*612.05*	*687.29*	*645.76*	*707.95*	*649.17*	*675.51*	*658.96*
	Total	412.47	475.83	470.36	496.61	462.53	482.12	468.82
Sugar *(grams)*	*snack*	*19.68*	*20.27*	*22.88*	*21.54*	*21.13*	*22.70*	*22.24*
	Lunch	*50.16*	*43.20*	*43.24*	*44.49*	*42.68*	*45.28*	*45.64*
	Total	34.92	31.74	33.06	33.02	31.90	33.99	33.94
Carbs (grams)	*snack*	*39.25*	*36.07*	*39.61*	*38.05*	*37.26*	*39.79*	*38.08*
	Lunch	*85.95*	*76.92*	*74.82*	*79.67*	*72.20*	*76.76*	*79.05*
	Total	62.60	56.49	57.21	58.86	54.73	58.27	58.57
Fat (grams)	*snack*	*2.24*	*9.38*	*10.55*	*10.10*	*9.98*	*10.22*	*9.45*
	Lunch	*13.94*	*23.65*	*21.01*	*24.86*	*21.21*	*21.77*	*20.88*
	Total	8.09	16.52	15.78	17.48	15.60	15.99	15.17
Sodium (milligrams)	*snack*	*347.01*	*368.42*	*405.41*	*399.79*	*373.70*	*406.24*	*391.79*
	Lunch	*778.72*	*800.10*	*799.07*	*820.77*	*757.27*	*827.06*	*933.34*
	Total	562.86	584.26	602.24	610.28	565.48	616.65	662.57
Protein (grams)	*snack*	*5.68*	*9.97*	*11.06*	*10.85*	*10.34*	*10.71*	*10.44*
	Lunch	*26.93*	*30.99*	*29.73*	*31.24*	*30.64*	*31.35*	*29.51*
	Total	16.30	20.48	20.40	21.04	20.49	21.03	19.97
Fiber (grams)	*snack*	*2.27*	*2.45*	*2.77*	*2.51*	*2.44*	*2.80*	*3.00*
	Lunch	*9.01*	*7.90*	*7.60*	*8.16*	*7.43*	*7.69*	*7.93*
	Total	5.64	5.17	5.19	5.33	4.94	5.24	5.46

Source: Own elaboration

Results

Findings for H1 and H2:

The results show that providing the snack leads to a positive reduction in the level of hunger after the snack has been consumed and this effect is consistent among all treatments groups (model (a) in Table 6) Similarly, we found a positive effect on the difference of hunger between the pre and post snack, meaning the gap between the level of hunger prior to snack and post snack is increasing (model (b) in Table 6). Even this result is consistent among all treatments, with only exception for treatment 6 where the DID estimate is not significant.

Findings for H3:

The results show that providing the snack has a significant positive impact on the student's consumption of fruit and vegetables during snack (model(c) Table 6). This result is consistent for all treatments considered and it suggests that increasing the availability of fruit and vegetables in school for different occasions besides lunch, might lead children to consume them more.

This results has important policy implications as people in the US generally consume too few fruits and vegetables. Providing more opportunities to consume healthy foods can be an easy way to both satiate student hunger and improve their overall diet.

Findings for H4, H5 and H6:

We find that the snack leads students to reduce their sugar and carbohydrates intake during lunch (Table 7). This result is consistent for all six treatments groups with the exception for carbohydrates in treatment 6 with the inclusion of control variables. The reduction in calorie intake is significant in some of the treatments specifications. We find some significant reduction in protein intake for treatment groups two and four. The snack causes a significant reduction in fiber intake during lunch time among most part of the treatments.

Table 6. Results for all different type of treatments to test H1 (a), H2 (b), H3 (c).

MODEL	VARIABLES	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
(a)	Hunger degree	-0.327*	-0.314*	-0.314*	-0.327*	-0.421**	-0.665***
(b)	Change in hunger	0.486**	0.437*	0.437*	0.486**	0.517**	0.532
(c)	F/V Probabilities	0.266**	0.337**	0.234*	0.220*	0.363***	0.335**
	Subject dummy	yes	yes	yes	yes	yes	yes
	Day dummy	yes	yes	yes	yes	yes	yes
(a) and (b)	Observations	144	134	134	144	124	97
(c)	Observations	228	198	209	202	188	141

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

Exploring the effect on nutrient and calorie consumption during snack, we find a significant increase in calories, sugar, proteins, fat and fiber which is consistent among most treatments groups (Table 8). Moreover, we found the snack positively affects the sodium and carbohydrate intake for some of the treatments. Results suggest the snack had an effect on the distribution of nutrients consumption over time. In particular, subjects seem to substitute consumption from lunch to snack time. This behavior might have a positive effect on reducing glycemic peaks and on preventing hunger cues eating behavior during lunch time.

Running model (1) with snack and lunch combined we find there is not a significant overall change in consumption of all the nutrients with the only exception of an increase in fat for treatment 6 (results not reported). This result suggests students might self-regulate their food intake over time. That is, providing a snack to students leads them to increase their consumption at snack but reduce their consumption at lunch.

Table 7. : DiD estimates of change in calorie and nutrient consumption at lunch without (1) and with (2) control variables.

	Treatment1		**Treatment2**		**Treatment3**		**Treatment4**		**Treatment5**		**Treatment6**	
Variable	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Calories	-146.266	-135.474	-132.923*	-142.150*	-146.681	-125.901	-162.734*	-147.561	-114.762	-129.041*	-114.301	-71.896
Sugar	-17.842***	-15.828***	-16.660***	-15.707***	-17.960***	-15.800***	-18.890***	-17.274***	-16.781***	-15.509**	-16.282**	-12.474*
Carbs	-23.394**	-22.264**	-21.431**	-22.618***	-22.438**	-19.940*	-25.176***	-23.649**	-20.193**	-21.622**	-20.607**	-16.152
Fat	-0.401	-0.365	0.488	-0.207	-0.432	0.001	-0.956	-0.468	1.292	0.263	2.665	4.231
Proteins	-6.230	-5.281	-6.202*	-5.949*	-6.674	-5.569	-6.870*	-5.935	-5.445	-5.344	-6.737	-4.912
Sodium	-71.363	-79.955	-56.581	-78.994	-68.131	-61.772	-94.521	-90.170	-14.793	-48.426	82.222	104.780
Fiber	-2.472*	-2.282*	-2.128**	-2.195**	-2.360*	-1.995	-2.516**	-2.292*	-2.246**	-2.369**	-2.467*	-1.857
Gender=1 if Female		yes		yes		yes		yes		yes		yes
No-snack=1 if no snack		yes		yes		yes		yes		yes		yes
Hunger before snack		yes		yes		yes		yes		yes		yes
Subject dummy	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Day dummy	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	228	228	198	198	209	209	202	202	188	188	141	141

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

Table 8. DiD estimates of changes in calorie and nutrient consumption at snack without (1) and with (2) control variables.

	Treatment1		**Treatment2**		**Treatment3**		**Treatment4**		**Treatment5**		**Treatment6**	
Variables	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Calories	127.959**	101.167**	149.371***	121.983**	145.341***	116.934**	122.356**	104.899*	143.978**	110.621*	178.749***	125.394**
Sugar	9.922**	8.358*	12.328**	11.045**	10.478**	8.873*	9.234*	8.472*	11.428**	9.744*	12.053**	7.646
Carbs	10.501	5.732	12.873*	8.270	11.593	6.904	8.978	5.628	13.637*	7.831	15.856*	7.145
Fat	6.732***	6.246**	7.561***	7.136**	7.381***	6.850**	6.892**	6.655**	7.120**	6.554**	8.942***	8.088***
Proteins	7.757***	7.106***	8.766***	8.014***	8.690***	7.921***	7.760***	7.356***	8.395***	7.530***	9.077***	7.588***
Sodium	151.008*	105.394	172.658*	121.073	177.030**	125.771	135.287	99.692	196.429**	139.452	210.069**	145.965
Fiber	1.342**	1.099*	1.447**	1.155*	1.397**	1.258**	1.169*	1.050*	1.455**	1.083*	2.348***	1.840***
Gender=1 if Female		yes		yes		yes		yes		yes		yes
No-snack=1 if no snack		yes		yes		yes		yes		yes		yes
Hunger before snack		yes		yes		yes		yes		yes		yes
Subject dummy	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Day dummy	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	228	228	198	198	209	209	202	202	188	188	141	141

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

We further investigate the change in sugar intake during snack and lunch time identifying three different sources of sugar: fruit and vegetables, milk and other sources, which are mostly represented by processed food with added sugar. With this further analysis we want to verify the nature of the sugar consumption substitution between lunch and snack time. Results show a strong and consistent decrease of sugar from milk consumption during lunchtime and an increase of its consumption during snack time (Table 9). The analysis suggest students are substituting their milk consumption to snack time if they have the choice. Moreover, we can see a reduction of sugar from processed food for treatment 1 and treatment 4. This last finding suggests a policy which considers providing milk at snack time can be beneficial for students. However, further investigation of this option should be considered.

Table 9: Sugar sources intake from fruit and vegetables (V\F), milk or all other sources. DID estimates for lunch and snack time for all six treatment groups specification.

	Lunch			**Snack**		
	Sugar V/F	**Sugar milk**	**Sugar all others**	**Sugar V/F**	**Sugar milk**	**Sugar all others**
Treatment 1	-3.645	-7.301*	-6.897*	0.546	4.943**	4.433
Treatment 2	-2.708	-8.027*	-5.925	2.094	5.479**	4.755
Treatment 3	-3.476	-7.885*	-6.599	0.062	5.455**	4.961
Treatment 4	-2.244	-8.132*	-8.513**	0.115	5.519**	3.601
Treatment 5	-4.126	-7.365	-5.290	1.706	4.968*	4.754
Treatment 6	-3.759	-8.556*	-3.966	0.891	4.927*	6.236*

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

Discussion and conclusion

The results of this experiment provide relevant insight into the consumption behavior of children during school. Overall, we find that providing a nutritious snack to the students does impact their consumption behavior. In particular, students tended to shift their consumption to snack time and reduce their consumption during lunch. Interestingly, students significantly reduced their consumption of sugar during lunch time and increased their consumption of sugar during snack. The increase in sugar during snack, however was due to increases in milk consumption rather than from processed sugars. This has important implications for children as excessive consumption of sugar can have important health implications arising from obesity and diabetes.

The increase in fruit and vegetable consumption provides another promising result. Based on observation, students did not often bring fruits and vegetables with them to school for snack or lunch. Providing additional opportunities to consume fruits and vegetables increased the amount that they consumed. Given the benefits of fruits and vegetables, this is an important consideration for future studies of this type.

Finally, the change in hunger status due to the snack should not be dismissed. Although we did not measure classroom performance, there may be important implications for the behavior and performance of students when they are *not* hungry.

Clearly studies such as this can benefit from longer panels over greater populations. Given the intensity of such work, even at a small scale, this can be difficult to accomplish. It may be relevant for schools to develop their own ways to monitor and measure how children are eating in school.

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