

Investigating the Relationship between Food Pairings and Plate Waste from Elementary School Lunches

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Abstract

Plate waste, defined as the quantity of edible food left uneaten after a meal, is a challenge for schools participating in the National School Lunch Program (NSLP). The new nutrition standards in the NSLP of United States Department of Agriculture (USDA) were implemented at the beginning of school year (SY) 2012-2013. School foodservice authorities were concerned that the new standards would result in increased plate waste and reduced participation, especially by students who paid full prices for lunch. There are many reasons for plate waste, including students' dislike of the foods served, the composition of meals, the environment in which students are eating, the lack of time to eat, or perhaps other factors. The objective of this study was to examine the relationship between entrée/vegetable "pairings" and plate waste by elementary school students pre- and post-implementation of the new school meal standards. Plate waste was measured to determine which entrée/vegetable pairs produced the least amount of waste. Plate waste of 144 and 305 entrée/vegetable pairings was analyzed, pre- and post-implementation, respectively. Our results indicated that more nutritious meals were offered during the post-implementation period. The new school meal standards led to no significant changes in entrée plate waste, but vegetable plate waste increased by 5.6%. As such, increases in the combined entrée/vegetable plate waste were evident from 40.4% pre-implementation to 43.5% post-implementation. The top five vegetables in terms of popularity were all starchy vegetables, the majority of which were potatoes in various processed forms. The least popular vegetables were dark-green leafy vegetables, such as steamed broccoli, both pre- and post-implementation. Chicken nuggets were the most popular entrée and were wasted the least. Understanding the dynamics of food pairings and providing desirable entrée and vegetable pairings can help reduce waste from school lunches.

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Keywords

Food Pairings, National School Lunch Program, Nutrients, Plate Waste, Vegetables

1. Introduction

Most children do not consume enough fruits and vegetables in their diet [1]. Increased consumption of fruits and vegetables may reduce the risk of developing certain diet-related diseases in adulthood [2]. Children learn about healthy eating from their parents, extended family, schools, and communities in which they live. In this regard, the U.S. Department of Agriculture's (USDA) School Meal Programs—the National School Lunch Program (NSLP) and the School Breakfast Program (SBP), are in a unique position to help improve the nutritional quality of diets of school children [3]. The NSLP is the second largest food assistance program in the United States with federal spending of more than 11 billion dollars per year. It is a valuable nutrition safety net for school-age children that provides free, reduced or full-price¹ lunches to more than 31 million children each school day. In 2014, more than 70% of lunches served were free or reduced-price [1] [3].

To be eligible for Federal reimbursement, all lunches served in the NSLP must meet a defined set of nutrition standards. During the 2012-2013 school year, new school meal nutrition standards were implemented in accordance with USDA regulations stemming from the Healthy, Hunger-Free Kids Act (HHFKA) of 2010 and the 2010 Dietary Guidelines for Americans [2] [4]. The new USDA guidelines for school meals were designed to improve the nutrient density of foods offered and set standards for calories, sodium, and saturated fat. In addition, among other requirements, the guidelines required serving a greater variety and larger portion sizes of fruits and vegetables [4].

School foodservice authorities were concerned that plate waste would increase as a consequence of the new regulations. Plate waste, defined as the quantity of edible food left uneaten after a meal, has been a persistent problem for schools at all grade levels [5]. Moreover, the Government Accountability Office challenged the new school meal standards as potentially contributing to greater plate waste [6].

It is not clear why students waste as much food as they do. Many factors may contribute to the waste, including a dislike or unfamiliarity with the foods served, the environment in which students are eating, lack of time to eat, or many other factors. One factor that has not been explored is the meal composition or pairings of certain foods that could enhance appeal, palatability and acceptability of the meal and lead to less plate waste. We, therefore, hypothesize that pairings of certain entrées and vegetables may reduce overall food waste.

The objective of this study was to examine the relationship between food pairings, *i.e.*, entrées and vegetables, and plate waste by elementary school students. While a number of plate waste studies have been conducted in schools [7]-[15], none has focused on the relationship between the pairing of foods and plate waste in school lunches. To our knowledge, this paper is the first that examines pairings of entrées and vegetables associated with plate waste. This study will provide some insights on possible strategies to reduce overall plate waste from school meals.

2. Methods

2.1. Participants

Plate waste data were collected from three elementary schools (kindergarten through fifth grade) in one school district participating in the USDA's school meal program in central Texas. Plate waste collections were conducted in two phases. Phase 1 was conducted in April and May 2012, pre-implementation of the new nutrition standards, while Phase 2 was conducted in October and November 2012, post-implementation of the new nutrition standards. This timing allowed us to evaluate plate waste from school lunches pre- and post-implementation of new school meal standards. This design corresponds to a natural experiment in that the same schools were involved prior to and after the implementation of the new standards for the NSLP. In this light, this study was observational in nature without any additional interventions.

By design, the research did not involve personal identifiers regarding the participants and was approved as

¹Full priced meals are also subsidized by the government.

exempt from committee review by the Texas A&M University Institutional Review Board.

2.2. Data Collection Procedure

All lunch periods for the sampled schools were scheduled by grade (kindergarten through 5). The same menu and portion sizes were served during all lunches in all three elementary schools. In all the schools, 30 minutes was allowed for lunch and recess was scheduled after the lunch. In order to meet the requirements for the new meal standard, the school district changed the recipes of the menu items and served a greater variety of vegetables; serving sizes were not changed, however. Schools used an eight-week menu cycle both pre and post-implementation.

For each data collection day, five to ten servings of each sampled entrée and vegetable were served on “test trays” by school nutrition staff. The “test trays” were used to measure pre-weights for each entrée and each vegetable for which plate waste was collected. On average, two or more options for entrées and vegetables were provided on a given day. Before each lunch period, separate trash bins were prepared for each entrée and vegetable and lined with pre-weighed trash bags. Students finished their meals and brought their trays to the research team members waiting at the designated stations. Uneaten entrées and vegetables were separated into the corresponding trash bin and the remaining contents of the tray were discarded in the cafeteria trash can for disposal. This process was repeated for each lunch period. Aggregated waste per menu item was weighed and recorded per grade at each school.

Altogether, plate waste data from 8430 students were collected—corresponding to 4145 students pre-implementation and 4285 students post-implementation of school meal standards. A total of 144 observations of entrée/vegetable pairings repeated by grade and school (27 distinct pairings) were collected pre-implementation and 305 observations of entrée/vegetable pairings repeated by grade and school (56 distinct pairings) were collected post-implementation. Analyses of the respective entrée/vegetable pairings were conducted to determine plate waste and therefore, acceptability for particular entrée/vegetable pair subsequently.

2.3. Plate Waste Measurement and Food Pairings

Our data collection procedures allowed for plate waste to be examined for entrée and vegetable pairings as well as for each entrée and each vegetable separately. Plate waste (in grams) for each entrée and vegetable by grade and school was divided by the number of students choosing those items.

$$\text{Plate Waste per Student}_{jk} = \frac{\text{Total Plate Waste}_{jk}}{\text{Number of Students}} \quad (1)$$

The ratio provided the plate waste per student (in grams), where $j = 1$ if main entrée and $j = 2$ if vegetable and $k = 1, \dots, n$ is type of main entrée or type of vegetable.

Finally, the percentage of plate waste was calculated by dividing this ratio by the pre-weight (in grams) of the entrée or vegetable item, also measured in grams.

$$\% \text{ Plate Waste}_{jk} = \frac{\text{Plate Waste per Student}_{jk}}{\text{Prewrite}} \times 100 \quad (2)$$

By knowing the number of participating children, plate waste was able to be expressed as a proportion or percentage.

2.4. Statistical Analysis

The SAS statistical analysis system (version 9.4, 2013, SAS Institute, Inc, Cary, NC) was used to create a data file with food pairings, which served as variables in conducting descriptive and statistical analysis. Mean values and standard deviations of plate waste were calculated for entrée/vegetable pairings and separately for entrées and for vegetables, for pre- and post-implementation of new school meal standards. The popularity of entrées and of vegetables was calculated as a mean number of students selecting the particular item on the data collection days. T-tests were used to determine the differences in means in popularity of entrées and vegetables, and differences in means of plate waste for entrée/vegetable pairings. The level of significance chosen was at $\alpha = 0.05$.

3. Results

3.1. Characteristics of Schools

Table 1 provides characteristics of three elementary schools in our sample. These elementary schools were diverse based on race/ethnicity of the student population and percentage of students eligible to receive free/reduced-price school meals. Nearly all students in school A were eligible for free/reduced price lunches. In contrast, one-third or less of the students in school C qualified for free or reduced-price lunches. Post-implementation, a greater percentage of students in school B were eligible for free or reduced-price lunches compared to the pre-implementation period. The percentage of students eligible to receive free/reduced price meals from three elementary schools in our sample was about 66% pre-implementation and 68% post-implementation of nutrition standards. For the state of Texas, this percentage was 66% in 2012 and for the U.S. 50% in 2012 [16]. As reported in the School Nutrition Dietary Assessment Study-IV (SNDA-IV) report 64% of reimbursable lunches served in elementary school during 2009-2010 school year were served for free or at reduced prices. For our sample, we found that on average 74% and 76% of reimbursable lunches served were for free or at reduced prices, pre- and post-implementation, respectively. The percent of lunches sampled on the data collection days varied from 34% to 79%. Despite this variability, the data are representative of the population.

3.2. Popularity of Entrées and Vegetables

“Popularity” was defined as the mean number of students in our sample selecting the item on the data collection days. Popularity of the main entrées and vegetables, pre- and post-implementation of the new school meal standards, are reported in **Table 2** and **Table 3**. On average, two or more different entrées and different vegetables selections were offered on a given day. Greater varieties of entrées and vegetables were served post-implementation of the revised standards compared with pre-implementation. The five most popular vegetables were starchy vegetables, the majority of which were potatoes in various processed forms (mashed potatoes with gravy, oven baked French fries, tater tots, and potato wedges), both pre- and post-implementation. Steamed broccoli was the least popular vegetable both pre- and post-implementation. Chicken nuggets were the most popular entrée for both periods. Burgers (plain and with cheese) were also popular pre- and post-implementation. Pre-implementation, deli sliders were the least popular entrée, whereas the sunbutter sandwich was the least popular entrée post-implementation.

3.3. Food Pairings and Plate Waste

We hypothesized that there was a relationship between consumption of certain entrées and vegetables that would lead to less plate waste. Our hypothesis is that if students eat less of an entrée, then they might eat more of the accompanying vegetable(s). Similarly, if students ate more of the entrée (*i.e.*, waste less of it), then they might have eaten less of the accompanying vegetable(s).

Table 1. Total student enrollment, percent receiving free/reduced price meals, lunches served and sampled.

	Total Students		Lunches Served		Lunches Sampled
	N	% Free/Reduced	N	% Free/Reduced	%
<i>Pre-implementation of the new school meal standards</i>					
School A	666	96	598	98	51
School B	585	69	487	79	82
School C	519	33	309	45	81
<i>Post-implementation of the new school meal standards</i>					
School A	677	99	609	99	36
School B	601	74	437	84	65
School C	516	31	302	45	61

Table 2. Popularity of main entrées measured as mean number of students who selected various entrées.

	Mean \pm Std.	
	Pre-Implementation	Post-Implementation
Chicken Nuggets	60.2 \pm 9.4	57.2 \pm 6.5
Steak Fingers	40.7 \pm 14.2	21.3 \pm 4.3
Hamburger or Cheeseburger	40.0 \pm 18.9	32.0 \pm 20.2
Popcorn Chicken	---	37.1 \pm 10.1
Pancakes and Omelets	36.8 \pm 2.1	---
Ham and Cheese Hot Pocket	35.9 \pm 9.9	---
Cheese or Sausage Pizza	---	34.2 \pm 15.9
Pepperoni Hot Pocket	33.3 \pm 7.4	---
Beef & Bean Burrito	---	32.0 \pm 15.8
Cheese or Stuffed Crust Pizza	30.8 \pm 11.2	---
Hot Dog on a Bun	25.3 \pm 7.4	10.0 \pm 4.5
Chicken Tender Snack Wrap	---	23.0 \pm 4.5
Cheese or Pepperoni Pizza	---	20.3 \pm 11.3
BBQ on a Bun	16.9 \pm 13.4	10.5 \pm 3.5
Baked Chicken on Bone	---	16.2 \pm 6.4
Grilled Chicken Sandwich	16.0 \pm 5.8	13.0 \pm 4.7
Deli Wrap	---	16.0 \pm 4.8
Hamburger	14.3 \pm 6.8	---
Breaded Chicken Sandwich	14.0 \pm 7.1	14.6 \pm 9.3
Toasted Ham and Cheese Sandwich	13.5 \pm 3.3	---
Corn Dog on a Stick	12.0 \pm 2.8	41.8 \pm 14.6
Chicken Spaghetti	---	10.8 \pm 3.4
Munchables	10.0 \pm 5.7	---
Deli Sandwich	---	8.3 \pm 3.0
Chicken Fried Steak Sandwich	---	8.1 \pm 3.9
Mini Chef Salad	---	6.5 \pm 2.1
Mini Sub Sandwich	---	6.1 \pm 4.4
Chef Boyardee Ravioli	5.7 \pm 2.6	7.8 \pm 4.1
Deli Sliders	4.6 \pm 1.9	---
Cheese Stuffed Bread Stick	---	4.6 \pm 2.1
Italian Spaghetti & Meat Sauce	---	4.5 \pm 3.4
Cheesy Baked Potato	---	4.1 \pm 1.6
Sunbutter Sandwich	---	3.3 \pm 1.9

Values are means \pm standard deviations.

Table 3. Popularity of vegetables measured as mean number of students who selected various vegetables.

	Mean \pm Std.	
	Pre-Implementation	Post-Implementation
Mashed Potatoes w gravy	43.1 \pm 15.2	29.7 \pm 21.1
French Fries	33.1 \pm 19.1	24.1 \pm 12.1
Tater Tots	24.4 \pm 13.2	35.4 \pm 18.0
Corn on the Cob	23.2 \pm 15.5	31.3 \pm 13.4
Whole Kernel Corn	---	18.4 \pm 15.7
Sweet Potato Fries	---	16.3 \pm 10.4
Pork & Beans	---	14.4 \pm 8.8
Potato Wedges	14.4 \pm 6.0	31.5 \pm 22.0
Steamed Broccoli w/cheese Sauce	---	14.1 \pm 6.7
Green Peas	13.3 \pm 9.2	4.9 \pm 3.1
Green Beans	13.3 \pm 8.0	15.0 \pm 10.5
Ranch Style Beans	13.2 \pm 10.5	6.5 \pm 3.8
Mixed Normandy Vegetables	---	11.8 \pm 6.6
Baked Beans	---	10.0 \pm 5.9
Whole dill pickle	10.0 \pm 5.7	8.2 \pm 5.4
Veggie Dippers	7.1 \pm 5.1	6.8 \pm 5.3
Raw Baby Carrots and Celery	---	6.1 \pm 2.8
Sonoma Vegetables	---	6.0 \pm 3.4
Garden Salad w/ranch on the side	---	4.8 \pm 2.4
Broccoli florets	---	3.8 \pm 1.6
Raw Sweet Potato Sticks	---	3.5 \pm 1.4
Steamed Broccoli	3.7 \pm 2.2	3.5 \pm 1.3

Values are means \pm standard deviations.

Figure 1 illustrates the relationship between plate waste of burgers and vegetables. As shown, burgers were a popular entrée pre- and post-implementation. Greater plate waste from burgers was observed when this popular entrée was paired with a popular vegetable like tater tots or oven-baked French fried potatoes—each having relatively low plate waste. In contrast, the burger was wasted less when paired with a less popular vegetable like sweet potato fries. The relationship between green beans and entrée plate is reported in **Figure 2**. Green beans were wasted the most when paired with chicken nuggets—the most popular and least wasted entrée, pre- and post-implementation. However, when green beans were paired with steak fingers—a less popular entrée—plate waste of the vegetable was reduced.

Total plate waste for all entrée and vegetable pairings in our sample pre- and post- implementation of new school meal standards, respectively, are provided in **Table 4** and **Table 5**.

Overall, the pairing of deli sliders with corn on the cob resulted in the highest combined plate waste (62.5%), and the pairing of corn dog on a stick with tater tots resulted in the lowest combined plate waste (21%) (**Table 4**). Plate waste for entrées was the lowest for chicken nuggets (7.6%) paired with green beans and highest for deli sliders (44.3%) served with corn on the cob. Serving deli sliders as a main entrée and corn on the cob as a

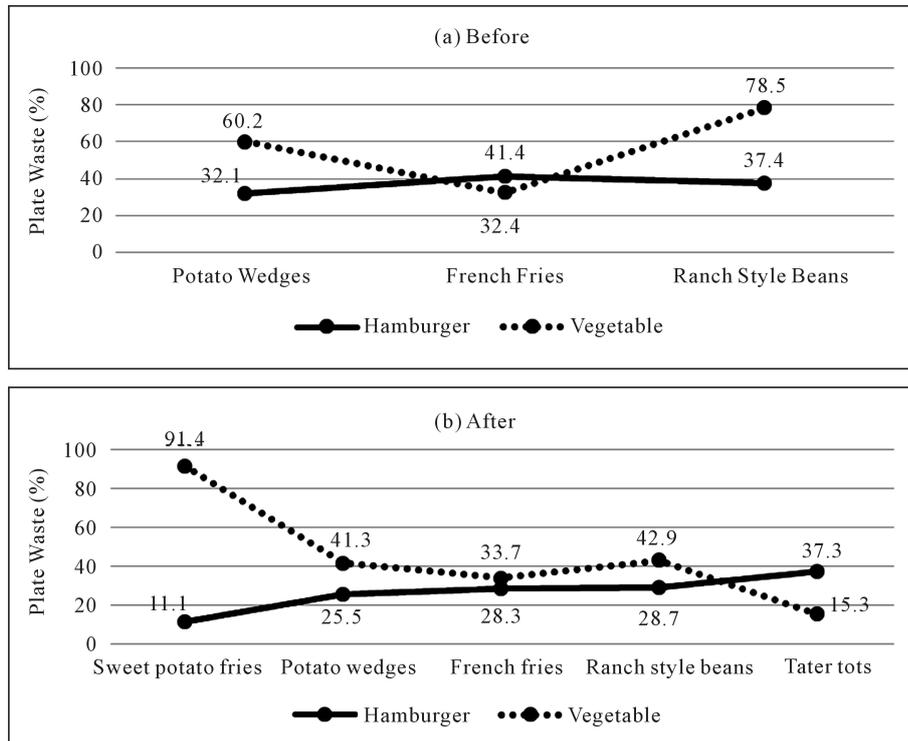


Figure 1. Relationship between hamburgers and vegetable plate waste (a) Pre-implementation of the new school meal standards; (b) Post-implementation of the new school meal standards.

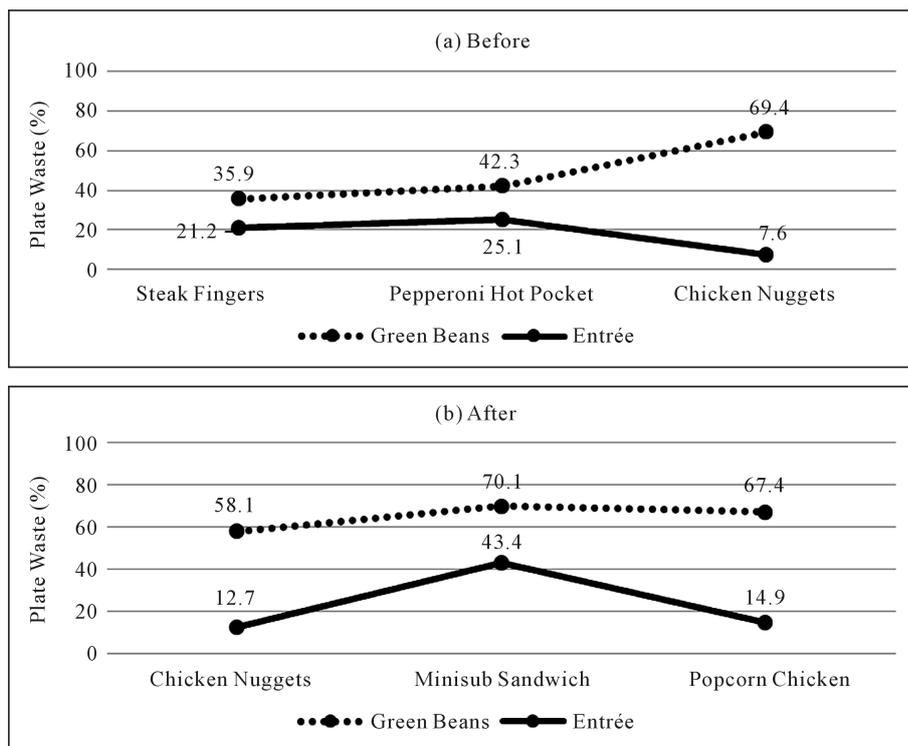


Figure 2. Relationship between green beans and entrée plate waste (a) Pre-implementation of the new school meal standards; (b) Post-implementation of the new school meal standards.

Table 4. Vegetable and entrée pairings percent plate waste, pre-implementation of the new school meal standards.

Vegetables	Main Entrées	n	Vegetable % Wasted \pm Std.	Entrée % Wasted \pm Std.	Total % Wasted \pm Std.
Tater Tots	Corn Dog on a Stick	6	24 \pm 18.3	17.9 \pm 8.8	21 \pm 13.5
French Fries	Hot Dog on a Bun	6	38.9 \pm 18.2	15.9 \pm 9.1	27.4 \pm 11.2
Green Beans	Steak Fingers	6	35.9 \pm 17.7	21.1 \pm 5.5	28.5 \pm 10.8
Tater Tots	Pancakes and Omelets	6	30.7 \pm 11.2	27.2 \pm 3.9	28.9 \pm 7.5
Mashed Potatoes w Gravy	Chicken Nuggets	5	49 \pm 16.2	9.2 \pm 5.9	29.1 \pm 10.8
Veggie Dippers	Chef Boyardee Ravioli	4	51.9 \pm 19.8	13.1 \pm 8.3	32.5 \pm 13.9
Green Beans	Pepperoni Hot Pocket	6	42.3 \pm 19.8	25.1 \pm 9.9	33.7 \pm 11.1
Mashed Potatoes w Gravy	Steak Fingers	6	48.4 \pm 9.3	21.1 \pm 5.5	34.8 \pm 6.7
French Fries	Hamburger or Cheeseburger	12	32.4 \pm 16.5	41.4 \pm 14.5	36.9 \pm 14.7
Green Beans	Chicken Nuggets	4	69.4 \pm 14.7	7.6 \pm 5.3	38.5 \pm 9.1
Steamed Broccoli	BBQ on a Bun	4	35.8 \pm 35.6	42.3 \pm 26.4	39 \pm 28.0
Mashed Potatoes w Gravy	Pepperoni Hot Pocket	6	56.5 \pm 10	25.1 \pm 9.9	40.8 \pm 8.6
French Fries	Toasted ham and Cheese Sandwich	4	42.4 \pm 22.1	42 \pm 7.2	42.2 \pm 13.7
Ranch Style Beans	Breaded Chicken Sandwich	2	58.5 \pm 0.4	26.4 \pm 5.8	42.5 \pm 2.7
Potato Wedges	Grilled Chicken Sandwich	5	49.4 \pm 20.2	36.7 \pm 15.8	43.1 \pm 13.6
Veggie Dippers	Deli Sliders	5	44 \pm 32.8	43 \pm 7	43.5 \pm 15.4
Whole Dill Pickle	Munchables	5	61.2 \pm 27.3	26.1 \pm 23	43.6 \pm 19.5
Steamed Broccoli	Ham and Cheese Hot Pocket	3	55.9 \pm 14.1	32.4 \pm 20.3	44.2 \pm 10.3
Veggie Dippers	Cheese or Stuffed Crust Pizza	11	64.1 \pm 18.1	25.7 \pm 8.3	44.9 \pm 6.8
Corn on the Cob	Ham and Cheese Hot Pocket	6	63.2 \pm 8.5	27.7 \pm 15.1	45.4 \pm 10.8
Potato Wedges	Hamburger	6	60.2 \pm 18	32.1 \pm 9.1	46.2 \pm 11.0
Green Peas	Chef Boyardee Ravioli	6	59 \pm 26.4	42.3 \pm 25.8	50.6 \pm 25.9
Corn on the Cob	BBQ on a Bun	6	63 \pm 12.8	39.1 \pm 21.8	51 \pm 15.0
Green Peas	Cheese or Stuffed Crust Pizza	3	78.1 \pm 6.5	28.8 \pm 14.3	53.4 \pm 7.6
Corn on the Cob	Cheese or Stuffed Crust Pizza	5	81.3 \pm 6	27.1 \pm 11.6	54.2 \pm 7.7
Ranch Style Beans	Hamburger or Cheeseburger	3	78.5 \pm 6.4	37.4 \pm 10.9	57.9 \pm 8.6
Corn on the Cob	Deli Sliders	3	80.8 \pm 5.4	44.3 \pm 6.6	62.6 \pm 4.5
All	All	144	52.12 \pm 22.5	28.6 \pm 15.3	40.4 \pm 14.7

^aValues are mean % \pm standard deviation; ^bRanked from smallest to largest total percent wasted; ^cHere *n* in the number of observations for each entrée/vegetable pairing.

Table 5. Vegetable and entrée pairings percent plate waste, post-implementation of the new school meal standards.

Vegetables	Main entrées	n	Vegetable % wasted \pm Std.	Entrée % wasted \pm Std.	Total % wasted \pm Std.
Tater Tots	Hamburger or Cheeseburger	6	15.3 \pm 9.8	37.3 \pm 11.3	26.3 \pm 10.2
Tater Tots	Beef & Bean Burrito	6	18.4 \pm 11.5	36.1 \pm 27.2	27.3 \pm 19.3
Mashed Potatoes w Gravy	Chicken Nuggets	6	44.3 \pm 6.3	12.7 \pm 7.1	28.5 \pm 6.4
Broccoli Florets	Hot Dog on a Bun	7	44.7 \pm 25.9	12.6 \pm 8.9	28.6 \pm 13.9
French Fries	Hamburger or Cheeseburger	6	33.7 \pm 15.3	28.3 \pm 7.9	31 \pm 9.1
Potato Wedges	Hamburger or Cheeseburger	6	41.3 \pm 19.7	25.5 \pm 3.6	33.4 \pm 9.9
Garden Salad w/Ranch	Italian Spaghetti & Meat Sauce	4	38.7 \pm 25.9	28.1 \pm 29	33.4 \pm 26.3
Mashed Potatoes w Gravy	Popcorn Chicken	11	54.5 \pm 15.9	13.6 \pm 7.8	34 \pm 11.6
Garden Salad w/Ranch	Cheese Stuffed Bread Stick	5	51.3 \pm 15.9	17 \pm 20.1	34.1 \pm 12.5
Ranch Style Beans	Breaded Chicken Sandwich	5	47.4 \pm 11.2	21.6 \pm 11.5	34.5 \pm 3.5
Garden Salad w/Ranch	Chef Boyardee Ravioli	5	61.7 \pm 14.5	7.6 \pm 3.3	34.7 \pm 5.7
Green Beans	Chicken Nuggets	6	58.1 \pm 9	12.7 \pm 7.1	35.4 \pm 4.5
Steamed Broccoli	Corn Dog on a Stick	3	56.5 \pm 20.3	14.6 \pm 1.3	35.6 \pm 10.8
Ranch Style Beans	Hamburger or Cheeseburger	6	42.9 \pm 26.3	28.7 \pm 18.7	35.8 \pm 16.9
Whole Dill Pickle	Deli Wrap	3	43 \pm 6.6	29.7 \pm 12.6	36.3 \pm 8.3
Steamed Broccoli W/Cheese	Steak Fingers	6	56 \pm 18.4	20.8 \pm 10.6	38.4 \pm 12.7
Whole Dill Pickle	Mini sub Sandwich	9	43.2 \pm 26.9	35.6 \pm 12	39.4 \pm 14.4
Raw Baby Carrots and Celery	Steak Fingers	5	60.4 \pm 11.3	20 \pm 11.6	40.2 \pm 6.6
Broccoli Florets	Sea Shaped Fish Sticks	9	63.3 \pm 16.2	18.6 \pm 13.1	40.9 \pm 10.8
Green Beans	Popcorn Chicken	12	67.4 \pm 17.8	14.9 \pm 8.7	41.1 \pm 12.2
Corn on the Cob	Corn Dog on a Stick	6	71 \pm 5.7	14 \pm 2.6	42.5 \pm 2.1
Pork & Beans	Chicken Fried Steak Sandwich	6	46.6 \pm 18.2	38.4 \pm 21.1	42.5 \pm 18.0
Veggie Dippers	Cheese or Pepperoni Pizza	18	58.4 \pm 14.2	26.7 \pm 8	42.5 \pm 8.3
Whole Kernel Corn	Mini Chef Salad	5	67.2 \pm 33.4	18 \pm 24.1	42.6 \pm 5.9
Garden Salad w/Ranch	Chicken Spaghetti	3	52.4 \pm 19.5	32.8 \pm 10.2	42.6 \pm 14.8
Pork & Beans	Breaded Chicken Sandwich	6	51.1 \pm 9	34.9 \pm 11.4	43 \pm 7.6
Mixed Normandy Vegetables	Hot Dog on a Bun	6	71.5 \pm 17.6	14.9 \pm 10	43.2 \pm 11.1
Veggie Dippers	Mini Chef Salad	5	70.7 \pm 14.9	18.2 \pm 24	44.4 \pm 14.1
Veggie Dippers	Cheese or Sausage Pizza	5	66.8 \pm 10.9	22.7 \pm 9.9	44.8 \pm 6.2

Continued

Sonoma Vegetables	Chef Boyardee Ravioli	5	82.7 ± 10.2	7.6 ± 3.3	45.2 ± 5.6
Potato Wedges	Grilled Chicken Sandwich	6	49.2 ± 18.9	41.9 ± 9.1	45.6 ± 12.5
Whole Dill Pickle	Deli Sandwich	6	45.4 ± 18.6	46.4 ± 16.9	45.9 ± 16.5
French Fries	Pizza Sandwich	5	49.8 ± 14.2	42.1 ± 14.2	46 ± 11.7
Mashed Potatoes w Gravy	Mini Sub Sandwich	5	55.7 ± 24.9	39.2 ± 28.5	47.5 ± 26.4
Whole Kernel Corn	Cheese or Sausage Pizza	6	69.4 ± 11.6	26.4 ± 12.6	47.9 ± 11.4
Mixed Normandy Vegetables	Sea Shaped Fish Sticks	10	75.3 ± 10.9	20.6 ± 12.9	48 ± 8.8
Steamed Broccoli	Chicken Tender Snack Wrap	1	67.7 ± 0	28.8 ± 0	48.2 ± 0.0
Raw Baby Carrots and Celery	Deli Wrap	3	62.6 ± 11	34.3 ± 19.7	48.4 ± 5.5
Green Peas	Cheese or Pepperoni Pizza	9	71.5 ± 19.3	26.1 ± 10.7	48.8 ± 10.0
Veggie Dippers	Sunbutter Sandwich	3	43 ± 8.9	55.6 ± 26	49.3 ± 14.1
Corn on the Cob	Chicken Tender Snack Wrap	6	70.9 ± 12.7	28.2 ± 10.8	49.6 ± 11.0
Veggie Dippers	Chef Boyardee Ravioli	3	73.9 ± 13.6	26 ± 21.6	49.9 ± 6.2
Sonoma Vegetables	Chicken Spaghetti	2	65.6 ± 31.5	35.8 ± 12.5	50.7 ± 22.0
Whole Kernel Corn	Cheese or Pepperoni Pizza	6	74.8 ± 14	27.2 ± 5.3	51 ± 5.9
Sweet Potato Fries	Hamburger or Cheeseburger	1	91.4 ± 0	11.1 ± 0	51.2 ± 0.0
Raw Sweet Potato Sticks	Chicken Fried Steak Sandwich	4	66.1 ± 20.2	42.4 ± 17.5	54.2 ± 16.8
Mashed Potatoes w Gravy	Deli Sandwich	6	63.9 ± 17.7	46.4 ± 16.9	55.1 ± 14.6
Baked Beans	Chicken Fried Steak Sandwich	6	63.4 ± 13.4	47.1 ± 17.1	55.3 ± 6.1
Green Beans	Mini sub Sandwich	4	70.1 ± 17.7	43.4 ± 31.1	56.7 ± 13.3
Sweet Potato Fries	BBQ on a Bun	2	88.2 ± 5.1	32.4 ± 12.5	60.3 ± 8.8
Veggie Dippers	Cheesy Baked Potato	4	59.8 ± 24.1	63.6 ± 24	61.7 ± 24.0
Whole Kernel Corn	Cheesy Baked Potato	4	72.7 ± 23.2	54.4 ± 16	63.5 ± 12.1
Steamed Broccoli w/cheese	Deli Wrap	1	86.8 ± 0	42.3 ± 0	64.5 ± 0.0
Raw Sweet Potato Sticks	Baked Chicken on Bone	4	47.7 ± 23.3	85.7 ± 5.7	66.7 ± 14.3
Baked Beans	Baked Chicken on Bone	6	69.8 ± 16.2	84.5 ± 4.9	77.1 ± 8.8
Green Peas	Sunbutter Sandwich	1	89.1 ± 0	69.3 ± 0	79.2 ± 0.0
All	All	305	57.7 ± 21.2	29.3 ± 20.5	43.5 ± 14.9

^aValues are mean % ± standard deviations; ^bRanked from smallest to largest total percent wasted; ^cHere *n* in the number of observations for each entrée/vegetable pairing.

vegetable side dish resulted in a notable amount of plate waste for both entrée (44.3%) and vegetable (80.8%). Although chicken nuggets had the lowest percent plate waste when served with green beans, the percentage plate waste for green beans was among the highest (69%) and was higher than the plate waste for chicken nuggets and mashed potatoes and gravy.

Four out of five pairings that had the lowest overall plate waste involved white potato products. Entrées and vegetables pairings with the least overall plate waste involved the most popular entrées and the most popular vegetables for elementary school students.

Five most wasted pairings of entrée and vegetables were corn on the cob (80.8%) served with deli sliders (44.3%), hamburger or cheeseburger (37.4) with ranch style beans (78.5%), pizza (27.1%) with corn on the cob (81.3%), pizza (28.8%) with green peas (78.1%) and barbeque on a bun (39.1%) with corn on the cob (63.0%).

Similar to our findings for the pre-implementation period of nutrition standards, four out of five entrée and vegetable pairings that had the lowest overall plate waste involved potato products (tater tots, mashed potato with gravy, French fries) as side dishes for the period post-implementation of the new school meal standards (**Table 5**). Broccoli florets served with a hot dog on a bun were among the five least wasted entrée and vegetable pairings.

Post-implementation of the new standards, the mean combined percent plate waste for entrée and vegetable pairings increased slightly from 40.4% to 43.5% but this increase was not statistically significant (**Table 4** and **Table 5**). Mean percent plate waste for vegetables, both pre- and post-implementation of the new school meal standards, were over 50% (52.1% for pre-implementation and 57.7% for post-implementation). Entrées were wasted less compared to vegetables. Mean entrée plate waste increased by less than 1% post- compared to pre-implementation (28.6% for pre- and 29.3% for post-implementation).

3.4. Energy and Nutrients Available and Consumed from School Meals

The results reported in **Table 4** and **Table 5** raise a set of questions regarding the energy and nutrients intake from the most and the least wasted entrées and vegetables and their pairings. The nutrient profile for every entrée and vegetable sampled was provided by school district. The mean energy and nutrients intakes per student from entrée and vegetable pairing were calculated using total energy and nutrients provided per serving and the percentage of plate waste. **Table 6** and **Table 7** report mean energy and nutrients (dietary fiber, sodium, iron, vitamin A, vitamin C, calcium, protein, fat, and saturated fat) intake per student and mean energy and nutrients available to students from entrée/vegetable pairings from school meals for the ten most and least wasted entrée and vegetable pairings, pre- and post-implementation of the new standards, respectively². For the ten most wasted pairings, the mean combined waste from entrée/vegetable pairings was 51% pre-implementation and 60% post-implementation versus for the ten least wasted pairings, the mean combined waste from entrée/vegetable pairings was 31% both pre-implementation and post-implementation of the new school meal standards.

With respect to the ten least wasted pairings, more calories were offered post-implementation (377 kcal/student) compared to pre-implementation (247 kcal/student) and consequently more calories were consumed post- (260 kcal/student) compared to pre-implementation (240 kcal/student). Less sodium was offered post- (800 mg/student) compared to pre-implementation (889 mg/student). No notable differences in the amount of saturated fat offered were observed between pre- and post-implementation. In general, more dietary fiber, iron, vitamin A and C, calcium and protein were available to students from entrée/vegetable pairings served post-implementation compared to pre-implementation of the new school meal standards. Specifically, more dietary fiber were available to students during the post- compared to pre-implementation (5 g/student versus 3.2 g/student) and noticeably more vitamin C was available to students from food pairings post- compared to pre-implementation (16.5 mg/student versus 7.3 mg/student).

Similar patterns of nutrients available to students from the entrée/vegetable pairings were observed for the ten most wasted food pairings. Noticeable increases in the amounts of vitamin A and C as well as calcium available to students were observed for the post- compared to pre-implementation period.

After the changes in school meal standards, the minimum and maximum energy required for lunch for kindergarten through fifth grade are between 550 - 650 kcal. For our sample of the ten least and most wasted pairings, mean energy available from entrée/vegetable pairings was 365 kcal/student pre-implementation and 382

²In this paper, we reported only the results for the ten most and least wasted entrée/vegetables pairing due to space limitations. A full summary of results is available from the authors upon request.

Table 6. Mean intakes of energy and nutrients mean energy and nutrients available from combined entrée/vegetable pairings, per student, pre-implementation of the new school meal standards.

	Calories (kcal)	Dietary Fiber (g)	Sodium (mg)	Iron (mg)	Vitamin A (RE)	Vitamin C (mg)	Calcium (mg)	Protein (g)	Fat (g)	Sat fat (g)
<i>Most wasted 10 pairings</i>										
Corn on the Cob (Deli Sliders)	116.5 ^a /311.3 ^b	1.1/3.0	427.7/1142.3	1.0/2.7	13.1/35	1.6/4.4	81.7/218.3	8.2/21.9	3.7/9.9	1.1/3.1
Ranch Style Beans (Hamburger or Cheeseburger)	164.3/390.7	4.2/10.0	467.6/1111.7	2.0/4.7	39.3/93.4	0.0/0.0	92.2/219.2	10.5/25.1	5.3/12.7	2.0/4.7
Corn on the Cob (Cheese or Stuffed Crust Pizza)	168.7/368.3	2.4/5.3	401.8/877.2	1.9/4.1	45.8/100	1.6/3.6	114.5/250	8.4/18.3	5.8/12.6	1.8/4.0
Green Peas (Cheese or Stuffed Crust Pizza)	181.3/389.4	4.0/8.5	428.8/921.1	1.9/4.2	76.4/164.1	4.4/9.5	127.1/273	10.0/21.4	6.2/13.2	1.9/4.2
Corn on the Cob (BBQ on a Bun)	166.1/339.0	2.6/5.3	411.1/839.4	1.8/3.7	19.0/38.9	2.1/4.4	61.7/125.9	8.7/17.7	3.9/8.0	1.4/2.9
Green Peas (Chef Boyardee Ravioli)	160.3/324.6	5.1/10.3	374.6/758.9	2.1/4.2	51.4/104.1	4.7/9.5	21.2/43.0	10.3/20.9	4.1/8.3	1.8/3.5
Potato Wedges (Hamburger)	199.2/370.0	2.2/4.0	277.3/515.0	1.9/3.6	8.4/15.6	2.6/4.8	75.4/140.0	9.7/18.0	7.8/14.5	2.7/5.0
Corn on the Cob (Ham and Cheese Hot Pocket)	286.1/524.3	1.3/2.4	776.4/1422.9	2.0/3.6	34.8/63.8	3.8/6.9	141.4/259.1	13.5/24.7	8.3/15.2	2.9/5.3
Veggie Dippers (Cheese or Stuffed Crust Pizza)	181.5/329.5	2.6/4.7	491.6/892.7	1.8/3.2	351.5/638.2	1.1/2	149.7/271.8	9.3/16.9	7.1/12.9	2.3/4.1
Steamed Broccoli (Ham and Cheese Hot Pocket)	274.3/491.3	1.8/3.3	783.1/1402.5	1.7/3.1	137.3/245.9	23.4/41.9	162.4/290.9	14.3/25.7	8.6/15.3	3.0/5.3
Overall Mean	189.8/491.3	2.7/5.7	484.0/988.4	1.8/3.7	77.7/149.9	4.5/8.7	102.7/209.1	10.3/21.1	6.1/12.3	2.1/4.2
<i>Least wasted 10 pairings</i>										
Green Beans (Chicken Nuggets)	149.4/242.9	0.8/1.3	596.9/970.8	1.3/2.0	19.8/32.2	0.4/0.6	30.4/49.4	10.8/17.6	8.0/13.0	1.5/2.5
French Fries (Hamburger or Cheeseburger)	238.4/378.0	2.8/4.4	495.1/785.1	1.9/3.0	24.0/38.1	1.8/2.8	155.7/246.8	12.8/20.3	10.0/15.8	3.8/6.0
Mashed Potatoes w gravy (Steak Fingers)	249.1/381.9	1.3/2.0	517.3/793.0	2.3/3.5	20.2/31	20/30.7	86.9/133.2	10.8/16.6	13.3/20.4	3.3/5.0
Green Beans (Pepperoni Hot Pocket)	227.4/342.9	4.2/6.3	703.3/1060.8	2.2/3.3	61.2/92.2	0.6/0.9	185.2/279.4	9.7/14.6	7.3/11.0	2.7/4.0
Veggie Dippers (Chef Boyardee Ravioli)	181.0/268.2	4.3/6.4	494.7/733.0	2.1/3.1	390.3/578.2	1.4/2.0	28.2/41.8	11.1/16.5	5.5/8.1	2.4/3.5
Mashed Potatoes w gravy (Chicken Nuggets)	228.2/321.9	0.7/1.0	555.0/783.0	1.6/2.2	7.9/11.2	21.8/30.7	80.2/113.2	13.2/18.6	10.9/15.4	2.1/3.0
Tater Tots (Pancakes and omelets)	339.8/478.1	2.2/3.1	587.6/826.7	1.8/2.6	56.9/80.0	0.7/1.0	88.4/124.4	9.8/13.7	13.8/19.4	3.9/5.5
Green Beans (Steak Fingers)	216.6/302.9	1.6/2.3	701.3/980.8	2.4/3.3	37.2/52.0	0.5/0.6	49.6/69.4	11.2/15.6	12.9/18.0	3.2/4.5
French Fries (Hot Dog on a Bun)	248.0/341.8	1.8/2.4	666.6/918.7	1.6/2.2	0.0/0.0	2.0/2.8	124.6/171.7	9.2/12.6	12.5/17.3	3.3/4.6
Tater Tots (Corn Dog on a Stick)	330.3/417.9	2.2/2.7	818.7/1035.8	2.6/3.3	0.0/0.0	0.8/1.0	77.0/97.4	9.3/11.7	17.9/22.7	4.9/6.2
Overall Mean	240.8/347.7	2.2/3.2	613.7/888.8	2.0/2.9	61.8/91.5	5.0/7.3	90.6/132.7	10.8/15.8	11.2/16.1	3.1/4.5

^aMean energy or nutrient intake from the combined entrée and vegetable pairing; ^bMean energy or nutrient available from the combined entrée and vegetable pairing.

Table 7. Mean intakes of energy and nutrients and mean energy and nutrients available from combined entrée/vegetable pairings, per student, post-implementation of the new school meal standards.

	Calories (kcal)	Dietary Fiber(g)	Sodium (mg)	Iron (mg)	Vitamin A (RE)	Vitamin C (mg)	Calcium (mg)	Protein (g)	Fat (g)	Satfat (g)
<i>Most wasted 10 pairings</i>										
Green Peas (Sunbutter Sandwich)	77.8 ^a /374.1 ^b	2.8/13.3	87.0/418.6	0.8/3.6	13.3/64.1	2.0/9.5	25.5/122.9	4.1/19.9	3.8/18.2	0.4/2.0
Steamed Broccoli w/cheese Sauce (Deli Wrap)	138.5/390.3	1.6/4.5	630.7/1777.3	0.8/2.2	255.8/720.9	15.2/42.9	183.9/518.2	7.9/22.4	6.6/18.7	2.1/5.8
Whole Kernel Corn (Cheesy Baked Potato)	128.7/352.8	2.6/7.1	177.2/485.6	0.8/2.2	39.9/109.5	17.8/48.7	121.9/334.1	6.4/17.5	2.5/6.8	1.4/3.9
Veggie Dippers (Cheesy Baked Potato)	116.3/303.5	2.5/6.5	202.2/527.7	0.8/2.2	241.1/629.3	18.3/47.8	135.4/353.4	6.1/15.8	2.4/6.4	1.5/3.9
Sweet Potato Fries (BBQ on a Bun)	182.4/459.0	2.5/6.3	368.8/928.4	1.2/3.0	0.0/0.0	1.7/4.4	58.0/145.9	7.0/17.7	6.3/16.0	1.4/3.4
Green Beans (Mini sub Sandwich)	114.3/264.2	1.0/2.3	693.0/1602.0	1.0/2.2	29.1/67.2	0.6/1.4	107.2/247.7	8.9/20.5	4.3/9.9	1.3/3.1
Baked Beans (Chicken Fried Steak Sandwich)	246.4/550.9	4.3/9.6	770/1721.2	2.0/4.6	17.8/39.8	0.7/1.5	70.6/157.8	12.9/28.7	7.7/17.2	2.3/5.0
Mashed Potatoes w gravy (Deli Sandwich)	95.1/211.9	1.3/3.0	225.7/503.0	0.8/1.9	5.0/11.2	13.8/30.7	46.3/103.2	2.5/5.6	1.8/3.9	0.5/1.0
Raw Sweet Potato Sticks (Chicken Fried Steak Sandwich)	230.4/503.5	3.6/8.0	527.4/1152.6	2.3/4.9	1220.3/2667	2.0/4.4	82.2/179.6	11/24.1	7.1/15.6	2.1/4.5
Sweet Potato Fries (Hamburger or Cheeseburger)	227.0/465.4	2.9/6.0	378.9/776.9	1.6/3.2	0.0/0.0	1.8/3.6	117.6/241.3	10.5/21.5	10.0/20.5	2.8/5.8
Overall Mean	155.7/387.6	2.5/6.7	406.1/989.3	1.2/3.0	182.2/430.9	7.4/19.5	94.9/240.4	7.7/19.4	5.3/13.3	1.6/3.8
<i>Least wasted 10 pairings</i>										
Ranch Style Beans (Breaded Chicken Sandwich)	294.7/450.0	6.5/10.0	818.7/1250	3.1/4.7	39.3/60.0	0.0/0.0	117.9/180.0	15.7/24	10.8/16.5	2.0/3.0
Garden Salad w/ranch (Cheese Stuffed Bread Stick)	233.1/353.9	3.1/4.6	649.2/985.6	1.7/2.7	146.8/222.8	3.8/5.8	245.3/372.4	10.0/15.2	10.4/15.7	3.0/4.6
Mashed Potatoes w gravy (Popcorn Chicken)	251.0/380.5	1.5/2.3	398.5/604.1	1.7/2.6	23.9/36.3	20.3/30.7	78.0/118.3	11.0/16.7	13.2/20.0	2.4/3.7
Potato Wedges (Hamburger or Cheeseburger)	270.0/405.4	2.7/4.0	447.5/671.9	2.4/3.6	30.6/46.0	3.2/4.8	160.7/241.3	14.3/21.5	11.0/16.5	4.2/6.3
Garden Salad w/ranch (Italian Spaghetti & Meat Sauce)	275.8/413.9	5.5/8.3	369.6/554.7	2.9/4.3	242/363.1	13.5/20.3	149.0/223.6	16.4/24.6	9.5/14.2	2.9/4.4
French Fries (Hamburger or Cheeseburger)	267.2/387.2	3.0/4.4	569.7/825.7	2.0/3.0	31.7/46.0	1.9/2.8	188.4/273.0	14.6/21.2	11.2/16.3	4.4/6.4
Broccoli florets (Hot Dog on a Bun)	189.5/265.5	2.1/3.0	552.9/774.7	1.9/2.7	82.4/115.5	47.7/66.9	110.8/155.2	9.4/13.1	9.8/13.8	2.5/3.5
Mashed Potatoes w gravy (Chicken Nuggets)	230.2/321.9	0.7/1.0	559.8/783.0	1.6/2.2	8.0/11.2	22/30.7	80.9/113.2	13.3/18.6	11.0/15.4	2.2/3.0
Tater Tots (Beef & Bean Burrito)	262.5/360.9	5.5/7.6	438.9/603.5	2.4/3.4	1.5/2.1	1.6/2.1	51.9/71.3	10.0/13.7	10.8/14.9	2.8/3.9
Tater Tots (Hamburger or Cheeseburger)	319.3/433.3	3.5/4.7	702.1/952.7	2.6/3.5	33.9/46.0	0.8/1.0	175.9/238.7	15.7/21.3	15.6/21.2	5.5/7.4
Overall Mean	259.3/377.3	3.4/5.0	550.7/800.6	2.2/3.3	64.0/94.9	11.5/16.5	135.9/198.7	13.0/19.0	11.3/16.5	3.2/4.6

^aMean energy or nutrient intake from the combined entrée and vegetable pairing; ^bMean energy or nutrient available from the combined entrée and vegetable pairing.

kcal/student post-implementation. The target requirement for sodium for lunch is ≤ 1230 mg that started in SY 2014-2015. For our sample, the mean sodium available from entrée/vegetable pairings from school meals were 938 mg/student pre- and 895 mg/student post-implementation. The new standards require that saturated fat should be less than 10% total calories. Saturated fat available to students from entrée/vegetable pairings in our sample was less than 1% of total calories available to students in both the pre- and post-implementation periods of the new school meal standards.

4. Discussion

Existing behavioral and experimental studies that looked at the relationship between main dish and side dishes found that about 50% of the variability in overall meal acceptance ratings could be explained by liking/disliking of the main entrée, 16% and 12% could be explained by starches and the vegetables, respectively, and 7% by the salad [17]. The same entrée presented with different side dishes can get different liking ratings compared to rating only the entrée by itself [18]. Jimenez *et al.* found that when the main entrée was served with well-liked side dishes, the main entrée was liked less. In contrast, if side dishes are disliked by individuals, the main dish will receive higher liking scores [18]. Our findings from elementary school lunches, therefore, are consistent with those from previous behavioral and experimental studies. We observed that specific pairings of entrées and vegetables reduced total food waste. Pairings of more popular entrées with less popular vegetables resulted in higher vegetable waste. Specifically, chicken nuggets were wasted less when paired with green beans and wasted more when paired with mashed potatoes. Compared to pairing of green beans with chicken nuggets, green beans were wasted less when paired with steak fingers and pepperoni hot pockets. In general, pairing of popular entrées, such as chicken nuggets and burgers, with popular vegetables, such as potato products, resulted in lower combined plate waste.

In order to meet the new nutrition standards, schools in our sample offered more selection of vegetables and modified recipes post-implementation of the new standards, but the serving sizes did not change. Overall, our results indicated that more nutritious meals were offered during the post-implementation period compared to the pre-implementation period. The new school meal standards had no effect on the entrée plate waste and led to a small insignificant increase in the combined plate waste from entrée and vegetable pairings (40.4% pre- and 43.5% post-implementation). Modification of the recipes and possibly less familiarity with some of the vegetables offered may have contributed to the increased vegetable waste observed post-implementation. Further research is needed to understand this dynamic and if food pairings can reduce food waste and cost. Other strategies to reduce plate waste include adjusting portion sizes to child age and involving students in taste-testing of new food offerings.

Relatively few studies examined plate waste after the implementation of the new standards. Byker and *et al.* (2014) collected food waste data from one pre-kindergarten and five kindergarten classes from one elementary school for one full week in March 2013, after the new standards went into effect. They found that 45.3% of all food that was served was wasted with vegetables being wasted the most (51.4%) followed by the main entrée (51.0%). Cohen *et al.* (2014) measured plate waste from four schools (grades 3-8), with two data collection days per school, in an urban low-income district, in which roughly 85% of the students were eligible to receive free or reduced-price meals. The analysis was conducted using the data from before and after the implementation of new standards. They found that, although students' consumption of entrées and vegetables increased after the implementation of the new standards, roughly 24.9% of vegetables and 72.3% of entrées were consumed before the implementation of the new standards. About 41.1% of vegetables and 87.9% of entrées were consumed after the implementation. Schwartz *et al.* (2015) collected data from 12 middle schools (5th to 7th grade) located in an urban, low-income district with over 70% of students qualifying for free lunches and 13% qualifying for reduced-price lunches. They found that the percentage of vegetable servings consumed increased from 45% to 64% before versus after the changes in standards. The consumption of entrées also increased from 71% to 84% before versus after the changes in standards. Their study concluded that the revised NSLP nutrition standards and policies led to more nutritious meals and less overall plate waste.

This current study has several limitations. First, plate waste information was collected for main entrées and vegetables only. We did not collect data on fruit selection and waste of fruit, milk or grains. Consumption of these meal components could have affected plate waste of the entrées and vegetables. Second, the data for pre- and post-implementation of the new standards were collected at different times of the school year, spring seme-

ster for pre-implementation and fall semester for post-implementation. It is possible that participation in school meals and potential plate waste may have differed not only because of the changes in standards but also due to the time of the school year. Third, students' entrée and vegetable choices in our study were predetermined by menus designed by school food service administrators. Students had limited choices as to what vegetables were available with a particular entrée. In order to fully understand the actual effect of entrée/vegetable pairings on plate waste, each potential entrée would need to be paired with each potential vegetable and there would need to be sufficient power to detect significant differences. This situation would require greater control over the schools' menu than is possible in a natural setting. Even so, our observations suggest that school food service administrators may reduce plate waste from school meals as well as incur fewer wasted dollars for foodservice by optimizing entrée/vegetable pairings. On an average school day, school lunch participants consume more vegetables at school compared to nonparticipants [19]. As a result of serving tasty and nutritious meals, students may enjoy and waste less of their school meals, which is especially important for those students relying on school meals for most of their energy and nutrient needs.

5. Conclusion

Pairings of entrées and vegetables are an important consideration when assessing plate waste among elementary school children, and lost dollars to school food service. A relationship was noted between entrées and vegetables suggesting that greater consumption of certain entrées was associated with greater waste of certain vegetables. It was observed that popular entrées, such as burgers and chicken nuggets, contributed to greater waste of less popular vegetables, such as green beans and sweet potato fries. However, it was unclear if decreased popularity of a vegetable was a direct result of the vegetable itself, or of the child having "filled up" on a popular paired entrée, indirectly causing decreased consumption of the vegetable. Entrées paired with popular vegetables such as potatoes (served as tater tots, oven-baked French fries, and wedges) experienced the least amount of waste. In view of these findings, understanding entrée/vegetable pairings may assist schools in serving tasty yet nutritious meals while maintaining high program participation rates and staying within constrained operating budgets.

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