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Key Nutrient Selection and Consumption by Elementary Students in the National School Lunch Program

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KEY NUTRIENT SELECTION AND CONSUMPTION BY ELEMENTARY STUDENTS IN THE NATIONAL SCHOOL LUNCH PROGRAM

CAPSTONE PROJECT PAPER

A paper submitted in partial fulfillment of the
requirements for the degree of
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in the
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By
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INTRODUCTION

While the recent decline in the rate of obesity amongst preschool children in 19 states is encouraging,(1) the overall rate of obese children in the United States remains at 17%.(2) Obese children suffer physical, emotional, and psychological health consequences such as high blood pressure, high cholesterol, impaired glucose tolerance, breathing problems, fatty liver disease, poor self-esteem, and depression.(3) Furthermore, obese children are more likely to become obese adults with their health problems worsening with age.(3)

The National School Lunch Program (NSLP), which provided meals to over 30 million students in 2013,(4) was recently revised to improve school food environments to help address the childhood obesity epidemic and to improve the dietary quality of school-aged children. With the “Healthy, Hungry Free Kids Act of 2012,” the United States Department of Agriculture (USDA) updated standards for the NSLP based on recommendations from the Institute of Medicine (IOM), including more fresh fruits and vegetables, more whole grains, only nonfat and low fat milk, and stricter caloric and fat content limits.(5)

Findings on the effects of the policies that dictate what should be served to schoolchildren have been unequivocal. Compared to nonparticipants, school lunch participants have been found to more likely consume milk, fruit, and vegetables while less likely to consume desserts, snack items, and beverages other than milk or 100% juice.(6) It has also been found that the more stringently a school follows the nutrition standards established by the USDA, the more likely its students are to be an appropriate weight.(7) On the other hand, a study conducted in Louisiana examined food intake and plate waste to conclude that the majority of students exceeded the upper limits of energy and saturated fat recommendations.(8) There is further evidence that few children select and consume the recommended servings of vegetables.(9)

Existing research lacks a comparison between what children select and consume and the specific nutritional guidelines for school lunches using precise student consumption of all foods offered and selected, including beverages. Such a comparison is critical to fully understanding how nutritional

guidelines change the diets of individual students. The weakness inherent in most previous studies of school meal programs is that they rely on self-report data, even though accuracy of food recalls and food frequency questionnaires by children in grades ranging from one to twelve are questionable.(10) There are a growing number of exceptions using more precise techniques such as digital photography to estimate plate waste but not all food categories, most notably beverages, were evaluated in these studies.(8, 11) If a significant line of defense against childhood obesity is improving the nutritional quality of school lunches, monitoring accurate selection and intake by the target population is a key component.

This study will compare the means of key nutrients selected and consumed by students against both the standards set by the USDA prior to their strengthening by the “Healthy, Hungry Free Kids Act of 2012,” and the more stringent guidelines recommended by the IOM. To address the limitations of previous studies, this study uses the combined method of direct observation of selection and plate waste via digital photography, a method shown to be highly accurate and precise,(12) and before and after carton weights to measure beverage consumption. The research will first determine whether students are selecting the appropriate foods to meet nutritional standards and secondly whether students are consuming enough of the foods to fully benefit from these standards. This will address the effectiveness of nutritional standards for school meals, potentially highlighting needed changes to the school lunch program to ensure children are consuming appropriate nutrients to maintain a healthy weight.

METHODS

Study Setting

This cross-sectional, observational study uses data collected for other research projects in six elementary schools across four rural Kentucky counties over a period of two years. In five of the schools, data were collected on three non-consecutive days per school, while one school had only one day of observation, resulting in a total of sixteen-lunch periods of observations. Schools were chosen based on

their rural location and the invitation of the food service director to collect data in the cafeteria.

Participation rates in the NSLP were as high as 95% in two of the counties(13): The national participation rate in elementary schools was 70% in SY 2009- 2010.(14) The majority of the students in all the schools are non-Hispanic Whites with less than 6% African American and Hispanic combined.(15) The research was approved by the Institutional Review Board of the University of Kentucky. Data were divided by grade level; otherwise, no personal information was collected on any student, and no student was captured in any photography or linked to any lunch tray.

Procedure

Data were collected on total meals served and consumed under the NSLP in six school cafeterias for a total of 3,435 of observed trays. Independently, the separate samples were purposive for the original research project, but combined they function as a convenience sample for the present study. Meals brought from home were excluded. Each disposable lunch tray was marked with a unique ID number color-coded by grade level for identification purposes. Two photographs of each tray were taken: a “before” picture showing the student’s selections, and an “after” picture showing what the student consumed. In order to obtain an accurate measure of milk consumption, milk cartons were weighed prior to being discarded to ascertain the number of grams consumed.

Measures

The study will first measure daily menu choices selected by individual students against the nutritional standards set by the USDA and those recommended by the IOM. The study will then measure consumption by individual students against the same standards and will further examine the effect of grade level on nutrient levels consumed. The key nutrients that will be examined are total calories, the percent of calories from fat and saturated fat, grams of protein and fiber, and milligrams of Vitamin C, iron, calcium, and sodium. The students range from Kindergarteners to fifth graders.

Actual selection and consumption by students was measured by analyzing the photographic evidence as compared through the “before” and “after” pictures. As described by Swanson, two analysts “estimated the percentage of each item consumed to the nearest 10% increment.”(13) The estimates were averaged, and the data were entered into Microsoft Excel.(13) The percentage of each item consumed was then converted to serving equivalents, and nutrient intake was calculated using menu analysis from Fayette County Public Schools in Lexington, KY.(16)

Analytic Plan

This study compares mean food selection and consumption of school lunches as provided by the NSLP to nutrition standards of the USDA and IOM in six rural Kentucky elementary schools. Three stages of analyses were conducted: first, the number of trays meeting or exceeding standards through selection and consumption was quantified, secondly, the mean selection and consumption of key nutrients were compared to IOM and USDA nutrition standards, and lastly, an ANOVA model determined if nutrition standard compliance differed by grade level. Only meals bought and consumed in the school cafeteria were included, and meals with missing data (i.e. lack of either before or after photograph) were excluded from final analysis. All statistical analyses were performed using SPSS software, version 21.

RESULTS

Characteristics of the study sample

A total of 3,455 lunches were served in six rural Kentucky elementary schools over the course of 16 days. After excluding missing data, there were a total of 3,345 observed trays. Because of the original purposes of data collection, distribution between grades is not equal: First through third grades were represented in six schools; Kindergarten and fourth grade in three schools; and fifth grade in only two schools. Most trays were selected and consumed by 1st graders (26%) followed by 3rd graders (20%), 2nd

graders (19%), 4th graders (16%), Kindergartners (15%), and finally, 5th graders (3%). The percent of children receiving free or reduced lunches at the participating schools ranged from 56 – 95%.(17)

Mean selection and consumption of key nutrients

Children selected on average 580 calories per tray but only consumed 384 calories. They had a mean fat selection and consumption of 26% and 27% respectively of total calories while they had a mean saturated fat selection and consumption of 7.8% and 8% respectively of total calories. This shows that children select and consume foods that fall below the calorie standard for the USDA as well as foods with a lower fat and saturated fat content. Conversely, children selected and consumed foods with higher protein and sodium levels than recommended, and while children selected foods with more Vitamin C, calcium, fiber, and iron than is required, they nonetheless did not actually consume the necessary levels.

Compliance with USDA Standards

A one-sample T Test was conducted to compare food selection and consumption to USDA standards in place at the time of observation (Table 2).(18) All key nutrients were significantly different from standards on mean selection and consumption. Meals fell below the USDA standards for total calories selected and consumed (81% and 99.96%), total percent of calories from fat selected and consumed (74% and 64%), total percent of calories from saturated fat selected and consumed (70% and 69%), total calcium consumed (66%), and total Vitamin C consumed (63%). Meals met or exceeded the USDA minimal standards for total protein selected and consumed (97% and 85%), total Vitamin C selected (60%), total calcium selected (68%), and total iron selected and consumed (68% and 68%).

Compliance with IOM Recommendations

A one-sample T Test was also conducted to compare the IOM Recommendations for 5 – 10 year olds (Table 2) against selection and consumption of key nutrients. The IOM Recommendations are

generally more stringent than the USDA Standards, calling for lower levels of calories and calories from fat and saturated fat, higher levels of Vitamin C and protein, and specifying a target on fiber and sodium. The recommendations are lower than the standards on calcium and iron.(19) All key nutrients were significantly different from standards on mean selection and consumption except for the number of milligrams of iron consumed. Meals met or exceeded the recommendations on calories selected (67%), total fiber selected (49%), total protein selected and consumed (96% and 82%), total Vitamin C selected (58%), total calcium selected and consumed (77% and 47%), total iron selected (87%), and total sodium selected and consumed (99% and 77%). Meals fell below the recommendations on total calories consumed (80%), the percent of calories from fat selected and consumed (74% and 64%), the percent of calories from saturated fat selected and consumed (61% and 60%), total Vitamin C consumed (64%), and total fiber consumed (83%). Trays met the iron recommendations for consumption (48%) but far exceeded the sodium recommendations by selection and consumption (99% and 77%).

Variance by Grade

A one-way between subjects ANOVA was conducted on the two schools with all five grade levels to explore the difference between grade levels on key nutrient consumption. It revealed that there was a significant difference between at least two grade levels on the consumption of all nutrients except for percent of calories from saturated fat and milligrams of calcium and Vitamin C. The clearest trends were apparent between kindergarten and all other grades. Post-hoc comparisons using the Tukey HSD indicated that Kindergarteners' mean score for calories ($M = 322.2$, $SD = 145$) and the percent of calories from fat ($M = 22.6$, $SD = 12$) was significantly less than the mean score for all other grades. Furthermore, Kindergartners consumed fewer grams of fiber ($M = 3.03$, $SD = 2.5$) and protein ($M = 16.1$, $SD = 7.2$) and milligrams of iron ($M = 1.8$, $SD = 1.1$) and sodium ($M = 664.7$, $SD = 372.3$) than four other grades. First grade also consumed fewer grams of iron ($M = 2.1$, $SD = 1.1$) than four other grades.

DISCUSSION

The NSLP was officially enacted in 1946 to address undernourishment of American children, which became evident when young men were rejected for military service during World War II because of diet-related health problems.(20) It has since been accused of increasing the likelihood of overweight and obesity in school-aged participants and even increasing the prevalence of overweight and obesity in adulthood.(21, 22) While many schools have recently made efforts to offer more fruits and vegetables and a higher proportion of whole grains, there is evidence that these more nutritious foods are not being consumed: fruit and vegetables in fact are the most “wasted parts of school lunch” with 42% being discarded.(23)

This study observed the selection and consumption of meals served under the NSLP in six rural elementary schools to evaluate selection and consumption patterns when compared to USDA and IOM standards. For some key nutrients, students’ diets fare better than the standards, while for others improvement is needed. Students consume ample levels of protein, and while students select over the total IOM calories, they nonetheless consume fewer calories than the optimal levels prescribed in both the USDA standards and the IOM recommendations. They furthermore select and consume a lower percent of their calories from fat and saturated fat. Based on the lower than recommended total energy, fat, and saturated fat intake, this study does not appear to support previous findings that show the NLSP directly increases the likelihood of overweight and obesity.(24)

The students’ diets need improvement on several key nutrients. While students select enough fiber to satisfy the IOM recommendations, they do not consume enough fiber: students put the fiber rich fruits and vegetables essential to a healthy diet on their trays but then ultimately discard them, a finding consistent with previous research.(9, 23) Their school diets also do not contain enough Vitamin C, another key nutrient mainly found in fruits and vegetables.(25) They consume enough iron and calcium according to the IOM recommendations although fall short of the USDA standards. Considering the health benefits of

iron and calcium consumption in growing young children, namely preventing anemia and maintaining healthy bones and teeth, increasing consumption of these key nutrients to USDA standards is a worthy effort.(26, 27) Conversely, over 99% of students select over the recommended maximum of 434 mg of sodium: their selections have a mean sodium level of almost three times the IOM level, and they go on to consume 1.5 times the target amount. Increased exposure to salty foods leads to a preference for salty foods, meaning that children may opt for foods with higher sodium contents outside of the school environment.(28) High sodium intake is associated with higher blood pressure, one of the leading risk factors for heart disease.(29) Decreasing sodium consumption at school to the recommended levels is essential.

Evaluating mean consumption by grade level in the two schools with Kindergarten to fifth grade revealed the otherwise unremarkable trend that calorie consumption generally increases as age increases as does fat and saturated fat consumption. No grades consume enough calcium, fiber, or iron against the USDA standards, but all grades get more than enough protein and contrary to the findings of the entire sample, Vitamin C. Looking at the oldest and youngest students, the study shows that fifth graders eat a greater quantity of foods that have higher levels of fiber, protein, Vitamin C, and sodium, yet they do not drink milk at an optimal level. Kindergartners consume protein rich foods that have fewer calories but also have high levels of fat, Vitamin C, and sodium. The eating pattern of different age groups does not appear to vary significantly except for that of Kindergartners. This suggests that cafeterias might explore offering younger children different choices than their older peers.

Several limitations to this study are noted. Data were collected from previous studies designed for various purposes, rather than to specifically answer the current research question. However, the large number of observations from multiple studies likely overcomes any bias that the original study designs might have imposed. Both the USDA and IOM standards are intended for a five-day school week while the study only covered three days in most schools and only one day in one school. The schools were limited to

six rural Appalachian schools, making generalizability questionable. There was no way to account for any food sharing amongst the students, and any a la carte foods were not included in the analyses.

It is also important to note that the standards have been changed since the study was conducted. To address issues surrounding the dietary quality of the NSLP, policy makers updated standards through the Healthy, Hungry Free Kids Act of 2012. While this study used data from before the current law, it nonetheless provides important insights into the relationship between federal standards and what children select and consume through the NSLP. The current study could furthermore contribute to future research by serving as baseline data to evaluate selection and consumption under the new standards. It should also be noted that the USDA and IOM may set standards recognizing the difference between what students select and what they actually consume and adjust accordingly.

Additionally, while this study examined selection and consumption by the total sum of separate nutrients, the next step would be to examine precisely from which foods the nutrients come (i.e. which foods are being consumed) and therefore which foods are being discarded. This could provide insight into students' taste preferences and ways to make beneficial foods more enticing. Also, any unintended consequences from under consumption of calories at school should be studied to ensure that students do not make up for fewer calories at school by over indulging in other environments.

TABLE 1—Characteristics of study sample by grade (N=3,435) and mean of key nutrients selected and consumed

	N (trays)	Mean±SD
Trays by grade		
K	523	
1	894	
2	638	
3	671	
4	539	
5	170	
TOTAL	3,345	
Variable		
Total Calories selected	3329	580±154
Total Calories consumed	3018	384±154
Total calories from fat selected (%)	3321	26.0±7.0
Total calories from fat consumed (%)	3004	27.2±9.6
Total calories from saturated fat selected (%)	3321	7.8±3.5
Total calories from saturated fat consumed (%)	3004	8.0±3.7
Total Fiber selected (g)	3330	6.9±5.8
Total Fiber consumed (g)	3019	3.7±2.4
Total Protein selected (g)	3331	24.9±7.3
Total Protein consumed (g)	3025	17.6±7.5
Total Vitamin C selected (mg)	3330	42.9±77.4
Total Vitamin C consumed (mg)	3036	20.2±37.7
Total Calcium selected (mg)	3330	344.7±178.7
Total Calcium consumed (mg)	3034	234.2±159.4
Total Iron selected (mg)	3331	3.4±1.2
Total Iron consumed (mg)	3036	2.3±3.0
Total Sodium selected (mg)	3322	1039.1±700.0
Total Sodium consumed (mg)	2988	666.3±700.0

Table 2-Standards and recommendations for NSLP, significant means compared to standards and recommendations, and percent of trays meeting or exceeding recommendations/standards

Variable	National School Lunch Program		Mean differed from standards ⁵ :		% of trays meeting or exceeding standards:	
	USDA Standards	IOM Recommendations	USDA	IOM	USDA	IOM
Total Calories selected	667	500	Yes	Yes	19.35	67.05
Total Calories consumed	667	500	Yes	Yes	0.037	19.88
Total % of calories from fat selected	30 ¹	25-35 ²	Yes	Yes	26.10	26.10
Total % of calories from fat consumed	30 ¹	25-35 ²	Yes	Yes	35.65	35.65
Total % of calories from saturated fat selected	10 ³	<10 ⁴	Yes	Yes	29.93	38.69
Total % of calories from saturated fat consumed	10 ³	<10 ⁴	Yes	Yes	31.06	39.51
Total Fiber selected (g)		5.7	NA	Yes		48.59
Total Fiber consumed (g)		5.7	NA	Yes		16.70
Total Protein selected (g)	9.3	10.2	Yes	Yes	96.73	96.46
Total Protein consumed (g)	9.3	10.2	Yes	Yes	84.79	81.88
Total Vitamin C selected (mg)	14.6	16	Yes	Yes	59.90	57.90
Total Vitamin C consumed (mg)	14.6	16	Yes	Yes	37.41	35.50
Total Calcium selected (mg)	267	223	Yes	Yes	68.26	77.27
Total Calcium consumed (mg)	267	223	Yes	Yes	34.34	47.03
Total Iron selected (mg)	3.3	2.3	Yes	Yes	68.12	87.00
Total Iron consumed (mg)	3.3	2.3	Yes	No	20.49	47.83
Total Sodium selected (mg)		≤434	NA	Yes		99.28
Total Sodium consumed (mg)		≤434	NA	Yes		76.57

¹Not to exceed 30 percent over one school week.

²Not to exceed 25 – 35 percent over one school week.

³Not to exceed 10 percent over one school week.

⁴To be less than 10 percent over one school week.

⁵ Yes cells indicate the sample mean differed from standard or recommendation at $P<0.05$

Table 3-Means of key nutrients consumed with ANOVA of mean differences by grade

Grade	Diff From Grade	Total Calories	Calories from Fat (%)	Calories from Sat Fat (%)	Fiber (g)	Protein (g)	Vitamin C (mg)	Calcium (mg)	Iron (mg)	Sodium (mg)
K		322.2	22.6	4.9	3.0	16.1	24.6	176.9	1.8	664.8
	1	-56.1*	-3.8*	-0.7	-0.3	-1.8	2.0	-3.9	-0.3	-116.1
	2	-86.9*	-4.1*	-0.5	-1.1*	-3.6*	-8.6	-10.0	-0.7*	-208.1*
	3	-117.7*	-5.8*	-1.4*	-1.0*	-4.9*	-1.2	-27.3	-0.7*	-313.0*
	4	-121.2*	-5.5*	-1.0	-1.2*	-5.0*	-7.1	-21.2	-0.9*	-280.7*
	5	-103.5*	-3.5*	-1.1	-1.4*	-3.7*	-13.7	-10.2	-0.7*	-213.5*
1		378.3	26.4	5.6	3.3	17.9	22.6	180.0	2.0	780.9
	K	56.1*	3.8*	0.7	0.3	1.8	-2.0	3.9	0.3	116.2
	2	-30.8	-0.3	0.2	-0.8*	-1.8	-10.6	-6.1	-0.4*	-92.0
	3	-61.6*	-1.9	-0.7	-0.7	-3.1*	-3.1	23.5	-0.5*	-196.9*
	4	-65.1*	-1.6	-0.3	-0.9*	-3.2*	-9.0	-17.3	-0.6*	-164.5*
	5	-47.4*	0.3	-0.4	-1.1*	-1.9	-15.7	-6.3	-0.5*	-97.3
2		409.1	26.7	5.4	4.1	19.7	33.2	186.9	2.4	872.9
	K	86.9*	4.1*	0.5	1.1*	3.6*	8.6	10.0	0.7*	208.1*
	1	30.8	0.3	-0.2	0.8*	1.8	10.6	6.1	0.4*	92.0
	3	-30.8	-1.6	-0.9	0.1	-1.3	7.5	-17.4	-0.0	-104.9
	4	-34.3	-1.4	-0.5	-0.1	-1.4	1.6	-11.3	-0.2	-72.5
	5	-16.6	0.6	-0.6	-0.3	-0.1	-5.1	-0.3	-0.1	-5.4
3		439.9	28.3	6.3	4.0	21.0	25.7	204.3	2.5	977.8
	K	117.7*	5.8*	1.4*	1.0*	4.9*	1.2	27.3	0.7*	313.0*
	1	61.6*	1.9	0.7	0.7	3.1*	3.1	23.5	0.5*	196.9*
	2	30.8	1.6	0.9	-0.1	1.3	-7.5	17.4	0.0	104.9
	4	-3.5	0.3	0.4	-0.3	-0.2	-5.9	6.1	-0.1	32.4
	5	14.1	2.2	0.3	-0.4	1.2	-12.5	17.1	-0.0	9.5
4		443.4	28.1	5.9	4.3	21.1	31.2	198.1	2.6	945.4
	K	121.2*	5.5*	1.0	1.2*	5.0*	7.1	21.2	0.9*	280.7*
	1	65.1*	1.6	0.3	0.9*	3.2*	9.0	17.3	0.6*	164.5*
	2	34.3	1.4	0.5	0.1	1.4	-1.6	11.3	0.2	72.5
	3	3.5	-0.3	-0.4	0.3	0.2	5.9	-6.1	0.1	-32.4
	5	17.7	1.9	-0.1	-0.2	1.4	-6.6	11.0	0.1	67.2
5		425.7	26.1	6.0	4.4	19.8	38.3	187.1	2.5	878.3
	K	103.5*	3.5*	1.1	1.4*	3.7*	13.7	10.2	0.7*	213.5*
	1	47.4	-0.3	0.4	1.1*	1.9	15.7	6.3	0.5*	97.3
	2	16.6	-0.6	0.6	0.3	0.1	5.1	0.3	0.1	5.4
	3	-14.1	-2.2	-0.3	0.4	-1.2	12.5	-17.1	0.0	-99.5
	4	-17.7	-1.9	0.1	0.2	-1.4	6.6	-11.0	-0.1	-67.2

*Indicates significant mean difference from other grade, $P < 0.05$.

Shaded boxes indicate highest or lowest mean by key nutrient consumed.

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Biographical Sketch

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