January 2015

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April 28, 2015

Abstract

Childhood obesity is on the rise in the United States, putting many of the nation's children at an increased risk of developing serious health conditions. One way this crisis is being addressed is through efforts such as those made by the National School Lunch Program to improve children's dietary quality by increasing the amount of fruits and vegetables provided in school meals. However, offering students more fruits and vegetables does not guarantee that they will consume more fruits and vegetables, and some critics believe these new regulations will simply lead to more meal waste without increasing students' fruit and vegetable consumption. This study applies behavioral economics-based principles to a school cafeteria setting to test the effectiveness of subtle "nudges" that encourage fruit and vegetable consumption on increasing students' selection and overall intake of fruits and vegetables using a pre-post quasi-experimental design. To test this, plate waste was recorded from 547 students prior to the implementation of the subtle nudging intervention and 1774 students post implementation of the intervention. Data was analyzed using Poisson and Logistic regression models to produce incidence rate ratios of fruit and vegetable selection and odds ratios of "trying" and consuming greater than or equal to a half serving of fruits and vegetables at post intervention compared to pre intervention. Overall, an increase was observed in both vegetable selection and consumption at post intervention compared to pre-intervention, while a decrease was observed in both fruit selection and consumption at post intervention compared to pre intervention. More studies are needed in this emerging area of research to better understand the effect of behavioral economics based interventions on fruit and vegetable consumption patterns in school cafeteria settings.

Background

Childhood obesity in the United States is at an all time high, with 17% of adolescents categorized "at-risk" of becoming obese in 2010 compared to just 5% of their 1980 counterparts.[1] Defined as having a body mass index (BMI) of 30 or greater, or above the 95th percentile for children, individuals experiencing obesity are at risk of developing serious health problems including: type 2 diabetes, non-alcoholic fatty liver disease, and cardiovascular disease.[1] Because the prevalence of obesity is greater at a much younger age than in previous generations, present trends in obesity project a growth in the proportion of the population living with chronic disabilities. Some researchers believe this rise in obesity, particularly childhood obesity, has the potential to halt increases in life expectancy achieved by medical and public health advances during the past century, and possibly lead to a decrease in life expectancy.[2] Therefore, drastic efforts must be made to address this crisis.

One way this can be addressed in through improving the nutritional content of children's diets. Research shows that replacing foods of high energy density (high calories per weight of food) with foods of lower energy density, such as fruits and vegetables, can be an important part of a weight-management strategy.[3] This is because fruits and vegetables are generally low in fat with a high water content, which gives them a relatively low caloric density. In fact, multiple studies find that individuals who eat the same weight of food throughout the day are able to calorically dilute their food intake, resulting in fewer calories consumed, without feeling increases in hunger or reductions in satiety.[4] Based on this information, it is highly probably that children who increase their average fruit and vegetable consumption also lower their risk for obesity. The United States Department of Agriculture (USDA) recently passed a series of new regulations requiring the National School Lunch Program (NSLP) to improve the nutritional content of schools meals by increasing the amount of whole grains served, reducing the fat content in milk to 1% or less, and requiring students to take at least one fruit or vegetable.[5]

However, merely providing students with access to fruits and vegetables does not guarantee fruit and vegetable consumption. Critics believe these new requirements will lead to excess food waste and reduced participation in the NSLP, and will be ineffective in achieving the USDA's goal of improving students' diets.[6] Some research also suggests that restricting children's access to solid fats and added sugars (SOFAS) or other highly palatable nutrient poor foods is not an effective means of promoting limited intakes of these types of foods and may even lead to increased consumption of these restricted foods.[7] Still, the body of literature is limited on this topic especially as it relates to school meal programs, and more research is needed to fully understand the affect of these new regulations on students' eating habits.

An emerging area of scientific research known as Behavioral Economics may provide effective strategies for addressing these concerns. Behavioral economics merges concepts from psychology behavioral models with economics-based decision making models to explain how factors related to perception, memory, and thought processes influence decisions. This behavioral economics approach can be used in school based cafeteria settings by influencing students' food selection and consumption behaviors without restricting choices. This can be achieved through subtle changes that increase the convenience, attractiveness, and normative nature of healthy foods in the lunchroom.[8] Based on this concept, students exposed to these strategies will naturally be more inclined to take the healthier food offerings, without feeling forced to make these choices, thereby avoiding the potential for negative consequences associated with food restriction. Guided by the principles of behavioral economics, this study aims to measure the effectiveness of small cafeteria changes, referred to as "subtle nudging" techniques, on increasing students' consumption of fruits and vegetables in five public schools in Connecticut.

Methods

Study Design

Results from the Smarter Lunchroom Makeover Pilot are based on data collected at five public schools in Connecticut between May 2014 and December 2014. All public schools participating in the NSLP in Connecticut were invited to apply to become study sites, with study site selection criteria being based on applicants' demonstrated commitment to change the cafeteria environment to encourage healthy choices in accordance with Smarter Lunchroom strategies, and agreement to provide all required data as part of the baseline and intervention evaluation process, with efforts made to include schools representing elementary, middle, and high school students from urban, rural, and suburban settings in final selection.

Data for this pre-post quasi-experimental study were collected to measure the percentage of food eaten and wasted by students participating in the National School Lunch Program, with the first round of data measuring the amount of food eaten and wasted by students prior to exposure to subtle nudging strategies, followed by an additional three rounds of data collection to measure students' food consumption and waste after exposure to subtle nudging strategies. Each school was instructed to serve students the same meal at all four rounds of data collection. Researchers measured the amount of each school meal component left uneaten on students' trays based on a zero to four scale, with zero indicating that the student had consumed 100% of the meal component, one indicating that the student had consumed 75% of the meal component, two indicating that the student had consumed 50% of the meal component, three indicating that the student had consumed 25% of the meal component, and 4 indicating that the student had consumed 0% of the meal component. Trays were collected from a convenience sample of 30-50 students per lunch wave, with the number of lunch waves at each school ranging from three to five. Schools were given autonomy in selecting the number and type of Smarter Lunchroom strategies to be implemented in their cafeterias. The number of Smarter Lunchroom subtle

nudging strategies implemented at each school ranged from six to twelve. Some of these strategies included hanging health promoting posters, displaying fruit in baskets, renaming vegetables, placing plain milk in front of chocolate milk, adding salad bars, and increasing the number of locations fruits and vegetables are offered in serving lines.

Analysis

Data were analyzed using the statistical analysis software SAS 9.3 to measure the effectiveness of these behavioral economics based subtle nudging strategies on increasing students' fruit and vegetable selection and consumption at lunchtime. Descriptive statistics were produced to show the mean number of fruit and vegetable servings selected per student, mean percent of fruit and vegetable wasted on each tray, and mean number of fruit and vegetable servings consumed per student at pre and post implementation of the intervention. Mean waste statistics were also calculated for fruits and vegetables stratified by type to determine the kinds of fruit and vegetable that were most popular and least popular among students. Poisson regression models were used to determine the effect of students' exposure to subtle nudging strategies on number of fruit and vegetable servings consumed, controlling for between school differences, and logistic regression models were used to determine the effect of exposing students to subtle nudging strategies on whether or not the students "tried" the fruit and vegetables (defined as eating a quarter of more of a serving), and whether or not students consumed a half serving or more of fruit and vegetables, controlling for between school differences.

Results

Data were analyzed from 547 school lunch meals at baseline collection and 1774 school lunch meals post intervention implementation. Overall, combined levels of fruit and vegetable consumption stayed constant at pre and post intervention. Compared to baseline levels, students experienced a decrease in fruit consumption, which was offset by a slight increase in vegetable

consumption. Students took 0.73 servings of fruit, of which they consumed 68% and 1.08 servings of vegetable, of which they consumed 64%, on average at baseline. At post intervention, student took 0.64 servings of fruit, of which they consumed 63% and 1.17 servings of vegetable, of which they consumed 65%. This amounts to a total average fruit and vegetable intake of 0.50 servings and 0.69 servings, respectively, at baseline, and 0.40 servings and 0.76 servings, respectively, post intervention. These descriptive statistics are shown below in **Figure 1**.

Figure 1. Mean Fruit and Vegetable Consumption at Pre and Post Intervention

	Pre (n=547)		Post (n=1774)	
	Fruit	**Vegetable**	**Fruit**	**Vegetable**
Number of Servings Selected	0.73	1.08	0.64	1.17
Percent Consumed	68%	64%	63%	65%
Number of Servings Consumed	0.5	0.69	0.4	0.76

Poisson regression models were run to determine the effect of the intervention on the number of fruit and vegetable servings selected by students, controlling for between school differences. Incidence rate ratios derived from analysis of maximum likelihood parameter estimates showed exposure to the subtle nudging techniques attributing to a 12.7% decrease in fruit serving selection compared to pre intervention ($p<0.01$) and a 7.8% increase in vegetable serving selection compared to pre-intervention ($p=0.02$), as shown in **Figure 2**.

Figure 2 Effect of Intervention on Number of Fruit and Vegetable Servings Selected by Students

Parameter Estimates (n=2321)								
			95% Confidence Limits					
Parameter	**Estimate**	**SE[1]**	**Lower**	**Upper**	**Chi-Square**	**IRR[2]**	**% Change**	**P-Value**

Fruit	Intercept	-0.33	0.06	-0.45	-0.21	29.63			<0.01
	Exposure to Nudges	-0.14	0.05	-0.23	-0.04	7.65	0.87	-12.7%	<0.01
	School	0.01	0.01	-0.02	0.03	0.26			0.61
Vegetable	Intercept	-0.22	0.04	-0.30	-0.14	26.62			<0.01
	Exposure to Nudges	0.07	0.03	0.01	0.14	5.13	1.08	7.8%	0.02
	School	0.08	0.01	0.06	0.09	97.78			<0.01

1. SE= Standard Error
2. IRR=Incidence Rate Ratio

In terms of consumption, frequency distributions were determined to show the percent of students eating 0.25 servings and the percent of students eating 0.5 servings of fruit and vegetable at pre and post intervention. Chi-square tests were run to calculate the statistical significance of these distributions. These distributions are displayed in **Figure 3**. The portion of students consuming 0.25 servings or more of fruit significantly decreased from 50.46% at baseline to 45.32% post intervention (p=0.04). Meanwhile the portion of students consuming 0.25 servings or more of vegetable significantly increased from 66.18% at baseline to 74.63% post intervention (p<0.01). The portion of students consuming 0.5 or more servings of fruit also significantly decreased from 46.98% at baseline to 41.83% post intervention (p=0.03). The portion of students consuming 0.5 or more servings of vegetable increased from 62.71% at baseline to 66.97% post intervention (p=0.07).

Figure 3. Frequency Distribution of Fruit and Vegetable Consumption at Pre and Post Intervention

Fruit (n=2321)			
	Pre	**Post**	**P-Value**
<0.25 servings	49.54	54.68	0.04
>=0.25 servings	50.46	45.32	
<0.5 Servings	53.02	58.17	0.03
>=0.5 Servings	46.98	41.83	
Vegetable (n=2321)			
	Pre	**Post**	**P-Value**

<0.25 servings	33.82	25.37	<0.01
>=0.25 servings	66.18	74.63	
<0.5 Servings	37.29	33.03	0.07
>=0.5 Servings	62.71	66.97	

Results from logistic regression models showed the odds of students consuming at least 0.25 servings of fruit post intervention is 0.81 that of baseline (p=0.03), and the odds of consuming at least 0.25 servings of vegetable post intervention is 1.49 that of baseline (p<0.01). The odds of consuming at least 0.5 servings of fruit post intervention is also 0.81 that of baseline (p=0.03), and the odds of consuming at least 0.5 servings of vegetable is 1.19 that of baseline (p=0.09). These results are displayed in **Figure 4**.

Figure 4. Odds of "Trying" and Consuming a Half Serving or More of Fruits and Vegetables

		Fruit (n=2321)				Vegetable (n=2321)			
			95% Confidence Limits				95% Confidence Limits		
	Variable	**Odds Ratio**	**Lower**	**Upper**	**P-Value**	**Odds Ratio**	**Lower**	**Upper**	**P-Value**
>=0.25 Servings	Exposure to Nudges	0.81	0.67	0.99	0.03	1.49	1.21	1.84	0.00
>=0.5 Servings	Exposure to Nudges	0.81	0.67	0.98	0.03	1.192	0.975	1.457	0.09

When looking at the breakdown of fruit and vegetable waste by type, it becomes clear that some fruits and vegetables are more likely to be consumed in their entirety than others. For fruits, strawberries and bananas produced the least amount of waste with students who took these fruits consuming an average of 77% and 76% of their servings, respectively. Fruits that garnered the highest amounts of waste were apples and pairs with students only consuming an average of 34% and 53% of their servings, respectively. For vegetables, the most highly consumed types were marinara sauce and French fries with students consuming and average of 85% and 82% of

their servings, respectively. Least popular were seasoned green beans and bagged carrots with students consuming just 18% of their green beans and 21% of their bagged carrots, on average.

In certain cases, the way fruits and vegetables are prepared and presented may have a significant effect on students' consumption. This was most notably seen in apples, which were consumed by students in greater quantities when they were presented in a pre-sliced form compared to when they were presented whole. Despite being the same kind of fruit, this difference was observed with students consuming 61% of apples when they were sliced compared to just 34% when they were presented whole.

Discussion

Overall, implementation of the Smarter Lunchroom Movement Pilot lead to a slight decrease in fruit consumption, which was offset by slight increase in vegetable consumption. Despite a lack of significant net increase in combined fruit and vegetable intake, this finding can still be argued to be a positive outcome, since vegetables are typically more nutrient dense than fruits, offering students greater health benefits for fewer calories.[9] Children are also less likely to meet recommended guidelines for vegetable consumption than they are for fruit consumption, suggesting a greater need for increasing vegetable consumption than fruit consumption.[10]

This study adds to the current body of research in the emerging field of behavioral economics. Results on the effectiveness of nudging strategies on dietary behaviors have been mixed, and few studies have been published that apply behavioral economics concepts in school-based settings. The Smarter Lunchroom Movement Pilot helps to fill this gap in research. The large sample size in this study provides statistical power to detect effects at a significance level of alpha<0.05. Another strength in this study lies in its use of multiple rounds of data collection, which ensures that any observed differences in dietary habits during the intervention are not simply the results of a novelty effect and are indeed long-lasting behavioral changes. This study provided participating schools with a great deal of autonomy, allowing them to tailor the Smarter

Lunchroom subtle nudging strategies to suit their own unique needs. An additional strength in this study lies in its low cost and low maintenance which makes the study very feasible future replication and sustainable.

This study uses a Pre-Post design and is limited by its lack of control group. Since baseline data was collected in the spring and early summer and post intervention data was collected in the fall and early winter, a seasonal effect may have negatively confounded results. Previous studies have documented seasonal differences in fruit and vegetable consumption with higher quantities of fruit and vegetables being consumed in the summer months. [11, 12, 13, 14, 15] Considering this seasonal effect, Smarter Lunchroom nudging strategies may have acted as a buffer to curtail a season related decrease in fruit and vegetable consumption in the intervention's fall and winter months. Future studies should be conducted to further test the effectiveness of subtle nudging techniques on school-based fruit and vegetable consumption using control groups, with pre intervention and post intervention data collection occurring within the same season.

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