Original Investigation

Effect of the Healthy Hunger-Free Kids Act on the Nutritional Quality of Meals Selected by Students and School Lunch Participation Rates

Donna B. Johnson, PhD; Mary Podrabsky, MPH; Anita Rocha, MS; Jennifer J. Otten, PhD

IMPORTANCE Effective policies have potential to improve diet and reduce obesity. School food policies reach most children in the United States.

OBJECTIVE To assess the nutritional quality of foods chosen by students and meal participation rates before and after the implementation of new school meal standards authorized through the Healthy Hunger-Free Kids Act.

DESIGN, SETTING, AND PARTICIPANTS This descriptive, longitudinal study examined changes in the nutritional quality of 1 741 630 school meals at 3 middle schools and 3 high schools in an urban school district in Washington state. Seventy two hundred students are enrolled in the district; 54% are eligible for free and reduced-price meals. Student food selection data were collected daily from January 2011 through January 2014 during the 16 months prior to and the 15 months after implementation of the Healthy Hunger-Free Kids Act.

EXPOSURE The Healthy Hunger-Free Kids Act.

MAIN OUTCOMES AND MEASURES Nutritional quality was assessed by calculating monthly mean adequacy ratio and energy density of the foods selected by students each day. Six nutrients were included in the mean adequacy ratio calculations: calcium, vitamin C, vitamin A, iron, fiber, and protein. Monthly school meal participation was calculated as the mean number of daily meals served divided by student enrollment. Mean monthly values of mean adequacy ratio, energy density, and participation were compared before and after policy implementation.

RESULTS After implementation of the Healthy Hunger-Free Kids Act, change was associated with significant improvement in the nutritional quality of foods chosen by students, as measured by increased mean adequacy ratio from a mean of 58.7 (range, 49.6-63.1) prior to policy implementation to 75.6 (range, 68.7-81.8) after policy implementation and decreased energy density from a mean of 1.65 (range, 1.53-1.82) to 1.44 (range, 1.29-1.61), respectively. There was negligible difference in student meal participation following implementation of the new meal standards with 47% meal participation (range, 40.4%-49.5%) meal participation prior to the implemented policy and 46% participation (range, 39.1%-48.2%) afterward.

CONCLUSIONS AND RELEVANCE Food policy in the form of improved nutrition standards was associated with the selection of foods that are higher in nutrients that are of importance in adolescence and lower in energy density. Implementation of the new meal standards was not associated with a negative effect on student meal participation. In this district, meal standards effectively changed the quality of foods selected by children.

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Effective food policy actions are part of a comprehensive approach to improving nutrition environments, defined as those factors that influence food access.[1] Improvements in the nutritional quality of all foods and beverages served and sold in schools have been recommended to protect the nutritional health of children, especially children who live in low-resource communities.[2] As legislated by the US Congress, the 2010 Healthy Hunger-Free Kids Act (HHFKA) updated the meal patterns and nutrition standards for the National School Lunch Program and the School Breakfast Program to align with the 2010 Dietary Guidelines for Americans.[3] The revised standards, which took effect at the beginning of the 2012-2013 school year, increased the availability of whole grains, vegetables, and fruits and specified weekly requirements for beans/peas as well as dark green, red/orange, starchy, and other vegetables. The standards also increased the portion sizes of fruits and vegetables and required students to select at least 1 serving of fruits and/or vegetables.[4] Because the National School Lunch Program reaches more than 31 million students each day in 99% of US public schools and 83% of private schools, the new standards have the potential to significantly and consistently affect the nutritional health of children.[5]

Lifelong dietary patterns and behavioral choices are influenced by environmental factors. School environments are complex, and many factors have an effect on the foods that children eat at school. Such factors include the availability of food and beverages that compete with school meals, the frequency of offering fruit and vegetables at lunch, and the amount of time students have to eat lunch.[6-8] The more an environment consistently promotes healthy behavior, the greater the likelihood that such behavior will occur.[9] The goal of the 2010 HHFKA is to foster a healthy school food environment and promote lifelong healthy eating behaviors among children.[4] Keys to its success include assurance of the provision of healthy food in schools and an environment where healthy food preferences can be learned, expressed, and reassessed.[1]

Prior studies examining changes in children's diets after implementation of the HHFKA have found significant increases in student selection of fruit and consumption of vegetables and entrées as well as significant improvements in both selected and consumed key nutrients, including increases in fiber and reductions in sodium and saturated fat.[10-12]

This study adds to previous work by evaluating detailed changes in energy and nutrient density of the 1 741 630 school lunches selected by students in study schools and daily meal participation rates over a 3-year period that included the implementation of the new school meal standards.

At a Glance

- This study aimed to assess changes in nutrient quality of school meals chosen by students before and after implementation of new meal standards authorized through the Healthy Hunger-Free Kids Act of 2010.
- Nutrient density increased with the new standards as measured by mean adequacy ratio of 58.7 (range, 49.6-63.1) before policy implementation and 75.6 (range, 68.7-81.8) after policy implementation.
- Energy density decreased with the new standards from a mean of 1.65 (range, 1.53-1.82) to 1.44 (range, 1.29-1.61) before and after implementation, respectively.
- School lunch participation did not change following implementation of the new meal standards, with 47% participation (range, 40.4%-49.5%) before the policy was implemented and 46% participation (range, 39.1%-48.2%) afterward.

Methods

Design

For this longitudinal study, school lunch student food selection data were collected daily from January 2011 through January 2014 in the 16 school-year months prior to and the 15 school-year months after implementation of the HHFKA. Only food production records were used to collect these data. These records are normally kept by the district and contain no information about students, therefore, consent was not necessary. Study procedures were approved by the University of Washington institutional review board.

Sample and Setting

This study took place in 3 middle schools and 3 high schools in a large, urban US school district that serves predominantly low-income, racial/ethnic minority students. Within this school district, 28% of students are non-Hispanic white, and 54% are eligible for free and reduced-price meals. The total enrollment of the 6 study schools is approximately 7200.

Measures

Student Food Selection

School food service managers provided researchers with daily food production records based on standardized menus and recipes developed by the district's Nutrition Services Department. Food service managers used order guides for specific foods and recipe ingredients and projected amounts needed based on the anticipated number of servings of each menu item. Foods were distributed to schools from a central facility, and each school had a finishing kitchen where final steps of food preparation took place. Individual school production records documented the number of food items produced (including entrées and side dishes) and the number of servings of each individual food item, such as milk, selected by students at lunch along with the daily reimbursable lunch count. Individual items served at the daily salad bars were ordered in bulk and were not included in the production records. Thus, the nutritional contribution of the self-serve salad bars was estimated through school-level purchase records of the most common specific fruit and vegetable items selected from a common food order guide exclusively for use in the salad bars. Researchers converted purchased amounts to individual portions based on school meal serving size standards. Schools had salad bars both before and after the change in regulations. Salad bar items are listed in the **Box**.

Box. Salad Bar Food Items

Apple red: fresh whole
Apple: fresh sliced
Bananas: whole
Broccoli florettes
Cabbage: shredded
Carrots: baby
Cauliflower florettes
Celery sticks
Cucumbers: fresh whole
Grapes: seedless red
Kiwi: fresh whole
Lettuce romaine chopped
Lettuce salad mix with cabbage and carrots
Oranges: mandarin canned light syrup
Oranges: fresh whole
Pineapple chunks in juice
Potato salad: bulk
Spinach: cello stemless
Tomatoes: fresh cherry

Each food item on the menu was given a unique code name. Nutritional information for all items served as part of the school lunch program was provided by the district's Nutrition Services Department, using NUTRIKIDS nutrition analysis software (Heartland Payment Systems Inc). Nutritional information for salad bar items was determined using the Food Processor SQL, version 10.9.0 nutrition analysis software (ESHA Research). Spreadsheets with information about individual student food selections from the daily production records and the nutrient content of foods were match-merged on their unique food item codes, forming a single data set.

Dependent Variables: Mean Adequacy Ratio and Energy Density

Mean adequacy ratio (MAR) was computed as the mean of percentage daily value provided in all the foods selected each day, averaged per month for 6 nutrients per 1000 kcal of energy.[13] These nutrients were included in the MAR because they were contained in the NUTRIKIDS analyses provided by the school district, and they represent nutrients of importance for children and adolescents. The 6 nutrients included in the MAR calculation and the daily value of each are as follows: protein, 50 g; vitamin C, 60 g; vitamin A, 5000 IU; calcium, 1000 mg; iron, 18 mg; and dietary fiber, 25 g. This means that if aggregate student choices during months when the foods served had provided nutrients that met or exceeded the recommended levels for these 6 nutrients per 1000 kcal, the MAR would be 100% or more. Energy density (ED) was calculated as available energy divided by the weight (kilocalories per gram) of foods served.[14,15] Foods with a lower ED provide fewer calories per gram than foods higher in ED. In general, foods with lower ED (ie, fruits and vegetables) tend to be foods with either a high water content, high in fiber, or low in fat. Consuming a low-ED diet is associated with reduced energy intake.[16] Because beverages have high water content and tend to have low ED, they may disproportionately influence dietary ED values.[15] For this reason, ED was analyzed without beverages. For each school, the nutritional content of an average school lunch by month was computed using the recorded food items selected by students that month along with the salad bar food portions divided by the number of lunches served.

Student Participation Rates

Participation in the school lunch program was calculated for each month of the study by dividing the mean number of daily meals served each month by student enrollment.

Statistical Analyses

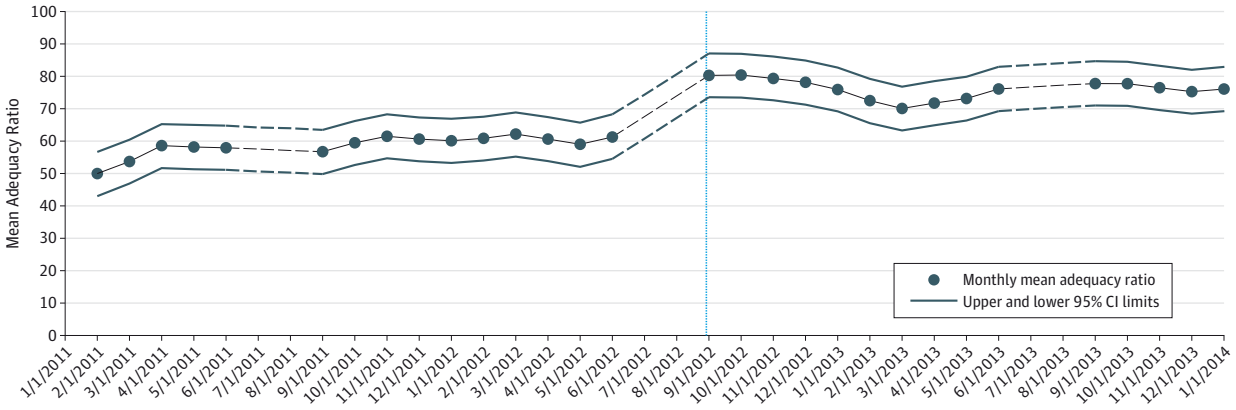
Univariate time series are values of a single measure collected over time. In this study, there were 3 univariate time series that were analyzed separately: 2 nutritional content measures (MAR and ED) and 1 lunch participation measure. Each series was composed of values averaged over each month, for a total of 31 months during which school was in session. Therefore, the time scale for our model was months. Stationarity tests, the white noise test, and the Dickey-Fuller test for unit roots were performed as well as examination of autocorrelation function and partial autocorrelation function plots[17] to help identify appropriately parameterized models for MAR, ED, and lunch participation time series. Because the preliminary examination suggested evidence of nonstationarity and autocorrelation in these series, models were chosen to account for such conditions accordingly. As a consequence, autoregressive integrated moving average models of the first autoregressive order and 1 degree of differencing with constants (autoregressive integrated moving average; 1, 1, 0) were fit to each univariate series. Included in each model was the predictor "policy" intended to account for the effect of a districtwide policy departure after June 2012. This predictor was set to 0 through June 2012 and set to 1 thereafter. All analyses were performed using SAS/STAT software, version 9.3 (SAS Institute Inc).

Results

After implementation of the HHFKA, the change was associated with a significant improvement in the nutritional quality of foods chosen by students, as measured by increased MAR from a mean of 58.7 (range, 49.6-63.1) prior to policy implementation to 75.6 (range, 68.7-81.8) after policy implementation and decreased ED from a mean of 1.65 (range, 1.53-1.82) to 1.44 (range, 1.29-1.61), respectively. There was negligible difference in student meal participation following implementation of the new meal standards, with 47% meal participation (range, 40.4%-49.5%) prior to the implemented policy and 46% participation (range, 39.1%-48.2%) afterward.

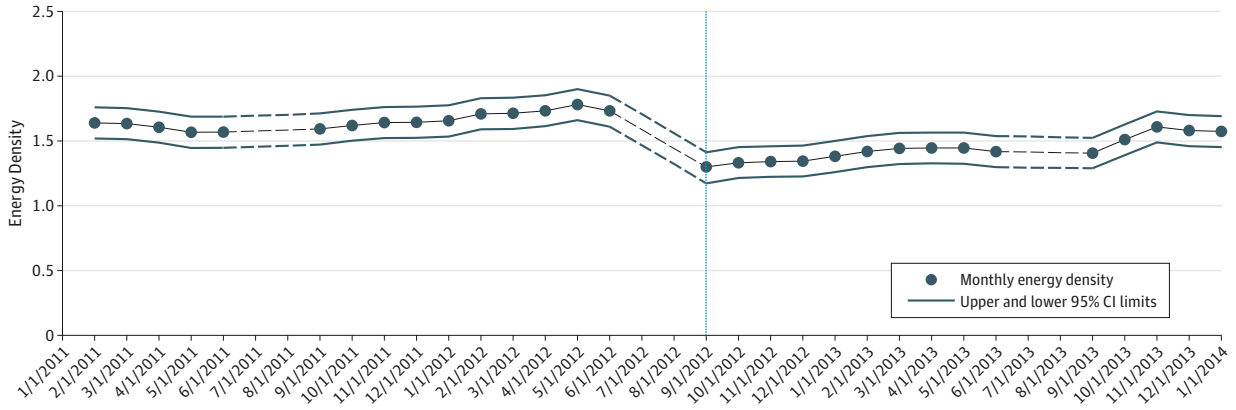
All series demonstrate negative autoregressive 1 estimates, which lend support for their stationary properties. The estimated coefficient for policy was positive and statistically significant (estimated coefficient = 20.18, $P < .001$) for the mean MAR outcome, suggesting a discrete upward shift in

Figure 1. Estimated Mean Monthly Mean Adequacy Ratio Before and After Implementation of New Meal Standards (September 2012)



The vertical dashed line indicates the beginning of the Healthy Hunger-Free Kids Act policy implementation. The dashed horizontal lines between markers represent summer months when no data were collected.

Figure 2. Estimated Mean Monthly Energy Density Before and After Implementation of New Meal Standards (September 2012)



The vertical dashed line indicates the beginning of the Healthy Hunger-Free Kids Act policy implementation. The dashed horizontal lines between markers represent summer months when no data were collected.

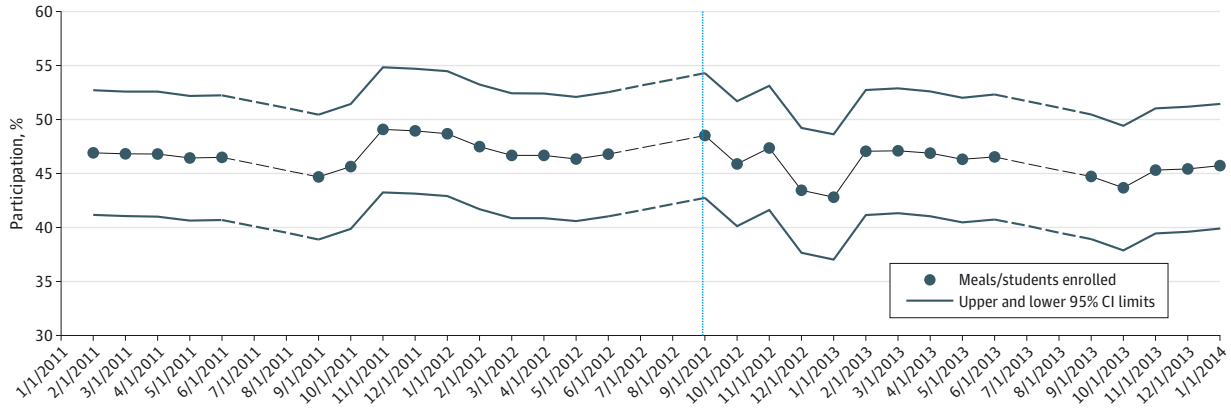
mean MAR following the change in policy (**Figure 1**). On the other hand, the policy coefficient was negative and statistically significant (estimated coefficient = −0.46, $P < .001$) for the ED outcome, suggestive of a down shift in mean ED following the policy implementation (**Figure 2**). The coefficient for policy did not attain the significance threshold (estimated coefficient = −0.05, $P = .10$) for the lunch participation model (**Figure 3**).

Discussion

This longitudinal study in 3 middle schools and 3 high schools in a large, urban US school district in Washington state compared the nutritional quality of student school lunch food selections before and after the implementation of the new National School Lunch Program meal standards. Nutritional quality was calculated using a nutritional index designed to measure nutrients important for children and adolescents (MAR) and a nutritional index designed to measure the calorie content per weight of food (ED). We found that the implementation of the new meal standards was associated with the improved nutritional quality of meals selected by students. These changes appeared to be driven primarily by the increase in variety, portion size, and number of servings of fruits and vegetables. This study also assessed the impact of the new standards on meal participation rates. This issue has been of concern to school administrators and some legislators. Our study found no effect of the new standards on student school lunch participation.

Our findings are consistent with other studies that indicate that the revised school nutrition standards have led to more nutritious school meals, but our study overcomes limitations of previous studies that used cross-sectional data, short study durations, small samples, and surveys.[10-12,18] Unlike other studies, our study included high schools and had the strength of longitudinal food selection data that spanned 31 months and more than 1.7 million reimbursable meals. Many of the previous studies sacrificed sample size to measure not only food se-

Figure 3. Estimated Proportion of Students Participating in School Lunch Before and After Implementation of New Meal Standards (September 2012)



The vertical dashed line indicates the beginning of the Healthy Hunger-Free Kids Act policy implementation. The dashed horizontal lines between markers represent summer months when no data were collected.

lection, but also consumption. Our approach allowed for a larger sample size; the consideration of seasonal changes in menu offerings and available foods; and other factors such as holiday meals, taste tests, and other cafeteria events or promotions that could influence student selection of foods at lunch in the short term. Our study also uniquely used 2 different nutrition indices to measure nutritional quality.

Our study had some limitations. Our sample included only middle schools and high schools and took place in 1 urban school district in Washington state. Therefore, results are not generalizable to rural schools or elementary schools. In addition, while the new National School Lunch Programs regulations affected beverage choices, this could not be reflected in the ED because the high water content disproportionately influences the energy to weight ratio, and beverages are not included in ED calculations. The actual autoregressive integrated moving average model captured increases in ED during the months of November 2013 through January 2014, but it was a limitation of this statistical method that we could not provide a month-to-month comparison. It is worth noting, however, that there seemed to be some seasonality at play. The ED went up during the winter months in both 2013 and 2014, probably reflecting the limited quality and variety of produce that is available during those months.

While data represent foods selected by students, we did not measure consumption. However, the new standards include increases in portions and variety of fruits and vegetables, and the MAR calculation used in this study included nutrients that would be affected by key nutrients provided by these foods, such as vitamin A, vitamin C, and fiber. The increase in MAR of foods selected by students appears to reflect the increased availability of these foods. Research by Wansink and Kim[19] showed that people consume more food when they are given larger portions and greater variety, so it is likely that consumption of nutrient-dense foods increased along with the increase in the amounts of foods served.[20] Recent studies assessing the effect of the new school meal regulations on consumption and food waste have shown increases in fruit, entrée, and vegetable consumption[10,11]; increases in consumption of fiber and reduction in nutrients of concern[12]; and no increase in total food waste.[10,11]

Future work can build on these findings by using similar techniques to evaluate changes over time in the nutritional quality of foods selected by students. It would be beneficial to expand the analysis to nutrient profiling methods that include both desirable nutrients, such the vitamins, minerals, and fiber that were included in the current study, as well as less desirable nutrition components, such as sodium, added sugars, and saturated fats that should be limited in health-promoting diets.[21] A time series analysis of the quality of food selections is a useful approach to measuring sequential policy impacts.

Conclusions

Findings from this study provide further evidence that the new US Department of Agriculture meal standards are addressing key nutritional concerns among adolescents, especially the need for increased consumption of the nutrients in fruits and vegetables and a reduction in ED.

These results contribute to the evidence that significant improvement in the nutrition environments in schools is associated with the enactment and implementation of the new US Department of Agriculture meal standards, with corresponding improvement of student selection of nutritious foods, without negatively affecting meal participation.

The improved US Department of Agriculture meal standards are an example of an effective food policy action. Implementation of the policy was associated with improved school food environments by increasing the nutritional quality of foods served to children. The results support the ongoing implementation of the HHFKA and maintenance of strong nutrition standards during its reauthorization.

The combined effect of the standards along with other initiatives to improve nutrition environments in school settings may enhance attitudes about nutrition and consumption of healthy foods, both inside and outside schools.[1]

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Study concept and design: Johnson, Podrabsky.
Acquisition, analysis, or interpretation of data: All authors.
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Critical revision of the manuscript for important intellectual content: Johnson, Podrabsky, Otten.
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