# Association of the Healthy, Hunger-Free Kids Act With Dietary Quality Among Children in the US National School Lunch Program

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**Abstract**

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IMPORTANCE: The Healthy, Hunger-Free Kids Act of 2010, implemented nationwide in 2012, was intended to improve the nutritional quality of meals served in the National School Lunch Program (NSLP).

OBJECTIVE: To assess whether there was an association between the Healthy, Hunger-Free Kids Act of 2010 and dietary quality of lunch for students participating in the NSLP, stratified by income.

DESIGN, SETTING, PARTICIPANTS: Serial cross-sectional study design, using National Health and Nutrition Examination Survey (NHANES) data from 2007-2008, 2009-2010, 2013-2014, and 2015-2016, of students who were surveyed in the NHANES and were attending schools participating in the NSLP. Individuals who were aged 5 to 18 years, in kindergarten through12th grade, enrolled in a school that served school lunch, and had a reliable weekday dietary recall were included.

EXPOSURES: The Healthy, Hunger-Free Kids Act of 2010 (prepolicy period: 2007-2010; postpolicy period: 2013-2016), with participation in the NSLP estimated based on an algorithm.

MAIN OUTCOMES AND MEASURES: The primary outcomewas dietary quality of intake for lunch, measured by the Healthy Eating Index-2010 (HEI-2010) score (range, 0-100; 0 indicates a diet with no adherence to the 2010 Dietary Guidelines for Americans and 100 indicates a diet with complete adherence to the guidelines).

RESULTS: Among 6389 students included in the surveys (mean age, 11.7 [95%CI, 11.6-11.9] years; 3145 [50%] female students; 1880 [56%] were non-Hispanic white), 32%were low-income, 12%were low-middle–income, and 56%were middle-high–income students. A total of 2472 (39%) were participants in the NSLP. Among low-income students, the adjusted mean prepolicy HEI-2010 score was 42.7 and the postpolicy score was 54.6 among NSLP participants and the adjusted mean prepolicy score was 34.8 and postpolicy score was 34.1 among NSLP nonparticipants (difference in differences, 12.6 [95%CI, 8.9-16.3]). Among low-middle–income students, the adjusted mean prepolicy HEI-2010 score was 40.4 and postpolicy score was 54.8 among NSLP participants and the adjusted mean prepolicy score was 34.2 and postpolicy score was 36.1 among NSLP nonparticipants (difference in differences, 12.4 [95%CI, 4.9-19.9]). Among middle-high–income students, the adjusted mean HEI-2010 prepolicy score was 42.7 and postpolicy score 55.5 for NSLP participants and the adjusted mean prepolicy score was 38.9 and prepolicy score was 43.6 for NSLP nonparticipants (difference in differences, 8.1 [95%CI, 4.2-12.0]).

CONCLUSIONS AND RELEVANCE: In a serial cross-sectional study of students, the Healthy, Hunger-Free Kids Act of 2010 was associated with better changes in dietary quality for lunch among presumed low-income, low-middle–income, and middle-high–income participants in the NSLP compared with nonparticipants.

JAMA | Original Investigation

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Supplemental content

CME Quiz at jamacmelookup.com

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Nearly 99% of US public schools enroll in the National School Lunch Program (NSLP), a federally assisted program administered by the US Department of Agriculture (USDA) that provides nutritionally balanced free or low-cost lunches to students during the school day.[1] More than 30 million students participate in the NSLP daily.[1] In 2010, Congress passed the Healthy, Hunger-Free Kids Act (HHFKA) to change nutrition standards for the NSLP to align with the 2010 Dietary Guidelines for Americans,[2] the first change to nutrition standards in school lunches since 1994.[3,4]

The HHFKA was implemented nationwide, and compliance by all schools enrolled in the NSLP was required by July 2012.[4] Specific changes to the NSLP included requiring fruits and vegetables as 2 separate meal components, limiting the quantity of starchy vegetables allowed weekly, increasing the required amount of whole grain-rich grains, offering milk that is fat-free (flavored or unflavored) and/or low fat (unflavored only), setting limits on allowable sodium levels, requiring meals to not contain trans fat, and requiring students to select either a fruit or vegetable as part of the reimbursable NSLP meal.[4]

Evaluations have shown that the dietary quality of lunches served improved in association with implementation of the original HHFKA,[5] but it is unknown whether students subsequently ate enough of this healthier food for better overall dietary quality. This study was conducted to assess the dietary quality of intake at lunch for students participating in the NSLP before and after implementation of the original HHFKA policy in 2012.

### Key Points

**Question** Was there an association between the Healthy, Hunger-Free Kids Act of 2010 and dietary quality of lunch among students participating in the National School Lunch Program (NSLP)?

**Findings** In a serial cross-sectional study of 6389 students, the Healthy, Hunger-Free Kids Act of 2010 was associated with statistically significant mean differences in prepolicy vs postpolicy Healthy Eating Index-2010 scores of 11.9 for low-income NSLP participants vs −0.7 for low-income NSLP nonparticipants, 14.3 for low-middle–income NSLP participants vs 2.0 for low-middle–income nonparticipants, and 12.8 for middle-high–income NSLP participants vs 4.7 for middle-high–income nonparticipants.

**Meaning** The Healthy, Hunger-Free Kids Act of 2010 was associated with better dietary quality for lunch among low-income, low-middle–income, and middle-high–income students estimated to be participants in the NSLP.

## Methods

A serial cross-sectional design was used to assess the association of the HHFKA with dietary quality of NSLP participants. National Health and Nutrition Examination Survey (NHANES) data from 2007-2008, 2009-2010, 2013-2014, and 2015-2016 were used, while data from the 2011-2012 cycle were excluded because of policy implementation starting in July 2012.[4] The data were de-identified and no individuals on the study team had links to identifiers. The research was considered exempt from human subjects research according to the University of Washington Institutional Review Board. All participants or family members/legal guardians of participants provided written informed consent to participate in the original data collection. The NHANES interviewer conducted 1 in-person 24-hour dietary recall at the mobile examination center and a follow-up 24-hour dietary recall by phone 3 to 10 days later.

### Participants

Students were eligible participants if they were aged 5 to 18 years, enrolled in kindergarten through 12th grade in a school that served lunch that cost the same amount every day, and had a reliable weekday dietary recall. A dietary recall was considered reliable by the NHANES if the first 4 steps of the automated multiple-pass method were completed, foods and beverages consumed for each reported eating occasion were identified, and all relevant variables associated with the 24-hour dietary recall contained a value.[6] Although there is no biomarker for total dietary quality, the 24-hour dietary recall using the automated multiple-pass method among children with proxy-assisted reporting has been shown to provide an accurate assessment of population mean total energy intake compared with doubly labeled water, with mean underreporting of less than 100 total daily calories.[7,8] A proxy (family member or legal guardian aged at least 18 years) assisted children aged 6 to 11 years with the interview and completed the interview for children aged 5 years. The random number generator function runiform in Stata was used to assign participants with 2 reliable weekday dietary recalls to one or the other recall days.

### Exposures

The exposure was the HHFKA, with the prepolicy period defined as 2007 to 2010 and the postpolicy period defined as 2013 to 2016. Students were further classified by their participation in the NSLP.

Schools count students as NSLP participants each day if the student receives a reimbursable school meal sourced from the school cafeteria in which 3 of the 5 meal components are represented on the lunch tray. The 5 school meal components are fruits, vegetables, grains, meat/meat alternatives, and milk, in accordance with the USDA guidelines for reimbursable meals.[1,4] The USDA and state agencies review and audit school food authorities to ensure compliance with the nutrition standards to receive federal reimbursement.[1,4] Any student who attends a school enrolled in the NSLP has the option to receive a school lunch.

Because there was no question in the NHANES that explicitly asked whether the student participated in the NSLP on the day of the dietary recall, this study estimated a student's NSLP participation status using an algorithm meant to

reflect the likelihood that the student was an NSLP participant on the day of the dietary recall. Specifically, 2 questions from NHANES directly asked about school lunch: (1) "Does [your/the survey participant's] school serve school lunches? These are complete lunches that cost the same every day" and (2) "During the school year, about how many times a week [do you/does the survey participant] usually get a complete school lunch?" Responses to these 2 questions were combined with dietary recall information and questions in the NHANES dietary recall survey that accompanied each individual food item, including time of eating occasion, name of eating occasion, and source of food.

Students were classified as NSLP participants if they reported eating lunch between 10:00 AM and 2:00 PM and ate either any amount of 3 or more school meal components sourced from the school cafeteria, any amount of 2 school meal components sourced from the school cafeteria and reported getting school lunch 5 times per week, or any amount of 2 school meal components sourced from the school cafeteria and reported that all other lunch food items were from the school cafeteria. Students were classified as NSLP nonparticipants if they did not meet any of the above criteria.

## Outcomes

Dietary quality was assessed using the Healthy Eating Index-2010 (HEI-2010), a validated measurement score for how well diets comply with the 2010 Dietary Guidelines for Americans.[9] The USDA Food Patterns Equivalents Database was used to convert dietary nutrient composition into food patterns equivalent component quantities.[10] Those quantities were converted to 12 HEI-2010 component scores based on the HEI-2010 scoring algorithm.[11] All component scores were summed together, with a total score ranging from 0 to 100. Higher scores indicated healthier diets that more closely align with the 2010 Dietary Guidelines for Americans; a minimal clinically important difference has not been established (see eTable 1 in the Supplement).[12] The primary outcome of interest was the HEI-2010 score for lunch, which reflected dietary quality of the food and beverage intake from 10:00 AM to 2:00 PM in proportion to the number of calories consumed during that time. In secondary analyses, the HEI-2010 score for the entire day, HEI-2010 scores for foods consumed after 2 PM, and HEI-2010 component scores for lunch and the entire day were examined.

## Covariates

Covariates included age (5-8 y, 9-13 y, and 14-18 y), sex (male and female), education grade level (ordinal), race/ethnicity (non-Hispanic white, non-Hispanic black, Mexican American, other Hispanic, and other non-Hispanic [including multiracial] according to fixed categories provided by National Center for Health Statistics and classified by respondent or proxy if younger than 16 y), time of year of dietary recall (November-April or May-October), and body mass index (continuous). Information on race/ethnicity was included because it has previously been associated with both dietary quality and participation in the NSLP.[13-15] Participants were categorized by income using criteria for free, reduced-price, and full-price lunch (income to poverty ratio categories defined ≤130% of the federal poverty line as low income, >130%-185% of the federal poverty line as low-middle income, and >185% of the federal poverty line as middle-high income). Sensitivity analyses included physical activity (status in accordance with the Physical Activity Guidelines for Americans as sedentary, low active, and active)[16] and day of the week of dietary intake as indicator variables.

## Statistical Analysis

All analyses were conducted with Stata, version 15.1 (StataCorps), with statistical significance defined as a 2-sided *P* value <.05. Because this study relied on previously collected data of a fixed sample size, a power analysis was not conducted. All primary and secondary models used the NHANES-provided sample weights that accounted for nonresponse to the dietary recall component of the survey and for the complex sample design of the NHANES. Income-stratified, regression-based difference-in-differences models with robustness checks (described in detail in the eMethods in the Supplement) were used to estimate the degree to which the mean HEI-2010 lunch score for NSLP participants changed compared with the mean HEI-2010 lunch score for nonparticipants after the implementation of the HHFKA.

Secondary analyses were conducted to evaluate the association of the HHFKA with HEI-2010 total day scores, each of the 12 HEI-2010 component scores for lunch and total day, and differences in prepolicy changes in HEI-2010 scores for lunch and total day, stratified by income category. Back calculations using the point estimates from our models and the HEI-2010 scoring algorithm were conducted to assess how changes in specific HEI-2010 component scores relate to changes in quantities of food or nutrients consumed.[17] For example, for the whole grains component scoring (eTable 1 in the Supplement), a 0-ounce equivalent of whole grains per 1000 calories earns 0 points and 1.5-ounce equivalents per 1000 calories earns 10 points on the HEI-2010 scoring algorithm; points are distributed proportionally for all intake between 0-ounce and 1.5-ounce equivalents per 1000 calories. Therefore, every 0.15-ounce equivalent per 1000 calories equals an additional 1 point in the HEI-2010 whole grains component score (until the maximum points are reached). An exploratory analysis assessed changes in dietary quality of foods consumed after lunch (after 2 PM). Because of the potential for type I error due to multiple comparisons, findings for analyses of secondary end points should be interpreted as exploratory. A complete case analysis was performed, excluding participants with missing information on any covariate. Multiple imputation was performed as a sensitivity analysis.

# Results

There were 10 746 students aged 5 to 18 years surveyed in the 2007-2008, 2009-2010, 2013-2014, and 2015-2016 NHANES data cycles. Of these students, 6934 met inclusion

criteria. The analytic sample included 6389 students (5317 as proxy respondents) who had complete information on covariates (510 missing family income and 33 missing body mass index data) and an HEI-2010 score for the total day (2 missing HEI-2010 total day score), with 32% of the weighted sample categorized as low-income students (**Table 1** and eMethods in the Supplement). The characteristics of participants were similar for NSLP participants and nonparticipants. The main differences were age and time of year surveyed, with older students, students in higher grades, and students surveyed during May to October less likely to be NSLP participants. The characteristics of participants and nonparticipants within the prepolicy compared with postpolicy implementation period are shown in eTable 2 in the Supplement.

**Figure 1** and eTable 3 in the Supplement show unadjusted mean HEI-2010 lunch and total day scores for NSLP participants and nonparticipants by income and time period. Unadjusted mean HEI-2010 total day component scores using the population ratio method, stratified by income and time period, are shown in eTable 4 in the Supplement.[18]

**Table 2** shows the estimated association of the HHFKA policy with mean HEI-2010 scores for lunch and total day, according to income category from covariate-adjusted difference-in-differences models. NSLP participants had positive differences in the HEI-2010 lunch score, comparing prepolicy with postolicy scores, for low-income (42.7 [95% CI, 40.9-44.5] vs 54.6 [95% CI, 53.0-56.1]; difference, 11.9 [95% CI, 9.4-14.3]), low-middle-income (40.4 [95% CI, 37.2-43.7] vs 54.8 [95% CI, 51.1-58.4]; difference, 14.3 [95% CI, 9.6-19.1]), and middle-high-income (42.7 [95% CI, 40.6-44.9] vs 55.5 [95% CI, 53.2-57.9]; difference, 12.8 [95% CI, 9.8-15.8]) students. For NSLP nonparticipants, differences in the HEI-2010 lunch score comparing prepolicy with postpolicy scores were not statistically significant for low-income (34.8 [95% CI, 32.7-36.9] vs 34.1 [95% CI, 32.1-36.0]; difference, −0.7 [95% CI, −3.6 to 2.1]) and low-middle-income (34.2 [95% CI, 30.1-38.2] vs 36.1 [95% CI, 32.7-39.5]; difference, 2.0 [95% CI, −2.9 to 6.8]) students, but were positive and statistically significant for middle-high-income students (38.9 [95% CI, 37.4-40.4] vs 43.6 [95% CI, 41.7-45.5]; difference, 4.7 [95% CI, 2.3-7.0]).

The primary results of this study are the difference-in-differences estimates, which indicated significantly larger differences in the prepolicy vs postpolicy HEI-2010 score for NSLP participants compared with nonparticipants for low-income (difference in differences, 12.6 [95% CI, 8.9-16.3]), low-middle-income (difference in differences, 12.4 [95% CI, 4.9-19.9]), and middle-high-income (difference in differences, 8.1 [95% CI, 4.2-12.0]) students (Table 2). Primary analyses were substantively similar under model specifications explored in the robustness checks, including multiple imputation (eTable 5 and eTable 6 in the Supplement).

For secondary outcomes, for HEI-2010 total day scores, the difference-in-differences estimates indicated that the mean score increased by 3.4 (95% CI, 0.5-6.3) for low-income NSLP participants and 4.7 (95% CI, 0.8-8.7) for low-middle-income NSLP participants compared with the changes seen among nonparticipants after policy implementation (Table 2). There were no significant associations for HEI-2010 total day scores for middle-high-income students (difference in differences, 1.9 [95% CI, −0.8 to 4.5]).

Differences in HEI-2010 lunch scores by NSLP participation status were not statistically significant for any income group for prepolicy changes (low income: difference in differences, −2.4 [95% CI, −7.8 to 3.0]; low-middle income: difference in differences, −7.1 [95% CI, −15.3 to 1.2]; middle-high income: difference in differences, −2.2 [95% CI, −8.0 to 3.6]) (eTable 7 in the Supplement). The results of secondary analyses of differences in consumption of specific categories of food are shown in **Figure 2** and eTable 8 and the eResults in the Supplement. For HEI-2010 lunch component scores, there were significantly greater positive differences between NSLP participants compared with nonparticipants for greens and beans, whole grains, and refined grains within all 3 income categories (Figure 2).

In the post hoc analysis to assess how changes in component scores correspond to approximate changes in quantities of food or nutrients, a 0.2-point increase in the greens and beans adequacy component score corresponds to an increase in consumption of 0.01-cup equivalent per 1000 calorie servings of foods categorized as greens and beans (ie, 0.2 points × 0.04-cup equivalent per 1000 calories per point), a 3.5-point increase in the whole grain adequacy component score corresponds to an increase in consumption of 0.53-ounce equivalent per 1000 calorie servings of whole grain foods (ie, 3.5 points × 0.15-ounce equivalent per 1000 calories per point), and a 1.4-point increase for the refined grains moderation component score corresponds to a decrease in consumption of 0.35-ounce equivalent per 1000 calorie servings of refined grain foods (ie, 1.4 points × 0.25-ounce equivalent per 1000 calories per point) (eTable 1 in the Supplement). In the exploratory analysis to assess dietary quality for students after lunch, there were no significant associations for the difference-in-differences estimates for postlunch HEI-2010 scores for NSLP participants compared with nonparticipants after HHFKA policy implementation (eTable 9 in the Supplement).

## Discussion

In this serial cross-sectional study, there were greater positive differences in dietary quality of lunch among low-income, low-middle-income, and middle-high-income NSLP participants compared with nonparticipants after implementation of the HHFKA in 2012.

The differences in HEI-2010 lunch scores observed in this study (increase of 12.6 points among low-income, 12.4 points among low-middle-income, and 8.1 points among middle-high-income students) were greater in magnitude than differences observed in other studies that used the HEI-2010 as an outcome measure.[19,20] Differences for specific components of the HEI-2010 score correspond to changes in the consumption of specific foods or nutrients.

Table 1. Characteristics of Participants in a Study of the Association of the Healthy, Hunger-Free Kids Act With Dietary Quality Among Participants in the National School Lunch Program (NSLP)

| Characteristic | No. (%)[a] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | NSLP | | Income[b] | | | | | |
| | | | | Low | | Low-middle | | Middle-high | |
| | All students | Participants | Nonparticipants | NSLP participants | NSLP nonparticipants | NSLP participants | NSLP nonparticipants | NSLP participants | NSLP nonparticipants |
| No. | 6389 | 2472 | 3917 | 1211 | 1599 | 365 | 522 | 896 | 1796 |
| Year | | | | | | | | | |
| 2007-2008 | 1549 (24.4) | 634 (24.2) | 915 (24.4) | 272 (21.6) | 396 (25.5) | 83 (18.9) | 113 (23.4) | 279 (28.3) | 406 (24.2) |
| 2009-2010 | 1625 (24.2) | 588 (22.4) | 1037 (25.2) | 305 (22.7) | 417 (25.5) | 84 (20.9) | 146 (27.9) | 199 (22.5) | 474 (24.6) |
| 2013-2014 | 1675 (25.9) | 667 (27.0) | 1008 (25.3) | 382 (32.3) | 417 (24.2) | 93 (29.9) | 118 (20.1) | 192 (21.3) | 473 (26.7) |
| 2015-2016 | 1540 (25.5) | 583 (26.4) | 957 (25.0) | 252 (23.3) | 369 (24.7) | 105 (23.3) | 145 (28.6) | 226 (30.4) | 443 (24.5) |
| Age, y | | | | | | | | | |
| 5-8 | 1682 (24.3) | 772 (28.2) | 910 (22.1) | 394 (31.4) | 391 (22.1) | 107 (22.4) | 112 (19.6) | 271 (27.2) | 407 (22.6) |
| 9-13 | 2199 (32.3) | 921 (34.9) | 1278 (30.8) | 471 (36.9) | 508 (29.0) | 136 (37.1) | 179 (34.1) | 314 (32.3) | 591 (31.1) |
| 14-18 | 2508 (43.4) | 779 (36.9) | 1729 (47.0) | 346 (31.7) | 700 (48.8) | 122 (40.5) | 231 (46.4) | 311 (40.5) | 798 (46.3) |
| Sex | | | | | | | | | |
| Male | 3244 (50.1) | 1340 (54.9) | 1904 (47.5) | 626 (49.5) | 769 (46.6) | 195 (52.5) | 241 (42.7) | 519 (60.5) | 894 (48.7) |
| Female | 3145 (49.9) | 1132 (45.1) | 2013 (52.5) | 585 (50.5) | 830 (53.4) | 170 (47.5) | 281 (57.2) | 377 (49.5) | 902 (51.3) |
| Race/ethnicity[c] | | | | | | | | | |
| Non-Hispanic white | 1880 (55.9) | 639 (48.8) | 1241 (59.7) | 254 (35.1) | 318 (34.2) | 81 (39.8) | 116 (42.2) | 304 (64.2) | 807 (74.3) |
| Non-Hispanic black | 1570 (14.5) | 652 (16.7) | 918 (13.3) | 350 (22.0) | 414 (20.6) | 97 (19.1) | 158 (21.1) | 205 (11.2) | 346 (8.6) |
| Mexican American | 1531 (14.3) | 681 (18.2) | 850 (12.2) | 378 (24.5) | 496 (26.1) | 106 (20.3) | 136 (19.8) | 197 (11.7) | 218 (4.6) |
| Other non-Hispanic | 641 (7.8) | 218 (8.2) | 423 (7.6) | 84 (8.6) | 120 (6.5) | 41 (11.7) | 46 (6.4) | 93 (6.7) | 257 (8.4) |
| Other Hispanic | 767 (7.5) | 282 (8.1) | 485 (7.2) | 145 (9.9) | 251 (12.6) | 40 (9.1) | 66 (10.6) | 97 (6.0) | 168 (4.2) |
| Income level | | | | | | | | | |
| ≤130% of the federal poverty line | 2810 (32.4) | 1211 (40.7) | 1599 (27.8) | | | | | | |
| >130-≤185% of the federal poverty line | 887 (11.9) | 365 (14.5) | 522 (10.6) | | | | | | |
| >185% of the federal poverty line | 2692 (55.7) | 896 (44.8) | 1796 (61.6) | | | | | | |
| School level | | | | | | | | | |
| Elementary (K-5th grade) | 3510 (50.1) | 1561 (57.1) | 1949 (46.4) | 797 (62.3) | 809 (45.2) | 225 (54.1) | 252 (45.7) | 539 (53.2) | 888 (47.0) |
| Middle (6th-8th grade) | 1499 (25.0) | 535 (24.8) | 964 (25.1) | 257 (23.8) | 393 (25.9) | 87 (28.2) | 128 (25.0) | 191 (24.6) | 443 (24.7) |
| High (9th-12th grade) | 1380 (24.9) | 376 (18.1) | 1004 (28.6) | 157 (13.9) | 397 (28.8) | 53 (17.7) | 142 (29.3) | 166 (22.2) | 465 (28.3) |
| Period of dietary recall | | | | | | | | | |
| November-April | 3099 (40.8) | 1416 (51.1) | 1683 (35.1) | 703 (55.0) | 722 (41.5) | 212 (53.3) | 239 (39.0) | 501 (46.9) | 722 (31.6) |
| May-October | 3290 (59.2) | 1056 (48.9) | 2234 (64.9) | 508 (45.0) | 877 (58.5) | 153 (46.7) | 283 (61.0) | 395 (53.1) | 1074 (68.4) |

(continued)

Table 1. Characteristics of Participants in a Study of the Association of the Healthy, Hunger-Free Kids Act With Dietary Quality Among Participants in the National School Lunch Program (NSLP) (continued)

| Characteristic | No. (%)[a] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | NSLP | | Income[b] | | | | | | |
| | | | | Low | | Low-middle | | Middle-high | | |
| | All students | Participants | Nonparticipants | NSLP participants | NSLP nonparticipants | NSLP participants | NSLP nonparticipants | NSLP participants | NSLP nonparticipants |
| Age, mean (95% CI), y | 11.7 (11.6-11.9) | 11.2 (11.0-11.4) | 12.0 (11.8-12.2) | 10.8 (10.5-11.1) | 12.1 (11.9-12.3) | 11.4 (10.9-11.9) | 12.2 (11.7-12.7) | 11.5 (11.1-11.8) | 12.0 (11.7-12.3) |
| Body mass index, mean (95% CI) | 21.1 (20.9-21.4) | 21.0 (20.7-21.4) | 21.2 (20.8-21.5) | 21.0 (20.5-21.6) | 22.1 (21.6-22.6) | 21.6 (20.9-22.4) | 21.7 (21.0-22.4) | 20.8 (20.2-21.5) | 20.7 (20.3-21.1) |
| HEI-2010 score, mean (95% CI)[d] | | | | | | | | | |
| Lunch | 42.4 (41.6-43.3) | 49.4 (48.1-50.6) | 38.6 (37.4-39.8) | 49.6 (48.1-51.2) | 34.2 (32.7-35.7) | 49.8 (46.7-52.9) | 34.6 (31.5-37.6) | 49.1 (47.0-51.2) | 41.3 (40.0-42.6) |
| Total day | 48.0 (47.3-48.6) | 49.4 (48.6-50.3) | 47.2 (46.3-48.0) | 49.6 (48.4-50.9) | 45.0 (43.9-46.0) | 49.6 (47.7-51.6) | 45.2 (43.3-47.0) | 49.2 (48.0-50.4) | 48.5 (47.4-49.5) |

[a] Percentages are calculated based on the survey weighted sample; means and 95% CIs are estimated accounting for the complex sampling design and using Taylor series linearized standard errors.

[b] Income was categorized using criteria for free, reduced-price, and full-price lunch (≤130% of the federal poverty line indicates low income; >130%-≤185% of the federal poverty line, low-middle income; and >185% of the federal poverty line, middle-high income).

[c] Race and ethnicity were self-reported by the student or a proxy based on fixed categories provided by the National Center for Health Statistics.

[d] The Healthy Eating Index-2010 (HEI-2010) score is the sum of 12 component scores that align with key food groups and nutrients (range, 0-100; 100 represents complete adherence to the 2010 Dietary Guidelines for Americans and 0 represents no adherence). Scoring standards are set based on a density approach so that component scores are based on per 1000 calories or as a percentage of calories to measure dietary quality of children who have varying energy requirements. Nine of the component scores reflect adequacy of nutrient intake, including consumption of total vegetables (and dark green and orange vegetables and legumes), total fruit (and whole fruit), whole grains, dairy, total protein foods (and seafood and plant proteins), and fatty acids, and 3 of the component scores reflect moderation of intake, including refined grains; sodium; and energy from solid fats, alcohol, and added sugars. A score of 40 can be interpreted as a diet adhering to 40% of the recommendations from the dietary guidelines. A minimum clinically important difference has not been established.

Although no studies, to the authors' knowledge, have assessed the association of the HHFKA with the overall dietary quality of foods consumed at lunch or the entire day, the findings of this study are consistent with those of a study conducted by Gearan and Fox,[5] which found that nutritional quality of meals served in the NSLP improved by 41% after implementation of the HHFKA, and with the findings of the School Nutrition and Meal Cost Study,[21] which also assessed the association of the policy with child dietary quality of 4 HEI components (total fruit, whole fruit, total vegetables, and dairy) and found significant positive differences in dietary quality for total fruit and whole fruit for NSLP participants after policy implementation. Although the current study comes to similar conclusions, direct comparisons are difficult because the School Nutrition and Meal Cost Study did not measure changes in HEI-2010 scores, a summary measure of changes in overall nutritional quality of foods consumed, or account for changes in the comparison group.[21]

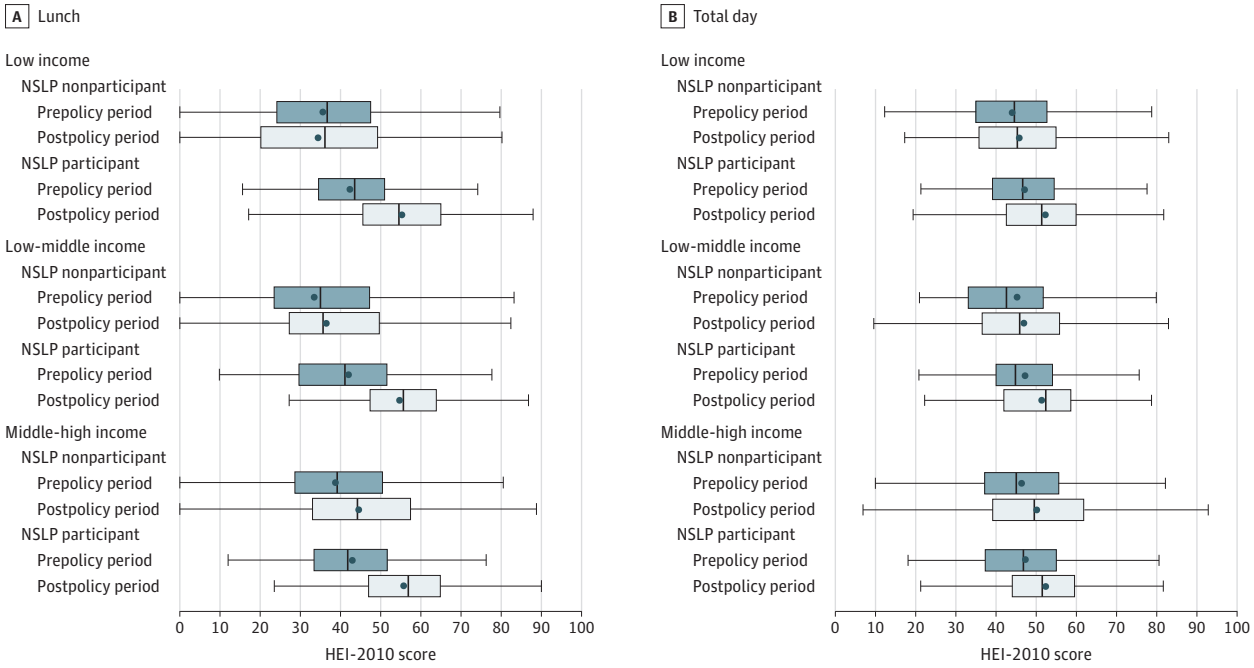
Although the primary analyses of this study focused on the dietary quality of lunch, because this was the meal hypothesized to be directly affected by the HHFKA, secondary analyses found greater differences in dietary quality for the entire day in association with the HHFKA for NSLP participants compared with nonparticipants for low-income and low-middle-income students. There are at least 2 potential ways by which this policy could be associated with dietary quality for the entire day. First, higher dietary quality scores for lunch may influence the score for the entire day (ie, lunch improves, but other meals remain unchanged). Second, dietary changes at lunch may result in altered intake at other meals as well (ie, lunch improves and other meals also improve). The exploratory analysis of all foods eaten after 2 PM indicate that there were no statistically significant differences in dietary quality of foods eaten after 2 PM for NSLP participants compared with nonparticipants in each income category. These findings support the former explanation, although future studies could more thoroughly explore the relationship between dietary quality scores for lunch compared with other meals.

The findings of this study indicate that the original HHFKA policy implemented in 2012 was associated with higher dietary quality for lunch among low-income, low-middle-income, and middle-high-income students from 2013 to 2016. In 2018, the policy was made less strict, allowing for fewer whole grains, more sodium, and more flavored milk.[22] In 2020, the USDA was actively considering additional changes to this policy to allow fewer weekly servings of a variety of vegetables.[23] The current study provides the first nationally representative evidence for the original, more stringent formulation of this policy's association with 1 of the intended health outcome intermediates—the overall nutritional quality of students' dietary intake. It is unclear whether these higher levels of dietary quality for students will continue if nutrition standards of the HHFKA are altered.

## Limitations

This study has several limitations. First, this study estimated whether a student was an NSLP participant or nonparticipant

Figure 1. Unadjusted Mean Healthy Eating Index-2010 (HEI-2010) Scores Before and After the Healthy, Hunger-Free Kids Act Among National School Lunch Program (NSLP) Participants and Nonparticipants




Dots represent the unadjusted mean HEI-2010 scores and boxes represent the 95% CIs. Boxplots show the 25th, 50th (median), and 75th percentile of the weighted distributions. The whiskers extend to the upper and lower adjacent values, the farthest values within 1.5 × the interquartile range beyond the 25th and 75th percentiles. Exact values are presented in eTable 3 in the Supplement.

Table 2. Regression-Based Difference-in-Differences Estimates of Mean Healthy Eating Index-2010 (HEI-2010) Scores Among National School Lunch Program (NSLP) Participants and Nonparticipants From Before to After the Healthy, Hunger-Free Kids Act (HHFKA)[a]

| | Mean (95% CI) | | | | | | |
|---|---|---|---|---|---|---|---|
| | NSLP participants | | | NSLP nonparticipants | | | Difference-in-differences estimate (95% CI)[e] |
| HEI-2010 score | Before HHFKA implementation[c] | After HHFKA implementation | Difference[d] | Before HHFKA implementation[c] | After HHFKA implementation | Difference[d] | |
| **Low income[b]** | | | | | | | |
| Lunch | 42.7 (40.9 to 44.5) | 54.6 (53.0 to 56.1) | 11.9 (9.4 to 14.3) | 34.8 (32.7 to 36.9) | 34.1 (32.1 to 36.0) | −0.7 (−3.6 to 2.1) | 12.6 (8.9 to 16.3) |
| Total day | 47.2 (45.5 to 48.9) | 51.3 (49.8 to 52.8) | 4.2 (2.0 to 6.4) | 44.7 (43.4 to 46.1) | 45.5 (43.8 to 47.2) | 0.8 (−1.3 to 2.9) | 3.4 (0.5 to 6.3) |
| **Low-middle income[b]** | | | | | | | |
| Lunch | 40.4 (37.2 to 43.7) | 54.8 (51.1 to 58.4) | 14.3 (9.6 to 19.1) | 34.2 (30.1 to 38.2) | 36.1 (32.7 to 39.5) | 2.0 (−2.9 to 6.8) | 12.4 (4.9 to 19.9) |
| Total day | 45.9 (43.7 to 48.2) | 51.4 (48.5 to 54.3) | 5.4 (2.2 to 8.6) | 45.2 (42.7 to 47.7) | 45.9 (43.7 to 48.0) | 0.7 (−2.6 to 4.0) | 4.7 (0.8 to 8.7) |
| **Middle-high income[b]** | | | | | | | |
| Lunch | 42.7 (40.6 to 44.9) | 55.5 (53.2 to 57.9) | 12.8 (9.8 to 15.8) | 38.9 (37.4 to 40.4) | 43.6 (41.7 to 45.5) | 4.7 (2.3 to 7.0) | 8.1 (4.2 to 12.0) |
| Total day | 46.7 (45.6 to 47.7) | 51.9 (50.0 to 53.9) | 5.3 (3.2 to 7.4) | 46.7 (45.7 to 47.7) | 50.1 (48.5 to 51.7) | 3.4 (1.6 to 5.3) | 1.9 (−0.8 to 4.5) |

[a] The HHFKA of 2010 was a policy implemented nationwide in July 2012 that required changes to the school nutrition standards for meals served as part of the NSLP to more closely align with the 2010 Dietary Guidelines for Americans. This was the first policy change to school nutrition standards since 1994. The pre-HHFKA period includes data from 2007-2010 and post-HHFKA period includes data from 2013-2016.

[b] Income was categorized using criteria for free, reduced-price and full-price lunch (≤130% of the federal poverty line indicates low income; >130%-≤185% of the federal poverty line, low-middle income; and >185% of the federal poverty line, middle-high income).

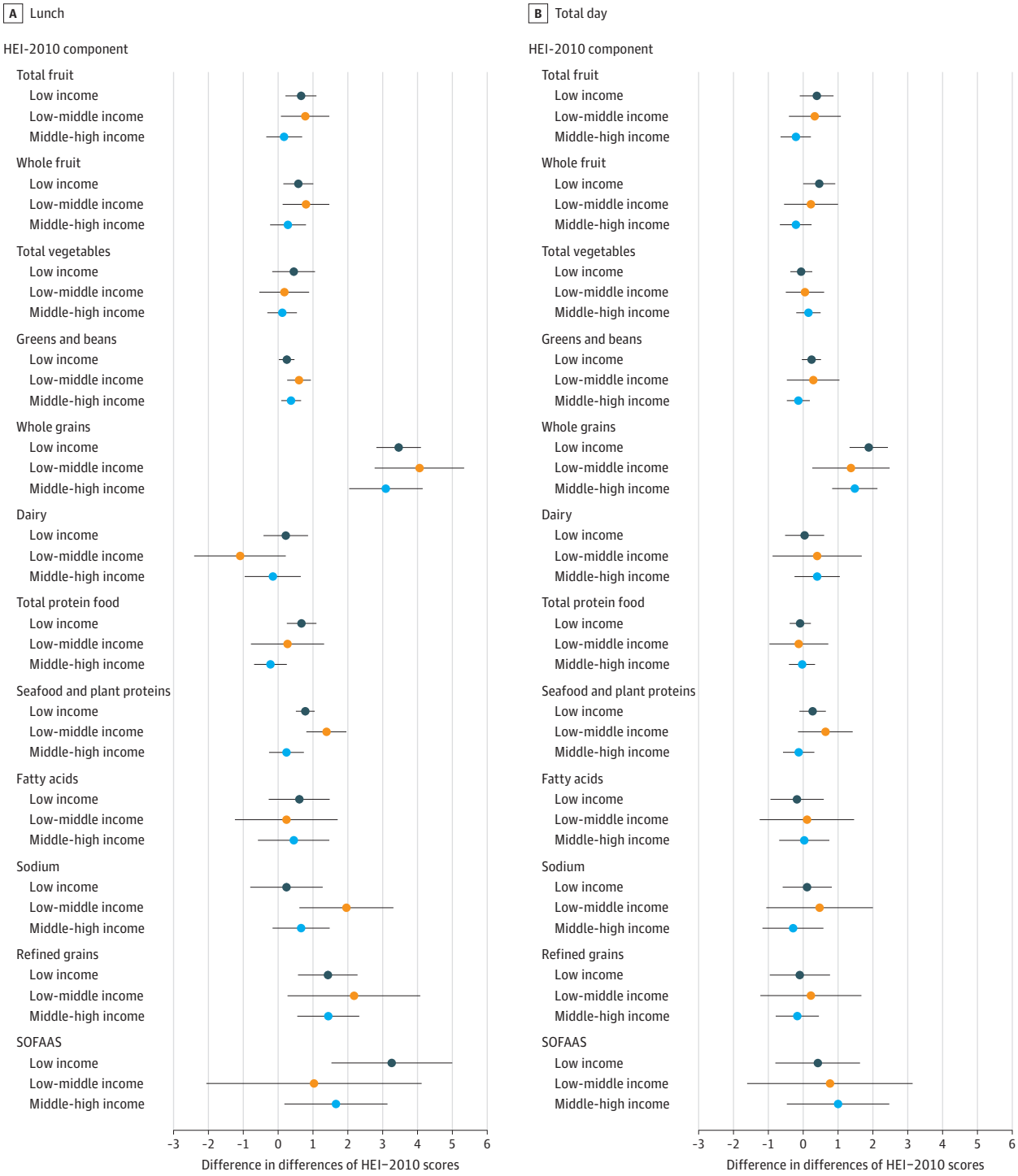
[c] 95% CIs are estimated accounting for survey sampling design from Taylor series linearized standard errors.

[d] Mean difference is calculated as post-HHFKA mean score minus pre-HHFKA mean score.

[e] Regression-based difference-in-differences estimates were adjusted for age, sex, race/ethnicity, school level, period of dietary recall, and body mass index.

with an algorithm that identified students who likely received a reimbursable lunch from the school cafeteria. Although this algorithm has been used previously, it has not been evaluated for criterion validity and, consequently, its sensitivity and specificity for classifying NSLP participants is unknown.[15,24,25] Students who brought lunch from home but

Figure 2. Difference in Differences of Healthy Eating Index-2010 (HEI-2010) Scores Before and After the Healthy, Hunger-Free Kids Act Among National School Lunch Program (NSLP) Participants and Nonparticipants




Error bars represent the 95% CI. Exact values of means and 95% CIs are presented in eTable 8 in the Supplement. SOFAAS indicates solid fats, alcohol, and added sugars.

supplemented it with items from the cafeteria could have been misclassified as participants if they supplemented with 3 meal components or if they supplemented with 2 meal components and reported that they obtained meals every day from the cafeteria. Students who took a school lunch, ate only 1 component from it, and did not have anything else to eat could have been misclassified as nonparticipants, even if they typically ate a school lunch. Second, self-reported

(or proxy-reported) 24-hour dietary intake is subject to random and systematic error. Systematic error is limited by adjusting for total energy in the scoring of the HEI-2010 and using a computer-assisted personal interview system for the dietary recall. Third, Smart Snacks guidelines were implemented in the last years of our observation period, changing nutrition standards for a la carte items and snacks at school.[26] If nonparticipants consumed these items, the results of this study could be an underestimation for the association of the HHFKA with dietary quality of lunch intake for children. Fourth, schools may have been in varying degrees of compliance with the HHFKA, because implementing a federal policy on a state and local level is complex. For this reason, the 2011-2012 NHANES data cycle was excluded because the policy was introduced in 2010 and schools were expected to be in full compliance with the policy by July 2012. Local school food authorities are audited by agencies that administer the NSLP on a state level and the USDA on a federal level.[4] Based on these audits, schools must be in compliance with the standards to receive reimbursement for meals served. Frequent audits enforce local school food authorities to implement and uphold the HHFKA policy. Consistent with this, Au and colleagues[27] found that, from 2013 to 2015, 74% of schools in a sample of 401 elementary and middle schools complied with the revised nutrition standards of the HHFKA with no differences in adherence to the HHFKA standards observed by school poverty level.

## Conclusions

In a serial cross-sectional study of students, the HHFKA of 2010 was associated with better changes in dietary quality for lunch among presumed low-income, low-middle-income, and middle-high-income participants in the NSLP compared with nonparticipants.


### ARTICLE INFORMATION

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**Author Contributions:** Ms Kinderknecht and Dr Jones-Smith had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.
*Concept and design:* Kinderknecht, Jones-Smith.
*Acquisition, analysis, or interpretation of data:* All authors.
*Drafting of the manuscript:* Kinderknecht, Jones-Smith.
*Critical revision of the manuscript for important intellectual content:* All authors.
*Statistical analysis:* Kinderknecht, Jones-Smith.
*Supervision:* Harris, Jones-Smith.

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