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School Lunch Waste among Middle School Students: Implications for Nutrients Consumed and Food Waste Costs

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Abstract

Background—The National School Lunch Program has been guided by modest nutrient standards, and the palatability of meals, which drives consumption, receives inadequate attention. School food waste can have important nutritional and cost implications for policy makers, students, and their families.

Purpose—Nutrient losses and economic costs associated with school meal waste were examined. The study also assessed if school foods served were valid proxies for foods consumed by students.

Methods—Plate waste measurements were collected from middle school students in Boston attending two Chef Initiative schools (n=1609) and two control schools (n=1440) during a two-year pilot study (2007-2009) where a professional chef trained cafeteria staff to make healthier school meals. The costs associated with food waste were calculated and the percent of foods consumed was compared with a gold standard of 85% consumption. Analyses were conducted in 2010-2011.

Results—Overall, students consumed less than the required/recommended levels of nutrients. An estimated $432,349 of food (26.1% of the total food budget) was discarded by middle school students annually at lunch in Boston middle schools. For most meal components, significantly less than 85% was consumed.

Conclusions—There is substantial food waste among middle school students in Boston. Overall, students' nutrient consumption levels were below school meal standards and foods served were not valid proxies for foods consumed. The costs associated with discarded foods are high; if translated nationally for school lunches, roughly $1,238,846,400 annually is wasted. Students would benefit if additional focus was given to the quality and palatability of school meals.

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Introduction

Millions of students receive school meals daily.[1,2] Until recently, the National School Lunch Program (NSLP) had minimal standards so initiatives to enhance cafeteria foods (e.g., reducing sodium and saturated fats and increasing whole grains and fiber) have been important.[3] Interventions can potentially improve student's dietary habits and their overall health.[4]

The NSLP standards set minimum and maximum levels for calories, and limits on total fat and saturated fat, and until recently, also set minimum levels for protein, calcium, iron, vitamin A, and vitamin C. [3,5] These standards are calculated assuming that all foods served are consumed, but may not be met if substantial amounts of foods are wasted.[6,7] Food waste may especially impact low-income students who depend on school meals for up to half of their energy intake.[8] It is therefore important to examine the nutrients consumed at lunch among low-income children.

In 2010, the NSLP received roughly $10.8 billion in federal funding, including labor and supplies.[9] To reduce waste, a provision called “offer vs. serve” was created to allow students to select three or more distinct meal components rather than be required to take everything offered.[10] Despite most schools implementing “offer vs. serve,” a 2002 report to Congress estimated that food waste costs might be as high as $600 million.[6] However, the authors had access only to aggregate school meal costs and were unable to examine costs of waste specific to vegetables, fruits, entrées, and milk.[6] These reported costs also underestimate the true value of food waste because the federal government subsidizes school meals. Waste costs are important to examine because this subsidized cost may represent part of what students and/or families spend to compensate for the lack of palatable calories consumed at lunch.

One important challenge to evaluate school food consumption is the accurate assessment of the students' diets. Plate waste studies that weigh foods at the beginning and end of a meal provide detailed, accurate information, but are expensive and time consuming.[6,11] While many school-based interventions use 24-hour recalls, food frequency questionnaires, or food diaries, studies have also focused on production records as a low cost method that does not rely on children's memory and encompasses all students served.[11-18] However, estimated consumption based on production records or point of sale purchases by students do not account for food waste and therefore likely overestimate consumption.

The objectives of this study were to assess the impact of food waste on nutrient consumption, if school foods served could be valid proxies for foods consumed among middle school students, and the costs associated with food waste. Data from a school lunch intervention, the Chef Initiative (ChI), was examined. The ChI was a two year school-based study in two low-income Boston middle schools designed to increase preferences for and consumption of healthier schools foods. Data collected from ChI schools and two control middle schools in Boston were used to estimate average nutrient intake during lunch among middle school students and to determine if school foods served could be valid proxies for foods consumed. Food costs provided by Boston Public Schools (BPS) and food waste information collected from the ChI were used to estimate costs of discarded food.

Methods

This plate waste study was part of a school-based intervention that integrated more whole grains, monounsaturated and polyunsaturated fats, fresh or frozen fruits & vegetables, and reduced salt and sugar in the school lunch program. The intervention occurred in two Boston public middle schools for two years (2007-2009). A non-profit organization, Project Bread (www.ProjectBread.org), hired a professional chef to create recipes and train existing cafeteria staff to increase the lunch menus' nutrient quality and palatability. ChI schools were matched to two control middle schools in Boston based on race/ethnicity, percent eligible for free or reduced-price school meals, and similar kitchen facilities (schools serving only pre-packaged meals were excluded). Baseline data was unavailable because data collection began after the cafeteria changes were made; therefore, food waste at ChI schools was compared with control schools receiving standard meals. Additional details of the ChI have been described previously.[19]

Participants

Participants were students at ChI (n=1609) or control schools (n=1440) in grades 6-8 (most students were between 12-14 years old). Students were eligible to participate in the plate waste study if they attended a lunch period on a study day. Passive consent procedures were used. Students were excluded if they refused to participate (n=12). Students were not included in the study if they did not receive a school lunch or ate outside the cafeteria, such as in detention (the schools had closed campuses). At ChI schools, student eligibility for free/reduced-price meals was 88% (approximately 78% participated in school lunch daily) and student eligibility in control schools was 86% (roughly 70% participated daily). The Committee on Human Subjects at the Harvard School of Public Health approved the study.

Data Collection Measures: Plate Waste Study

The plate waste study protocol was a modified version of methods described elsewhere.[20,21] All lunch periods were included on study days, and each school was visited on two consecutive days (n=8 days of plate waste measurements); ChI schools and their matched control schools were examined on the same day of the week in the spring of 2009. Menus were planned prior to the selection of study dates, but when feasible, the foods served were matched at the ChI and control schools based on the menus. For example, fresh apples were served in ChI schools while canned apple sauce were offered in control schools (additional lunch menu items served in ChI schools and BPS have been published previously[19]).

Before students arrived at the cafeterias on study days, research assistants (RA) labeled the trays with a unique identifying number and removed the trash cans from the cafeteria. To provide a stable estimate of the weight for the foods served, RAs took ten random samples of each portioned food served that day and weighed them and the serving containers (in grams) on a food scale (OXO 1130800, OXO Company, New York, NY).

At the beginning of each lunch period, a teacher announced that study staff was collecting trays and that the students could refuse to participate. As students went to the cash register, two RAs discreetly stood by and recorded the tray number, the foods on the trays, and the gender of the student. No other personal identifying information was collected. After students finished their meals, RAs collected the trays and weighed the remaining individual foods and beverages on each tray.

Data Collection Measures: Cost Information Study

BPS provided the per-item prices for foods (excluding labor costs) from four representative school lunch days, based on the 2010 school year, which reflects the current costs of foods available to BPS. Prices were itemized by entrées, carbohydrate-based sides, fruits, vegetables, and milk. Because the components of school lunches come from multiple sources, these days included fresh, frozen, and canned foods that were sourced from the United States Department of Agriculture (USDA) Commodity Supplemental Food Program, national commodity food processors, regional and local distributors, as well as local growers. Condiments were included with the price of the accompanying food (e.g., butter with rolls).

Statistical Analysis

To estimate the daily average nutrients consumed, the average percent of students who took foods was calculated and multiplied it by the average amount consumed at the intervention and control schools. These values were applied to the foods from six weeks of planned menus in the fall, winter, and spring from 2007 to 2009. The six weeks of planned menus were used to better estimate the average nutrients served to students throughout the school year. Percent consumption for each menu component was calculated using the following equation: (Average weight of the foods/beverages served [based on the ten samples] – weight of the food/beverage remaining at the end of the lunch period) ÷ average pre-lunch weight of the food/beverage × 100. The average nutrients for entrées, sides, fruits, vegetables, and milk were calculated separately. Paired t-tests were used to examine differences between ChI and control schools.

To test if foods served were valid proxies for foods consumed, t-tests were conducted to compare the amount consumed versus a standard for full meal consumption. While NSLP requirements are calculated based on the assumption that 100% of the foods served are consumed,[7] the comparison of 85% complete meal consumption was selected because middle school students need on average only 85% of the calories that schools are required to serve (calculated based on the USDA MyPyramid for ages 11-14, weighted for typical physical activity levels among youth in the United States).[22,23] One-sided t-test for the null hypothesis of 85% complete meal consumption versus less were then calculated. To account for the design effect due to students' clustering for food consumption, the highest intraclass correlation coefficient (ICC) within schools was found using mixed-model analysis of variance using this dataset (ICC=0.11), and inflated the standard errors by the design effect (DEFt) = $\sqrt{1+247*0.11}= 5.4$ when calculating the one-sided t-tests.[24] Results were also stratified by intervention status and sex. Differences between intervention status and sex were examined using simple mixed-model analysis of variance, with school included as a random effect. Analyses were performed in 2010-2011 using SAS (version 9.1, 2003, SAS Institute, Cary, NC).

The daily average per student waste cost was calculated by taking four representative days of school meal costs and multiplying the average price of each meal component by the average percent of students taking the component and the average waste of the component (based on the plate-waste data). This individual student cost was multiplied by the total number of students attending a BPS middle school, the average daily attendance (92%) and average NSLP participation rate (67%) for BPS, and the number of school days. These food waste costs were combined to estimate the money spent on foods discarded in middle schools. Because some BPS cafeterias cannot cook foods on site, this method was applied only to the 9,612 middle school students (84%) who attend schools where meals are prepared. The other 1,896 students (16%) attend schools that receive pre-made meals, where there is a flat tray cost for schools. The average overall waste calculated during the plate waste study was applied to the tray cost, and then multiplied by the number of 6-8th graders attending schools without kitchens, average daily attendance and NSLP participation rate for BPS, and the number of school days.

Results

Overall waste and the variability in waste among food groups had an important impact on the average nutrients consumed at lunch (Table 1). The average calories selected at lunch in BPS and ChI schools were similar, but students consumed on average only half the calories they were served. While intervention schools were successful in providing lunches that met the Dietary Guidelines' fiber recommendations, students consumed only half the target amount. Students at control schools consumed less than a third of the goal. The percent of energy from total fats and saturated fats in the meals served met the USDA requirements, but the percent of energy from saturated fats consumed exceeded this guideline because of higher entree consumption, the primary source of the saturated fats.

The iron, calcium, and vitamin C levels served exceeded the former USDA requirements but were consumed at well below those standards.[5] The levels of vitamin A greatly exceeded the former USDA lunch requirements, but because of waste, especially from fruits and vegetables, only ChI students consumed the recommended amount of vitamin A.

Table 2 shows the average consumption rates of foods and milk among students at intervention and control schools. On average, students discarded roughly 19% of their entrées, 47% of their fruit, 25% of their milk and 73% of their vegetables. Entrées were the only meal component that did not differ significantly from the assumption that 85% was consumed. The only difference in consumption between the intervention and control schools was in vegetable intake (40.2% vs. 10.8%; $p = 0.03$). There were no significant differences in food waste by sex.

With the current rates of food waste, it was estimated that on average $432,349.05 worth of food is wasted annually at lunch from 6-8 grade students in BPS (n=11,508 students; Table 3). Approximately $279,176.17 of this waste was food that was prepared in the cafeteria and roughly $153,172.88 was food discarded from pre-packaged meals at schools with meals prepared off-site. Overall, 26.1% of the total food budget, excluding labor and supplies, was associated with discarded foods. Compared with control schools, if the consumption rates at ChI schools were applied to all 6-8th grade students attending schools with on-site cooking in Boston (n= 9,612 students), this would translate to a reduction of roughly $19,034 in food waste costs annually in BPS. On average, the per student cost associated with foods and drinks wasted at lunch was $0.26 per day, or $47.12 annually per middle school student at schools where foods were prepared on-site. For schools with pricier prepackaged meals, the associated waste cost was estimated to be $0.72 per day and $129.60 annually per middle school student.

Discussion

Obesity is a serious problem among adolescents in the United States, especially in low-income families, and excess calories often come from nutrient-poor sources.[25-29] Weight gain may occur in part because students do not consume enough school lunch, leave school hungry, and search out replacement calories from calorie dense, high salt and/or sugary snacks and drinks at fast food establishments and corner stores.[30-32]

Consumption of healthier school meals could potentially replace less nutritious sources. Overall, it was found that students accepted the healthier foods served in ChI schools and wasted less vegetables compared with students in control schools, which suggests that increasing the food quality and decreasing meal waste is feasible.

Despite the high levels of nutrients served in the school meals, students consistently consumed less than the target level. On average about 60% of the foods served at lunch were consumed, and calorie intake was on average only half of the federal requirements. Students at ChI schools were closer to consuming the recommended levels of fiber and vitamin C compared with control schools and met the former requirements for vitamin A. These findings provide further evidence that schools should emphasize more palatable foods to increase nutrient consumption (food price, often another determinant of selection/

consumption, was likely not a factor since nearly all the participating students received free/reduced price meals, and no other known environmental or policy changes occurred).[33]

For most food categories, foods served were a substantial overestimation for food consumed at lunch. Two previous studies in elementary schools directly estimated foods consumed versus foods served and found that fruits and vegetables served were valid proxies for what was consumed.[11,12] The present study did find adequate consumption of entrées, but not for milk, fruits, or vegetables, which suggests that in an urban, low-income middle school population, most foods selected at lunch are not valid proxies for consumption.

The food waste estimates assumed that there were similar consumption levels among foods that are prepared on-site and pre-packaged meals, but it is possible that the average consumption differs. If the rates of consumption among 6-8th grade students in Boston were applied to the entire district (accounting for the elementary school rate of $1.55 for pre-packaged meals for 4,161 students), food waste costs would amount to $2,444,916 annually at lunch in Boston. If similar rates of food spending and waste were applied to the most recent NSLP costs ($10.8 billion for the 2010 fiscal year × 44% [average % of budget for food costs [34,35]] × 26.07% [percent of budget associated with foods discarded in this study]), food waste costs would translate to roughly $1,238,846,400 spent annually on food that gets discarded at lunch nationally.[9] This is considerably more than the $600 million estimated in the 2002 Congressional report even after accounting for inflation.[6]

While schools could save some money by reducing food waste, students or families may also benefit financially because students who consume more school lunch are likely to spend less outside of the cafeteria on food. While $0.26 to $0.72 on average for foods and drinks wasted daily may appear small, the government subsidizes these costs, therefore underestimating how much students and families must spend to compensate for the lack of food consumed during lunch. Thus providing healthier, more palatable foods at lunch may lead to considerable cost savings to students and families. For example, if the subsidy rate of milk was applied to all school foods, students would need to spend on average $0.92 a day to compensate for the lack of consumption at schools (calculated based on the conversion rate of subsidized school milk for BPS [$0.17 per 8oz] compared with typical supermarket value of milk in Massachusetts [$0.32 per 8oz], multiplied by the average estimated per day costs of foods and drinks wasted [$0.49]), this would translate to roughly $29.3 million per day, or $5.3 billion per school year (n=180 days), on foods and beverages for the 31.8 million students participating in the NSLP daily.

This study has several limitations. Only schools located in low-income, urban areas were included in the study, and consumption information was based on only two days at each school. Additionally, the food costs were based on only four days. However, there is no reason to believe that these days are not representative. The food prices were also similar to values provided by another large urban school district in Massachusetts and the present analysis found that food represented about 44% of the total meal cost, which was similar to previous studies.[34,35] The food prices also included the cost of both commodity and free market food items. This suggests that the overall costs in BPS may be generalizable to other school districts.

Further research is needed to evaluate if there are similar findings in high schools or among other middle school populations. Studies should also examine if there are differences in waste among foods prepared on-site at schools and pre-packaged meals. Efforts to increase the overall selection and consumption of school foods, especially fruits and vegetables, should be a priority of future school-based research.

Conclusion

In conclusion, this study is the first study to quantify the average nutrients consumed and, in parallel, the nutrients served but discarded from school lunches in a middle school population. It was found that the insufficient amount of calories, fiber, and vitamins and minerals consumed at school by this vulnerable, low-income population warrants serious attention. This study suggests that substantial quantities of foods are discarded at lunch and their associated costs are large. This study is also the first to document that most foods served to middle school students in an urban low-income setting are not valid proxies for foods consumed. Programs, like the ChI, that focus on the palatability of school meals, show promise to improve school meal consumption and the decrease the costs associated with waste. Overall, the results suggest that schools require additional funding for higher quality foods and for additional cafeteria staff training and support to produce more palatable meals and thus reduce food waste among students.

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Table 1

Nutrients in lunches offered and estimates of nutrients consumed in Chef Initiative and control schools.[a]

		Served (SE)	Consumed (SE)	Federal lunch requirements[b]	Lunch requirements based on MyPyramid.gov[c]	% consumed of lunch requirements based on MyPyramid.gov[c]
Food Energy (kcal)						
	Overall	660 (13.4)	388 (8.7)	600–700	667	58.2
	Control	658 (21.2)	373 (13.5)			55.9
	Intervention	661 (17.2)	402 (10.9)			60.3
Fiber (g)						
	Overall	9.5 (0.4)	4.3 (0.2)	11[d]	9	47.8
	Control	7.6 (0.3)*	3.0 (0.2)*			30.0
	Intervention	11.2 (0.5)	5.5 (0.3)			60.6
Total Fat (g)						
	Overall	18.6 (0.7)	13.2 (0.5)	N/A[e]	N/A[e]	
	Control	17.7 (1.1)	12.6 (0.8)			
	Intervention	19.3 (0.8)	13.7 (0.5)			
Total Fat (% Energy)						
	Overall	25.4 (0.8)	30.3 (0.9)	< 30% of energy	< 30% of energy	Exceed Requirements
	Control	24.3 (1.3)	29.8 (1.6)			Meets Requirements
	Intervention	26.3 (1.0)	30.8 (1.0)			Exceed Requirements
Saturated Fat (g)						
	Overall	6.2 (0.2)	4.3 (0.2)	N/A[e]	N/A[e]	
	Control	6.8 (0.4)*	4.7 (0.4)*			
	Intervention	5.7 (0.2)	3.9 (0.2)			
Saturated Fat (% Energy)						
	Overall	8.6 (0.3)	10.0 (0.4)	< 10% of energy	< 10% of energy	Meets Requirements
	Control	9.4 (0.5)*	11.3 (0.7)*			Exceed Requirements
	Intervention	7.8 (0.3)	9.0 (0.4)			Meets Requirements
Iron (mg)						
	Overall	4.4 (0.1)	2.7 (0.1)	4.2	3.1	87.1

		Served (SE)	Consumed (SE)	Federal lunch requirements[b]	Lunch requirements based on MyPyramid.gov[c]	% consumed of lunch requirements based on MyPyramid.gov[c]
	Control	5.1 (0.2)*	2.9 (0.1)			93.5
	Intervention	4.0 (0.2)	2.6 (0.1)			83.9
Calcium (mg)						
	Overall	528 (11.7)	304 (8.3)	370	433	70.2
	Control	541 (18.2)	311 (13.0)			71.8
	Intervention	516 (15.1)	299 (10.7)			69.1
Vitamin A (RE)						
	Overall	1020 (118)	321 (35.6)	285	217	147.9
	Control	713 (112)*	177 (12.7)*			81.6
	Intervention	1291 (188)	447 (57.9)			206.0
Vitamin C (mg)						
	Overall	32 (3.4)	9 (0.8)	17	17	52.9
	Control	25 (3.8)	6 (0.7)*			35.3
	Intervention	38 (5.3)	11 (1.2)			64.7

[a]Analyses based on the average of 6 weeks of planned menus in the Fall, Winter, and Spring of the 2008-2009 school year

[b]Micronutrient requirments based on the former federal nutrition requirements (using Traditional Menu Planning for grades 4-12) for school meals are based on the 1995 Dietary Guidelines for Americans

[c]Calculated based on average needs of 11-14 year old male and females, weighted by average physical activity levels for American youth

[d]Based on the 2010 Guidelines for Americans recommendation of 14 grams of fiber per 1000 calories (there are no federal requirements for fiber for school meals)

[e]There is not a requirement regarding absolute grams of total fats or saturated fats

*Mean significantly different from Intervention group ($p < 0.05$) using paired t-tests.

Table 2

Average consumption at lunch by Chef Initiative students and control students in grades 6-8

	Mean % Consumed (SE)[a]	P-value[b]
Entrées (N)[c]		
Intervention (1592)	79.7 (4.0)	0.21
Female (703) *	75.8 (6.3)	0.15
Male (804)	82.9 (5.3)	0.73
Control (1410)	83.5 (3.8)	0.75
Female (649)	81.7 (5.9)	0.61
Male (714)	85.8 (5.1)	0.82
Overall (3002)	81.5 (2.8)	0.25
Fruit (N)[c]		
Intervention (586)	45.2 (8.3)	<0.0001
Female (279)	40.3 (11.9)	0.0002
Male (281)	49.0 (12.1)	0.003
Control (492)	62.8 (9.6)	0.023
Female (224)	58.2 (14.7)	0.072
Male (247)	67.8 (13.0)	0.19
Overall (1078)	53.2 (6.5)	<0.0001
Vegetable (N)[c]		
Intervention (1007)	40.2 (6.3) **	<0.0001
Female (430)	36.5 (9.4)	<0.0001
Male (519)	42.2 (8.8)	<0.0001
Control (857)	10.8 (4.6)	<0.0001
Female (379)	9.4 (6.6)	<0.0001
Male (430)	12.5 (7.0)	<0.0001
Overall (1864)	26.7 (4.3)	<0.0001
Milk (N)[c]		
Intervention (1020)	77.6 (5.1)	0.16
Female (417)	70.8 (8.6)	0.11
Male (537)	82.0 (6.5)	0.67
Control (964)	72.3 (5.6)	0.027
Female (425)	62.7 (9.0)	0.015
Male (497)	80.4 (6.9)	0.53
Overall (1984)	75.0 (3.8)	0.011

[a]standard errors inflated by DEFt = $\sqrt{1+247*0.11}$= 5.4 (ICC=0.11 based on largest ICC from mixed-model analysis of variance, with schools included as a random effect, using this dataset).

[b]Mean % consumed vs the assumption that 85% should be consumed, using one-sided t-tests with inflated standard errors.

[c]Number of students selecting a food item or beverage; students are not required to take all the food/beverage categories offered

*The means were not significantly different by sex for any food component using mixed model analysis of variance with school as a random effect

**Mean significantly different from Control group using mixed model analysis of variance with school as a random effect ($p < 0.05$)

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Table 3

Estimated cost of foods discarded at lunch by children in grades 6-8 in Boston Public Schools[a]

Boston Public Schools where meals are cooked on-site (n=9,612 students)						
	Entrée	**Side**	**Vegetable**	**Fruit**	**Milk**	**Total**
Average cost per meal item ($)	0.56	0.07[b]	0.21	0.19	0.17	$1.20
Average % taking food/beverage	98.46%	19.88%	61.13%	35.36%	65.07%	-
Average % waste per meal component[c]	18.54%	45.35%	73.33%	46.80%	24.99%	-
Average daily waste cost per student[d]	$0.10	$0.02	$0.09	$0.03	$0.03	$0.27
Average annual waste cost[e]	$109,020.08	$6,749.63	$100,393.19	$33,532.09	$29,481.18	$279,176.17
Boston Public Schools that receive pre-packaged meals (n = 1,896 students) [f]						
	Tray with entrée, side, vegetable, and/or fruit				Milk	Total
Average cost per tray($)	1.63				0.17	-
Average overall % Waste[c]	42.09%				24.99%	-
Average daily waste cost per student[g]	$0.69				$0.03	-
Average annual waste cost[h]	$144,235.94				$8,936.94	$153,172.88
Total annual combined cost of lunch waste in Boston Public Schools						$432, 349.05

[a]Based on food costs from four representative days for Boston Public Schools from the 2010-2011 school year

[b]Calculated by multiplying the average cost of sides ($0.18) by the average percent of days that BPS serves sides (39% of days), based on the average of 6 weeks of planned menus in the Fall, Winter, and Spring of the 2008-2009 school year

[c]Based on the average waste from the plate waste study

[d]Calculated by multiplying the average cost per meal item by the average percent taking a food/beverage and the average % waste per meal component.

[e]Calculated by multiplying the average daily waste cost per student by the total number of middle school students attending schools where meals are prepared on-site (n=9,612), average daily attendance for Boston Public School students (92%), average daily participation in the national school lunch program (67%), and number of school days (180 days).

[f]Assumes that all pre-packed components offered were taken (some schools allow students to select food components, although the associated per tray cost remains the same)

[g]Calculated by multiplying the average cost per tray by the average daily waste cost per student

[h]Calculated by multiplying the average daily waste cost per student by the number of students receiving the meals (n= 1,896 middle school students), average daily attendance for Boston Public School students (92%), average daily participation in the national school lunch program (67%), and number of school days (180 days).