**Abstract**

**Objective** In 2012, the U.S. government overhauled school nutrition standards, but few studies have evaluated effects of these standards at the national level. This study examines the impact of the updated school nutrition standards on dietary and health outcomes of school children in a nationally-representative dataset.

**Design** Difference-in-differences. We compared weekday fruit and vegetable intake between students with daily school lunch participation and students without school lunch participation before and after implementation of updated school nutrition standards using a multivariable linear regression model. Secondary outcomes included weekday solid fats and added sugars (SoFAS) intake and overweight and obesity prevalence. We adjusted analyses for demographic and family socioeconomic factors.

**Setting:** United States.

**Subjects:** K-12 students, ages 6-20 years old (n=9,172), from the National Health and Nutrition Examination Survey, 2005-2016.

**Results** Implementation of updated school nutrition standards was not associated with a change in weekday fruit and vegetable intake (β= 0.02 cups, 95% CI: -0.23, 0.26) for students with daily school lunch participation. However, implementation of the policy was associated with a 1.5 percentage point (95% CI: -3.0, -0.1) decline in weekday SoFAS intake and a 6.1 percentage point (95% CI: -12.1, -0.1) decline in overweight and obesity prevalence.

**Conclusions** Changes to US school nutrition standards were associated with reductions in consumption of SoFAS as well as a decrease in overweight and obesity in children who eat school lunch. However, we did not detect a change in weekday intake of fruits and vegetables associated with the policy change.

**Keywords**: nutrition policy, school nutrition, diet, overweight and obesity

**Introduction**

Over the past half-century, rates of childhood obesity have tripled in the United States(1). In the midst of this childhood obesity epidemic, the Healthy, Hunger-Free Kids Act (HHFKA) was passed in 2010 to address both childhood obesity and food insecurity in the US(2). This Act included a mandate for the US Department of Agriculture (USDA) to overhaul the nutrition standards for school meals, which had not occurred since 1995. A 2010 Institute of Medicine (IOM) report previously found that school nutrition standards were not aligned with the contemporaneous Dietary Guidelines for Americans (DGA), specifically that standards required less fruits, vegetables, and whole grains than recommended by the DGA, and that students were deriving a higher than recommended percentage of calories from added sugars and saturated fats(3). The IOM’s recommendations, which were grounded in the DGA 2010, helped shape updated school nutrition standards that were implemented for the National School Lunch Program (NSLP) primarily in the 2012-2013 school year. The updated standards notably increased the amount and variety of fruits and vegetables, set maximum calorie limits for the first time, required that grains be whole-grain rich, and allowed only non-fat milks to be flavored (i.e. contain added sugar)(4).

Since implementation of updated school nutrition standards, studies have examined its impact on fruit and vegetable selection and consumption, food waste, nutritional profile of meals, and participation in the NSLP. Multiple studies showed improvements in the nutritional value of school meal options(5-8), and several studies showed no significant decrease in NSLP participation(7, 9-11). Field studies at school cafeterias found increases in fruit selection by 20%(10) and vegetable consumption by 16-20%(10, 12), and one large cross-sectional survey showed that Healthy Eating Index scores of lunch-specific dietary intake was significantly higher in students eating NSLP school lunches compared to those who did not eat NSLP school lunches(13). Most field studies did not show increased fruit and vegetable food waste after implementation of 2012 nutrition standards(10, 12, 14, 15), though one study in Vermont demonstrated otherwise(16).

Most prior studies of the updated school nutrition standards have occurred at the school or district level, precluding conclusions generalizable to the greater U.S. population(17, 18). Two recent national studies have captured a cross-section of school meals and dietary intake but occurred primarily after implementation of the updated school nutrition standards(8, 19). We used nationally-representative, repeated cross-sectional data before and after implementation of the updated school nutrition standards to study whether the policy was associated with changes in 1.) weekday fruit and vegetable intake, 2.) weekday solid fats and added sugars (SoFAS) intake, and 3.) overweight and obesity prevalence in children participating in NSLP compared to children who did not participate in NSLP.

**Methods**

*Study Design and Data Collection*

We used a difference-in-differences design with data from the 2005-2016 National Health and Nutrition Examination Survey (NHANES). NHANES is an annual nationally-representative survey examining the health and nutritional status of U.S. adults and children. Each year, 15 counties are selected to sample residents. Participants complete questionnaires with an interviewer in their own homes. On a subsequent day, they visit the medical examination center (MEC), a mobile trailer that travels from county to county, to complete medical evaluations and a 24-hour dietary recall with a trained dietary interviewer. Children ages six to 11 complete the dietary recall with a proxy, generally a parent, and children ages 12 and older complete the dietary recall independently. The majority of participants complete a second 24-hour dietary recall by phone three to ten days after the MEC visit. Further details on sampling and data collection methods for NHANES are reported elsewhere(20). We included NHANES data from questionnaires, the medical evaluation, and 24-hour dietary recalls.

We used the Food Patterns Equivalents Database (FPED) to obtain dietary intake from NHANES by food groups. Food intake data collected during 24-hour dietary recalls in NHANES are recorded as food item codes, and FPED converts these codes into the 37 USDA food groups with standardized units, such as fruits and vegetables in cup equivalents, solid fats in gram equivalents, and added sugars in teaspoon equivalents(21).

*Study Sample*

Eligible subjects were children, ages 6 to 20 years old, with weekday dietary intake data who either ate all lunches or no lunches from the in-house lunch at K-12 schools that served daily school meals in NHANES from 2005 to 2016. We excluded individuals less than 72 months old (6 years old) as their dietary recall data in NHANES was exclusively reported by proxy. We also excluded students on medical diets (diabetic, renal, or celiac)~~,~~ and those with missing data on study exposure status or outcomes.

As NHANES is public, de-identified data, this study was considered exempt by the Boston University Institutional Review Board.

*Exposures and Outcomes*

Using the question “During the school year, about how many times a week do you/does [sample person] usually get a complete school lunch?” from the Diet, Behavior, and Nutrition questionnaire, we classified those who reported eating school lunch five times weekly as NSLP participants and those who reported eating no school lunches weekly as non-participants.

Since the updated school nutrition standards were implemented in 2012 (henceforth referred to as “intervention”), we classified subjects responding to NHANES surveys from 2005-2010 as pre-intervention and subjects from 2013-2016 as post-intervention. Because NHANES releases data in two-year cycles but withholds the specific month and year of data collection for each subject, we categorized respondents from the 2011 to 2012 NHANES survey as being in a transition period as we were not able to distinguish between those who were surveyed before the start of the 2012-2013 school year and those who were surveyed during that school year when the intervention was implemented.

In the primary analysis, we restricted dietary data to weekday intake since the updated school nutrition standards only directly affected weekday intake. The primary outcome was weekday fruit and vegetable intake assessed over a 24-hour period and expressed in cup equivalents. This outcome included the following FPED components: citrus, melons, and berries; other fruits; fruit juice; dark green vegetables; red, and orange vegetables; starchy vegetables; other vegetables; beans and peas (legumes)(22). We used given day estimates for subjects with one day of weekday dietary recall data (55.4%) and within-person mean estimates for subjects with two days of weekday dietary recall data (44.6%). Prior to summing, high fruit intake and vegetable intake were truncated at the 99th percentile value to reduce implausible values(23). Secondary outcomes included weekday SoFAS intake, expressed as a percentage of daily calories, and overweight and obesity prevalence. BMI was calculated from measured height and weight in NHANES. We used conventional BMI-for-age percentiles to classify subjects as underweight, normal weight, overweight, or obese(24).

We identified potential covariates based on our *a priori* conceptualization of the relationship between school lunch and dietary intake. Covariates included age, sex, race/ethnicity, screen time, country of birth and marital status of the household reference person, household education level, and family income as a percentage of the federal poverty level (FPL). NHANES defines the household reference person as “the first household member 18 years of age or older listed on the household member roster, who owns or rents the residence where members of the household reside(25).” Reference person data is commonly used to characterize household socioeconomic status for survey subjects. Household education level was the higher of education levels between the household reference person and spouse. Family income as a percentage of FPL was categorized into three levels: less than 130% FPL, 130 to 185% FPL, and greater than 185% FPL.

*Statistical Analysis*

We calculated mean weekday fruit and vegetable intake, mean weekday SoFAS intake, and mean overweight and obesity prevalence in NSLP participants and non-participants for each of the NHANES two-year data cycles, adjusted for the previously mentioned covariates. Using multiyear sample weights for NHANES 2005 to 2016, we applied the one-day dietary weight to dietary outcomes and the MEC weight to BMI(26). We plotted mean values with standard error bars to visualize trends over the study period between NSLP participants and non-participants.

We used linear regression with a difference-in-differences design specification to estimate the impact of the intervention based on the comparison of post-intervention change in each outcome measure in NSLP participants with the corresponding change within non-participants not affected by the intervention(27, 28). Specifically, we used a linear regression model for each outcome, including indicators of school lunch participation, intervention period, transition period, and the interaction of school lunch participation and the intervention. The parameter estimate for the interaction term provides the difference-in-differences estimate of the effect of the updated school nutrition standards on our study outcomes.

We included covariates identified above in multivariable linear regression models, and retained each covariate that changed the effect estimate for each outcome by 10% or more. Due to a high prevalence of missing data for some covariates (16.2% missing screen time, 6.7% missing family income), we used multiple imputation to generate plausible values for missing covariate data. We generated 20 imputed datasets and calculated adjusted estimates for each of the imputed datasets. We combined effect estimates and standard errors from each imputed dataset.

To determine whether the effects of the intervention on our primary outcome differed by other factors, we considered stratification by 1.) sex, 2.) categorical family income as a percent of FPL, which has been shown to modulate school lunch participation(11), 3.) race/ethnicity, which is known to be correlated with dietary differences, and 4.) school level (elementary, middle, high), as students gain more autonomy to select and decline school lunch items when they graduate from elementary school to middle and high school(4). For each case, we estimated an extension of the above model wherein difference-in-differences are compared across the stratified groups (i.e., by including three-way interactions). We conducted stratified analyses if the three-way interaction term (intervention\*exposure\*stratifying variable) was significant at α = 0.10.

In sensitivity analyses, we further examined the effect of the intervention in weekday fruit and vegetable intake by separating out non-starchy vs. starchy vegetables and whole/cut fruit vs. fruit juice. We also estimated the effect of the intervention in 24-hour fruit and vegetable intake, 24-hour SoFAS intake, and overweight and obesity in eligible students with either weekday or weekend dietary data.

All analyses were performed with SAS 9.4 (SAS Institute Inc., Cary, NC), using survey procedures that accounted for the complex survey design of NHANES.

**Results**

From 2005 to 2016, NHANES surveyed 9,950 children with one or more weekday 24-hour dietary recalls who either ate all lunches or no lunches from the in-house lunch at a K-12 school. We excluded 637 individuals who were younger than 72 months old or on a medical diet. We also excluded 184 individuals who were missing data on NSLP participation, dietary intake outcomes, or BMI. The final sample size was 9,172 subjects.

Table 1 displays individual and household characteristics by NSLP participants and non-participants. On average, NSLP participants were younger, more likely to be male, and had higher proportions of non-Hispanic Black and Hispanic individuals than non-participants. Both groups generally spent an average of 3.2 hours per day using a TV or computer. At the household level, 42 percent of NSLP participants had family incomes below 130 percent of the FPL compared with 13 percent of non-participants. Of note, families below 130 percent of the FPL are eligible for free school meals. In addition, another 14 percent of NSLP participants and 9 percent of non-participants had family incomes between 130 and 185 percent of the FPL, the income threshold for reduced-price lunch. NSLP participants were also less likely to live in a household with two adults than non-participants. In 24 percent of NSLP participant households, the household education level was college graduate or higher, compared to 51 percent of non-participants.

From 2005 to 2016, mean weekday fruit and vegetable intake was approximately 2 cup equivalents per day for both NSLP participants and non-participants (Figure 1a). During the study period, weekday SoFAS intake declined in NSLP participants and non-participants to similar levels, though the NSLP group had a higher baseline SoFAS intake (Figure 1b). Overweight and obesity prevalence gradually increased over the study period in both groups (Figure 1c).

The crude effect estimate of the intervention on NSLP participants compared to non-participants showed no change in weekday fruit and vegetable intake (β = 0.06 cup, 95% CI: -0.21, 0.32; Table 2) or overweight and obesity prevalence (β = -4.0%, 95% CI: -9.8, 1.9). With implementation of the intervention, NSLP participants had a reduction of 1.7 percentage points (95% CI: -3.2, -0.2) in weekday SoFAS intake compared to non-participants. After adjusting for age, sex, race/ethnicity, daily screen time, country of birth and marital status of the household reference person, household education level, and %FPL, the effect estimates changed minimally for weekday fruit and vegetable intake (β= 0.02 cups; 95% CI: -0.23, 0.27) and weekday SoFAS intake (β= -1.5%; 95% CI: -3.0, -0.1). Adjustment for potential confounders strengthened effect estimates for overweight and obesity prevalence (β= -6.1%; 95% CI: -12.1, -0.1). Dividing fruit and vegetable intake into starchy vs. non-starchy vegetables (Figure 1S) and whole/cut fruit vs. fruit juice (Figure 2S) demonstrated no significant effects associated with the intervention (Table 1S).

*Stratified analyses*

Three-way interactions incorporating sex, family income level, and school level did not approach significance, and we did not further stratify data by those variables. However, the three-way interaction between the intervention, exposure and race/ethnicity had a p-value of 0.08, and we conducted a stratified analysis by race/ethnicity. The adjusted difference-in-differences estimate for weekday fruit and vegetable intake showed an increase of 0.37 cups (95% CI: 0.13, 0.61; Table 3) in non-Hispanic Black students and an increase of 0.27 cups (95% CI: 0.07, 0.46) in students whose race/ethnicity was categorized as “Other.” Hispanic students had a decline in weekday fruit and vegetable intake by 0.29 cups (95% CI: -0.50, -0.08) associated with the intervention. Estimates for non-Hispanic White students showed no change in weekday fruit and vegetable intake.

An analysis using both weekday and weekend dietary data in a cohort of all eligible NHANES participants (Table 2S) with dietary data, both weekday and weekend, showed attenuation of changes associated with the intervention in all primary and secondary outcomes (Table 3S; Figures 3S-5S).

**Discussion**

This study is the first to our knowledge to use national-level data before and after implementation of updated school nutrition standards to assess dietary changes related to the national policy. Our findings did not demonstrate a change in daily fruit and vegetable intake on weekdays after implementation of the updated school nutrition standards. This result is consistent with those of the USDA School Nutrition and Meal Cost Study, which found no difference in weekday fruit and vegetable intake between NSLP participants and nonparticipants despite reporting significantly higher lunch-specific fruit and vegetable intake in NSLP participants compared to non-participants(13), suggesting that dietary improvements from school lunch can be attenuated by dietary intake in the rest of the day.

Racial and ethnic differences in fruit and vegetable intake associated with the updated school nutrition standards suggest that the policy may have differential effects on different groups. Increased fruit and vegetable intake in Non-Hispanic Black and Other race/ethnicity students without changes in non-Hispanic White students could represent differences in the experiences of urban compared to rural school districts. Perceptions of student complaints, participation, and meal consumption by school administrators have demonstrated rural/urban and socioeconomic divides, with negative perceptions being more prevalent in rural and higher socioeconomic status schools(29). It is difficult to interpret the decline in fruit and vegetable intake in Hispanic students as the composition of this group was likely highly heterogeneous due to immigration and geographic variation from the NHANES sampling approach over the study period(30).

Implementation of updated school nutrition standards was associated with a decline in weekday SoFAS intake, even after adjusting for multiple factors. School nutrition standards that could have affected SoFAS were maximum calorie limits for school meals and limitation of added sugars in milk to only non-fat milk, which has since been liberalized to include low-fat milk(31). This suggests that the NSLP may be one contributor to declines in SOFAS intake in NSLP participants over this time period. While previous cross-sectional data from the School Nutrition and Meal Cost Study showed no significant difference in 24-hour SoFAS intake between NSLP participants and non-participants, use of dietary data prior to the updated school nutrition standards in our study shows that SoFAS intake was higher on average in NSLP participants than non-participants at baseline, which represents a greater decline in SoFAS intake in NSLP participants compared to non-participants. During our study period, Smart Snacks in School, a nutrition standard applied to non-federally-subsidized food sold in schools, was implemented in the 2014-2015 school year. While its implementation had minimal overlap with declines in SoFAS intake during our study period, it may have contributed to those declines due to the possibility that states that preemptively adopted such policies prior to 2014-2015 were included in this study.

After adjusting for potential confounders, our findings suggest that the rising trend in overweight and obesity prevalence was attenuated in NSLP participants due to implementation of updated school nutrition standards. A previous study had shown that states that exceeded 1995 school nutrition standards had lower obesity prevalence in middle school students compared to those who met standards(32). However, in our study, the reduction was weakened after repeating the analysis with a larger sample of students. Expanding our sample to children with weekend dietary data widened the confidence interval despite enlarging the sample size and suggests greater heterogeneity in overweight and obesity that was not captured in our primary sample. The sample was not likely biased by innate differences between NHANES subjects attending MEC visits on weekends vs. weekdays, as a Friday dietary recall was collected on a Saturday and a Sunday dietary recall was collected on a Monday. Changes to overweight and obesity rates occur slowly, and it is possible that a longer follow up period is necessary to precisely demonstrate change at the national level.

Overall, this study suggests that nutrition policies, such as school nutrition standards, can be effective in reducing unhealthy components from children’s diets. However, mandating increased exposure or selection of healthier foods in specific meals does not necessarily lead to significant consumption of those foods. Our null finding in fruit and vegetable intake may be explained by food waste during school meals, which is highest in fruits and vegetables(33) and can therefore undermine the purpose of nutrition standards. In a prior study of eight elementary schools in Houston, despite menu compliance to 2012 nutrition standards, no grades fulfilled the fruit and vegetable requirements by intake due to food waste(34). However, innovative school districts have found success with making vegetables more palatable to students by augmenting the updated school nutrition standards with strategies such as personalizing school meals (e.g. salad bars, spice stations) and student participation (e.g. meal feedback, taste tests, education)(35). Further studies should explore whether these interventions to engage children in healthy eating at lunch lead to sustained fruit and vegetable consumption inside and outside of school. Along with the increase in fruit and vegetable intake seen in certain groups (i.e. non-Hispanic black students), these results do not support reduction of fruit and vegetable requirements proposed by the USDA(36).

Comparing the maximum calories per meal of the 2012 school nutrition standards to the estimated calorie needs in the DGA-2015, daily school breakfast and lunch together often account for less than half of weekly calorie needs during the school year, with variation due to sex, age, and physical activity(37). While the School Breakfast Program also has nutrition standards, including a minimum of one cup of fruit per breakfast, participation in the program is much lower than NSLP(38, 39), and strategies to improve child nutrition in the U.S. may also need to engage parents and caregivers to influence the meals that are served outside the purview of school nutrition policy.

A limitation of our study is that NHANES is an annual cross-sectional survey, therefore effects are neither causal nor do they represent changes at the individual level. There may also be residual confounding due to unmeasured confounders between the exposure and control groups, including physical activity level, free/reduced-price school meal status, and school and community environmental factors. In addition, information on whether weekday dietary intake was collected on a school day was not available, so some weekday data represents dietary intake outside of school days. Furthermore, implementation of updated school nutrition standards was neither simultaneous nor are all schools fully compliant with them. Prior literature shows that some states had preemptively implemented healthier meal requirements before the 2012-2013 school year(32), whereas compliance in school lunch meals in 2014-2015 ranged from 91-93% for daily fruit and vegetable requirements, milk restrictions, and maximum calories(8). As NHANES does not identify surveyed counties, we do not know whether a sampled county had early implementation of meal requirements that more closely follows the updated school nutrition standards. Both issues likely led to non-differential misclassification of the predictors, which could bias our results towards the null. Finally, the Great Recession may have differentially affected NSLP participants more than non-participants, and a difference-in-differences model is unable to control for differential secular trends.

**Conclusions**

Implementation of the updated school nutrition standards for school lunch was associated with decreases in empty calories but not increases in daily fruit and vegetable consumption in this study. This suggests that policies that limit consumption of unhealthy foods in school meals can have a relatively fast effect, but improving dietary intake in K-12 students by increasing the presence of healthy foods in the school environment may change diet more slowly and could benefit from augmentation to make healthy foods more appealing to school children. Gains in fruit and vegetable intake in certain groups and reductions in empty calories suggests that amendment of the school nutrition standards to allow greater flexibility may be detrimental to the nutrition of school children. Furthermore, the updated school nutrition standards may be alleviating overweight and obesity in students participating in NSLP meals, though changes were not definitively demonstrated in all analyses. National trends in overweight and obesity may take several years after the intervention to be able to detect change, and further study of associated trends should continue as new data becomes available to fully understand whether school nutrition policy is a useful tool to address childhood obesity.

1. Fryar CD, Carroll MD Ogden CL (2016) Prevalence of overweight and obesity among children and adolescents: United States, 1963–1965 through 2011–2012. *NCHS Health E-Stats*.

2. Office of the Press Secretary (2010) President Obama signs Healthy, Hunger-Free Kids Act of 2010 into law. Washington, DC: The White House. <https://obamawhitehouse.archives.gov/the-press-office/2010/12/13/president-obama-signs-healthy-hunger-free-kids-act-2010-law> (accessed Nov 25 2019)

3. Committee on Nutrition Standards for National School Lunch and Breakfast Programs (2010) *School meals: Building blocks for healthy children*. Washington, DC: Institute of Medicine.

4. U.S. Department of Agriculture (2012) Nutrition standards in the National School Lunch and School Breakfast Programs; Final rule. *Federal Register* 77, 4088-4167.

5. Terry-McElrath YM, O'Malley PM Johnston LD (2015) Foods and beverages offered in US public secondary schools through the National School Lunch Program from 2011–2013: Early evidence of improved nutrition and reduced disparities. *Preventive Medicine* 78, 52-58.

6. Merlo C, Brener N, Kann L *et al.* (2015) School-level practices to increase availability of fruits, vegetables, and whole grains, and reduce sodium in school meals — United States, 2000, 2006, and 2014. *Morbidity and Mortality Weekly Report* 64, 905-908.

7. Johnson DB, Podrabsky M, Rocha A *et al.* (2016) Effect of the Healthy Hunger-Free Kids Act on the nutritional quality of meals selected by students and school lunch participation rates. *JAMA Pediatrics* 170, e153918.

8. Fox MK & Gearan E (2019) *Summary of findings*. School Nutrition and Meal Cost Study. Alexandria, VA: US Department of Agriculture, Food and Nutrition Service.

9. Vaudrin N, Lloyd K, Yedidia MJ *et al.* (2018) Impact of the 2010 US Healthy, Hunger-Free Kids Act on school breakfast and lunch participation rates between 2008 and 2015. *American Journal of Public Health* 108, 84-86.

10. Cohen JFW, Richardson S, Parker E *et al.* (2014) Impact of the new U.S. Department of Agriculture school meal standards on food selection, consumption, and waste. *American Journal of Preventive Medicine* 46, 388-394.

11. Cohen JFW, Gorski MT, Hoffman JA *et al.* (2016) Healthier standards for school meals and snacks: Impact on school food revenues and lunch participation rates. *American Journal of Preventive Medicine* 51, 485-492.

12. Schwartz MB, Henderson KE, Read M *et al.* (2015) New school meal regulations increase fruit consumption and do not increase total plate waste. *Childhood Obesity* 11, 242-247.

13. Fox MK, Gearan E, Cabili C *et al.* (2019) *Student participation, satisfaction, plate waste, and dietary intakes*. School Nutrition and Meal Cost Study. Alexandria, VA: US Department of Agriculture, Food and Nutrition Service.

14. Cullen KW, Chen T-A Dave JM (2015) Changes in foods selected and consumed after implementation of the new National School Lunch Program meal patterns in southeast Texas. *Preventive Medicine Reports* 2, 440-443.

15. Bontrager Yoder AB, Foecke LL Schoeller DA (2015) Factors affecting fruit and vegetable school lunch waste in Wisconsin elementary schools participating in Farm to School programmes. *Public Health Nutrition* 18, 2855-2863.

16. Amin SA, Yon BA, Taylor JC *et al.* (2015) Impact of the National School Lunch Program on fruit and vegetable selection in northeastern elementary schoolchildren, 2012–2013. *Public Health Reports* 130, 453-457.

17. Cullen KW & Dave JM (2017) The new federal school nutrition standards and meal patterns: Early evidence examining the influence on student dietary behavior and the school food environment. *Journal of the Academy of Nutrition and Dietetics* 117, 185-191.

18. Satija A, Yu E, Willett WC *et al.* (2015) Understanding nutritional epidemiology and its role in policy. *Advances in Nutrition* 6, 5-18.

19. Au LE, Gurzo K, Gosliner W *et al.* (2018) Eating school meals daily is associated with healthier dietary intakes: The Healthy Communities Study. *Journal of the Academy of Nutrition and Dietetics* 118, 1474-1481.e1471.

20. Zipf G, Chiappa M, Porter KS *et al.* (2013) *National Health and Nutrition Examination Survey: Plan and operations, 1999–2010*. Hyattsville, MD: National Center for Health Statistics.

21. Bowman SA, Clemens JC, Friday JE *et al.* (2017) *Food Patterns Equivalents Database 2013-14: Methodology and User Guide*. Beltsville, MD: U.S. Department of Agriculture.

22. Bowman SA, Clemens JC, Shimizu M *et al.* (2018) *Food Patterns Equivalents Database 2015-2016: Methodology and user guide*. Beltsville, MD: Food Surveys Research Group, Beltsville Human Nutrition Research Center, Agricultural Research Service, U.S. Department of Agriculture.

23. Mills S, Brown H, Wrieden W *et al.* (2017) Frequency of eating home cooked meals and potential benefits for diet and health: cross-sectional analysis of a population-based cohort study. *International Journal of Behavioral Nutrition and Physical Activity* 14, 109.

24. Centers for Disease Control and Prevention (2018) About Child & Teen BMI. <https://www.cdc.gov/healthyweight/assessing/bmi/childrens_bmi/about_childrens_bmi.html> (accessed June 13 2019)

25. National Health and Nutrition Examination Survey (2017) 2015-2016 Data documentation, codebook, and frequencies: Demographic variables and sample weights (DEMO\_I). (accessed June 13 2019)

26. National Center for Health Statistics (2019) Module 3: Weighting. *Continuous NHANES Tutorials*. https://wwwn.cdc.gov/nchs/nhanes/tutorials/module3.aspx (accessed Feb 25 2020)

27. Dimick JB & Ryan AM (2014) Methods for evaluating changes in health care policy: The difference-in-differences approach, JAMA Guide to Statistics and Methods. *JAMA* 312, 2401-2402.

28. Raifman J, Moscoe E, Austin SB *et al.* (2017) Difference-in-differences analysis of the association between state same-sex marriage policies and adolescent suicide attempts. *JAMA Pediatrics* 171, 350-356.

29. Turner L & Chaloupka FJ (2014) Perceived reactions of elementary school students to changes in school lunches after implementation of the United States Department of Agriculture's new meals standards: Minimal backlash, but rural and socioeconomic disparities exist. *Childhood Obesity* 10, 349-356.

30. Flores A, Lopez MH Krogstad JM (2019) U.S. Hispanic population reached new high in 2018, but growth has slowed. <https://www.pewresearch.org/fact-tank/2019/07/08/u-s-hispanic-population-reached-new-high-in-2018-but-growth-has-slowed/> (accessed Nov 25 2019)

31. Food and Nutrition Service USDA (2017) Child nutrition programs: Flexibilities for milk, whole grains, and sodium requirements (82 FR 56703). Washington, DC: Federal Register.

32. Taber DR, Chriqui JF, Powell L *et al.* (2013) Association between state laws governing school meal nutrition content and student weight status: Implications for new USDA school meal standards. *JAMA Pediatrics* 167, 513-519.

33. Byker Shanks C, Banna J Serrano EL (2017) Food waste in the National School Lunch Program 1978-2015: A systematic review. *Journal of the Academy of Nutrition and Dietetics* 117, 1792-1807.

34. Niaki SF, Moore CE, Chen T-A *et al.* (2017) Younger elementary school students waste more school lunch foods than older elementary school students. *Journal of the Academy of Nutrition and Dietetics* 117, 95-101.

35. Butler K (2014) Making school lunch healthy is hard. Getting kids to love it is harder. This lady did both. In *Mother Jones*

36. Food and Nutrition Service USDA (2020) Simplifying meal service and monitoring requirements in the National School Lunch and School Breakfast Programs (85 FR 4094). Washington, DC: Federal Register.

37. U.S. Department of Health and Human Services and U.S. Department of Agriculture. (2015) 2015–2020 Dietary Guidelines for Americans. 8th Edition. <https://health.gov/sites/default/files/2019-09/2015-2020_Dietary_Guidelines.pdf>

38. U.S. Department of Agriculture Food and Nutrition Service (2019) National School Lunch Program: Participation and lunches served. https://fns-prod.azureedge.net/sites/default/files/resource-files/slsummar-11.pdf (accessed Nov 12 2019)

39. U.S. Department of Agriculture Food and Nutrition Service (2019) School Breakfast Program participation and meals served. https://fns-prod.azureedge.net/sites/default/files/resource-files/sbsummar-11.pdf (accessed Nov 12 2019)

**Table 1.** Study subject characteristics by National School Lunch Program (NSLP) participation

|  |  |  |
| --- | --- | --- |
| *n* = 9,172 | NSLP participantsa  (*n* = 7,454)  Weighted % (se) | Non-participantsa  (*n* = 1,718)  Weighted % (se) |
| Age, *mean (se)* | 12.0 (0.1) | 13.8 (0.1) |
| Males | 54.0% (0.8) | 45.5% (1.5) |
|  |  |  |
| K-12 school level |  |  |
| Elementary | 52.0% (0.9) | 31.4% (1.6) |
| Middle | 27.7% (0.6) | 24.1% (1.5) |
| High | 20.3% (0.7) | 44.5% (1.8) |
|  |  |  |
| Born in US | 93.1% (0.5) | 94.8% (0.6) |
|  |  |  |
| Race/ethnicity |  |  |
| Non-Hispanic White | 47.3% (2.3) | 70.3% (1.7) |
| Non-Hispanic Black | 18.4% (1.4) | 8.5% (0.8) |
| Hispanic | 26.7% (1.9) | 11.8% (1.0) |
| Other Race | 7.6% (0.6) | 9.4% (0.9) |
|  |  |  |
| Sedentary activity |  |  |
| Daily total screen time  (in hours), *mean (se)* | 3.2 (<0.1) | 3.2 (0.1) |
|  |  |  |
| Family incomeb |  |  |
| <130% FPL | 41.9% (1.5) | 12.5% (1.0) |
| 130-185% FPL | 13.6% (0.7) | 8.7% (1.0) |
| >185% FPL | 44.6% (1.6) | 78.8% (1.3) |
| Family reference person |  |  |
| Born in US | 75.5% (1.4) | 83.4% (1.1) |
| Married or living with  partner | 71.8% (0.9) | 80.7% (1.3) |
| College graduate or  Higher (RP or spouse) | 23.7% (1.3) | 50.7% (2.1) |

aNSLP participants were those who reported eating school lunch 5 days per week and non-participants were those who reported eating no school lunches in a week.

bFamily income is expressed as a percentage of the federal poverty level (FPL).

**Table 2.** Difference-in-differences estimates of weekday fruit and vegetable intake, weekday SoFAS, and overweight and obesity prevalence with 95% confidence intervals using simple and multivariable linear regression

|  |  |  |
| --- | --- | --- |
| *n* = 9,172 | Crude estimate (95% CI) | Adjusteda estimate (95% CI) |
| Fruit and vegetable intake in cup equivalents | 0.06 (-0.21, 0.32) | 0.02 (-0.23, 0.27) |
| SoFAS as % of 24-hour calories | -1.7% (-3.2, -0.2) | -1.6% (-3.0, -0.1) |
| Overweight & obesity prevalence | -4.0% (-9.8, 1.9) | -6.2% (-12.1, -0.2) |

aAdjusted for age, sex, race/ethnicity, daily screen time, country of birth and marital status of the household reference person, household education level, and family income

**Table 3.** Difference-in-differences estimates of weekday fruit and vegetable intake stratified by race/ethnicity with 95% confidence intervals using simple and multivariable linear regression

|  |  |  |
| --- | --- | --- |
| Race/ethnicity (weighted %) | Crude estimate (95% CI) | Adjusteda estimate (95% CI) |
| Non-Hispanic White (53.1%) | 0.08 (0.03, 0.13) | 0.03 (-0.02, 0.08) |
| Non-Hispanic Black (15.9%) | 0.31 (0.09, 0.53) | 0.37 (0.13, 0.61) |
| Hispanic (22.9%) | -0.25 (-0.45, -0.04) | -0.29 (-0.50, -0.08) |
| Other (8.0%) | 0.19 (-0.01, 0.40) | 0.27 (0.07, 0.46) |

aAdjusted for age, sex, race/ethnicity, daily screen time, country of birth and marital status of the household reference person, household education level, and family income

**Figures**

**Figure 1a.** Survey-weighted mean weekday fruit and vegetable intake in cup equivalents with standard errors for NSLP participants (n=7,454) and non-participants (n=1,718) from 2005 to 2016, using multivariable linear regression adjusted for age, sex, race/ethnicity, daily screen time, country of birth and marital status of the household reference person, household education level, and family income

**Figure 1b.** Survey-weighted mean weekday SoFAS intake as a percentage of 24-hour calorie intake with standard errors for NSLP participants (n=7,454) and non-participants (n=1,718) from 2005 to 2016, using multivariable linear regression adjusted for age, sex, race/ethnicity, daily screen time, country of birth and marital status of the household reference person, household education level, and family income

**Figure 1c.** Survey-weighted overweight and obesity prevalence with standard errors for NSLP participants (n=7,454) and non-participants (n=1,718) from 2005 to 2016, using multivariable linear regression adjusted for age, sex, race/ethnicity, daily screen time, country of birth and marital status of the household reference person, household education level, and family income