Published in final edited form as:
J Acad Nutr Diet. 2017 April ; 117(4): 545–553.e3. doi:10.1016/j.jand.2016.10.012.

Percentage of youth meeting federal fruit and vegetable intake recommendations, Youth Risk Behavior Surveillance System, United States and 33 states, 2013

Latetia V Moore, PhD,
Epidemiologist, Division of Nutrition, Physical Activity, and Obesity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, 4770 Buford Hwy NE MS F77, Atlanta GA 30341, telephone 770.488.5213, fax 404.235.1802

Frances E Thompson, PhD, and
Epidemiology and Genomics Research Program, Cancer Control and Population Sciences, National Cancer Institute, 9609 Medical Center Drive, Rm. 4E124, MSC 9762 Bethesda, MD 20892, telephone (240) 276-6781, fax (240) 276-7906

Zewditu Demissie, PhD
Senior Research Scientist, Division of Adolescent and School Health, National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention, Centers for Disease Control and Prevention; U.S. Public Health Service Commissioned Corps, 4770 Buford Hwy NE, Atlanta GA 30341, telephone 404.718.8138, fax 404.471.8701

Abstract

Background—National and state-level self-reported frequency of fruit and vegetable consumption is available for high school students from the Centers for Disease Control and Prevention's Youth Risk Behavior Surveillance System (YRBSS). YRBSS monitors priority health-risk behaviors among a nationally representative sample of US high school students and representative samples of students in states and selected large urban school districts. However, YRBSS measures intake in times per day and not the cup equivalents national goals use, which limits interpretation.

Objective—To help states track youth progress, scoring algorithms were developed from external data and applied to 2013 YRBSS data to estimate the percentages of high school students in the nation and 33 states meeting US Department of Agriculture Food Patterns fruit and vegetable intake recommendations.

Design—24-hour dietary recalls were used from the 2007–2010 National Health and Nutrition Examination Survey to fit sex-specific models for 14–18 year olds that estimate probabilities of meeting recommendations as a function of reported frequency of consumption and race/ethnicity,

Correspondence to: Latetia V Moore.

The authors have no funding support or conflicts of interest to disclose.

adjusting for day-to-day dietary variation. Model regression parameters were then applied to national cross-sectional YRBSS data (N=12,829) and to data from the 33 states (N=141,006) that had complete fruit and vegetable data to estimate percentages meeting recommendations.

Results—Based on the prediction equations, 8.5% of high school students nationwide met fruit recommendations (95% confidence interval 4.9%, 12.1%) and 2.1% met vegetable recommendations (95% confidence interval 0.0%, 8.1%). State estimates ranged from 5.3% in Nebraska and Missouri to 8.9% in Florida for fruit and 1.0% in New Jersey, North Dakota, and South Carolina to 3.3% in New Mexico for vegetables.

Conclusions—This method provides a new tool for states to track youth progress towards meeting dietary recommendations and indicates that a high percentage of youth in all states examined have low intakes of fruits and vegetables.

Keywords

fruits; vegetables; recommended intake; usual intake; states; youth

Introduction

Healthy eating patterns are associated with a reduced risk of cardiovascular disease, type 2 diabetes, certain types of cancers such as colorectal and breast cancers, overweight, and obesity.[1] Higher intakes of vegetables and fruits have consistently been identified as characteristics of healthy eating patterns and are important sources of many nutrients that are under-consumed in U.S. diets including dietary fiber, potassium, magnesium, choline, and vitamins A, C, and E.[1] Despite these benefits, 2007–2010 data from the National Health and Nutrition Examination Surveys (NHANES) indicate that 75% of the US population consumed less fruit than recommended and 87% consumed fewer vegetables than recommended.[2]

Unhealthy dietary behaviors established early in life may extend into adulthood.[3] Among children, adherence to fruit and vegetable intake recommendations declines with age. [2] About one quarter of 1–3 year old children consumed fewer fruit than recommended versus 85–87% of 14–18 year olds.[2] Approximately 85% of 1–3 year olds did not consume enough vegetables versus 96–98% of 14–18 year olds.[2] Children and adolescents who are inactive should be consuming 1–2 cup equivalents of fruits and 1–3 cup equivalents of vegetables daily depending on their age and sex according to the US Department of Agriculture (USDA) Food Patterns intake recommendations, one pattern consistent with the Dietary Guidelines for Americans .[4;5] Active individuals should consume more. One cup is approximately 1 small apple (149 g) or 12 baby carrots (120 g).[4;5]

Twenty-four hour dietary recall (24HR) data from NHANES are the source for monitoring national progress towards meeting USDA Food Patterns fruit and vegetable recommendations, hereafter referred to as federal recommendations. However, national estimates may mask significant state level variation [6;7]; NHANES is not designed to produce state-specific estimates. The Centers for Disease Control and Prevention's Youth Risk Behavior Surveillance System (YRBSS) and Behavioral Risk Factor Surveillance System

(BRFSS) monitor state and local level priority health behaviors and risk factors among high school students and adults, respectively. Both surveys measure the frequency of fruit and vegetable intake, but frequency of intake cannot be directly compared to federal recommendations.[4;5;8] Federal recommendations are measured in cup equivalents and frequency of intake is not equal to cup equivalents consumed.[9;10] For example, males aged 18–27 drink a median of 1.5 cups of 100% fruit juice each time they have juice but only consume a third cup of salad each time.[10]

Scoring procedures that estimate the state-specific percentages of adults meeting federal recommendations using BRFSS were recently developed using 2007–2010 NHANES.[7] Comparable scoring algorithms are needed for YRBSS, which focuses on a younger population than the BRFSS and uses different questions to measure fruit and vegetable frequency of intake. To address this state level surveillance gap, scoring algorithms were derived based on prior methods for BRFSS [7] and applied to 2013 YRBSS frequency data to estimate the percentage of high school students meeting fruit and vegetable intake recommendations.

Materials and Methods

This study was deemed exempt by the Centers for Disease Control and Prevention Institutional Review Board because only public use data was used.

NHANES Background

NHANES data from 2007–2010 were used to derive the scoring algorithms to apply to YRBSS data. A full description of NHANES methods is available elsewhere.[11] Briefly, since 1999, NHANES has conducted annual interviews and physical examinations on a nationally representative sample of about 5,000 adults and children in the United States to assess health and nutritional status. Survey participants 12 years and older completed an initial interviewer-administered 24HR during the physical examination and a second 24HR by telephone approximately 3 to 10 days after the exam. All NHANES 2007–2010 participants aged 14–18 years of age with a complete 24HR were included in the development of the scoring algorithm (N=1,535 participants; 220 participants with only 1 24HR and 1,315 participants with 2 24HRs).

YRBSS Background

Conducted biennially since 1991, the YRBSS monitors priority health-risk behaviors, including fruit and vegetable intake, via a nationally representative survey of 9th–12th grade students in all public and private US high schools and separate state surveys that are representative samples of students in states and selected large urban school districts.[12] A full description of the surveillance system is provided elsewhere.[12] On the YRBSS national questionnaire, students are asked how often, during the past 7 days, they consumed 100% fruit juice such as orange juice, apple juice, or grape juice (not including punch, Kool-Aid, sports drinks, or other fruit-flavored drinks); fruit (not including 100% fruit juice); green salad; potatoes (not including French fries, fried potatoes, and potato chips); carrots; and other vegetables (not including green salad, potatoes, or carrots) via a self-administered questionnaire in their classrooms. Response options included 0, 1–3, or 4–6 times during the past 7 days or 1, 2, 3, or 4 or more times per day. In 2013, 33 states asked each of these 6 questions about fruit and vegetable intake and had a sufficient overall response rate to obtain data weighted to be representative of the state; these states were included in analyses. Five states were excluded from analysis because they did not have a sufficient response rate for state-representative data (response rates <60% for California, Colorado, Indiana, Iowa, and Pennsylvania). Nine states were excluded because data on these 6 fruit and vegetable questions were not asked or modified or were unavailable (Arizona, Delaware, Hawaii, Louisiana, Maine, Massachusetts, New Hampshire, New York, and Wisconsin). Three states did not participate in the 2013 YRBSS (Minnesota, Oregon, and Washington).

In 2013, the overall response rate for the YRBSS national sample was 68.0%.[13] The overall response rates for states in YRBSS surveys included in this analysis ranged from 60% to 87%.[14] Students from the YRBSS national sample and the 33 state samples who answered all 6 fruit and vegetable frequency questions as on the national survey and who reported their race/ethnicity were included in analyses. Among the 13,583 students in the 2013 national Youth Risk Behavior Survey dataset, 407(3%) did not answer all 6 fruit and vegetable frequency questions and 307(2%) did not report their race/ethnicity or age; these students were excluded from analyses. An additional 40 students under the age of 14 years were excluded to correspond to the data from the NHANES participants used to create the scoring algorithms. The final analytic sample for the national dataset was 12,829 students. On average, 6% of students were excluded from the state samples due to missing data ranging from 1% in Oklahoma to 12% in Maryland. Responses that included a range of values were assigned the midpoint of the range and then divided by 7 to determine daily intake. Daily frequencies were capped at 4 times a day for those respondents who indicated they consumed a fruit or vegetable 4 or more times per day. Student self-reported race/ethnicity was classified as non-Hispanic Black, Hispanic, or all others including non-Hispanic whites to be consistent with prior work estimating percentages meeting recommendations. [7;15]

Development of the Prediction Model

Scoring algorithms to estimate the percentage of the nation's and each state's youth population meeting fruit and vegetable intake recommendations were derived and applied to YRBSS following methods previously developed for BRFSS.[7] The steps involved in the development and application of the final scoring algorithm are outlined in Figure 1. Two types of variables derived from NHANES 24HR data were needed to develop the scoring algorithms: times per day each fruit and vegetable group was consumed (independent variables) and cup equivalents from all sources of fruits and vegetables (dependent variables). These variables are described below. Since YRBSS has been shown to overestimate mean intake of fruits and vegetables,[9] YRBSS daily frequencies of intake were examined to determine whether a correction was necessary to avoid overinflating percentages meeting recommendation estimates.

Independent Variables

Using NHANES 24HRs, the reported number of times per day fruits and vegetables were consumed was calculated. To derive this, all foods and beverages reported on the 24HRs were sorted based on main ingredients into one of the 6 fruit and vegetable food groups on the 2013 YRBSS questionnaire or labelled as all other foods (Online Supplementary Table 1). Fried potatoes (e.g. french fries, potato chips) and non-100% fruit juices (e.g. punch, Kool-Aid, sports drinks, or other fruit-flavored drinks) were excluded because YRBSS explicitly instructs respondents not to include these items. The number of times each participant reported any food classified as one of the 6 fruit and vegetable groups was then summed for each day of report. Some foods from the 24HRs were excluded because cognitive testing indicates that when individuals are asked food frequency questions, they do not consider some types of foods without explicit prompting.[16–18] These excluded foods consisted of baby foods, dried fruit, condiments including tomato sauces (salsa, ketchup, spaghetti sauce, etc.), olives, pickles, relishes, vinegars, and fruits and vegetables eaten in combination with other foods such as tomatoes and lettuce in sandwiches, fruit in yogurts, or tomato sauce on pizza. Reported frequencies greater than 4 times per day were capped at 4 to correspond with the highest allowable response option on the YRBSS questionnaire. Frequencies extracted from the NHANES 24HR were used as the independent variables in the scoring algorithms.

Dependent Variables

The second set of variables calculated from the NHANES 24HR data was reported cup equivalents of fruits (except non-100% fruit juice beverages) and of vegetables (except fried potatoes) consumed from all foods reported on the 24HRs. These variables include foods and beverages previously excluded when estimating times per day variables (e.g., baby foods, dried fruit) to account for foods typically forgotten when answering dietary screeners as background intake. All reported single and multi-ingredient foods and beverages were separated into their components and assigned cup-equivalents of fruits and vegetables according to standard recipes using the USDA Food Patterns Equivalents Databases 2007–2008 and 2009–2010.[19;20] For each individual, cup equivalents of fruits and vegetables from all relevant food sources (excluding non-100% fruit juices and fried potatoes) were totaled for each day of report. Total cup equivalents of fruits and total cup equivalents of vegetables were used as the dependent variables in the scoring algorithms.

Simulated Usual Intake Amounts

The two types of variables above were used to simulate individual usual intake amounts by fitting one- or two-part nonlinear mixed models using macros provided by the National Cancer Institute (NCI).[21] These simulated intakes reflect relationships between reported frequencies of the 6 fruit and vegetable groups per day and usual intake amounts after adjusting for day-to-day dietary variation, participant's race/ethnicity, day of week (weekend: Friday–Sunday vs. weekdays: Monday–Thursday), and sequence (first vs. second 24HR).

Consistent with prior work, models were estimated by sex for fruits and vegetables. [15;22] Two-part nonlinear mixed models were used to estimate the usual fruit intake amounts and the usual vegetable intake amounts since both fruit and vegetables were consumed episodically (40% of 24 hour recall days had zero intake for fruit and 12% had zero intake for vegetables).[15;23] For fruit, the first part of these two-part models, indicated as Part I models below, model the probability of consuming any fruit (defined as cup equivalents of fruit consumed > 0) by extracted times per day fruit juice and whole fruits were consumed for each NHANES participant's day of recall. The second part of the two-part fruit model, indicated below as Part II fruit models, estimate the amount of fruit consumed in cup equivalents by the frequencies of fruit juice and fruit intake for each reported recall day among those who ate any fruit. Amount data were transformed to approximate normality, using the Box-Cox transformation as part of the model-fitting process. Part I and Part II models were fit simultaneously.[23] Additional details regarding how models were fit are available from prior work.[7] Models for vegetables were similar to models for fruit and included extracted times per day green salad, potatoes, carrots, and other vegetables were consumed. Dummy variables were included for all models to account for variation due to collecting 24HR on weekends versus weekdays (weekend effect), first versus second 24HR (sequence effect), and race/ethnicity (Hispanic and non-Hispanic Black versus a referent group of non-Hispanic others). Similar to prior methods,[7] most (50%–63%) of the variation in the predicted amounts of fruits and vegetables consumed on consumption days is explained by frequency of intake. All modeling accounted for the NHANES survey design.

Two-part model for fruit

Part I: Probability of consumption model with a person-specific random effect

$$log\frac{p(consuming\ fruit)}{1-p(consuming\ fruit)}=\beta_0+\beta_1(T_{fruit\ juice})+\beta_2(T_{fruit})+\beta_3(weekend\ effect)+\beta_4(sequence\ effect)+\beta_5(Hispanic)+\beta_6(non-Hispanic\ Black)+person\ specific\ effect$$

where p(consuming fruit)=probability of consuming fruit, $T_{fruit\ juice}$ and T_{fruit} = number of times 100% fruit juice and fruit consumed on each 24HR, respectively, and the person-specific effect is normally distributed

Part II: Consumption amount model with a person-specific random effect (among those who ate fruit)

$$C_\lambda=\beta_0+\beta_1(\mathrm{T_{fruit\ juice}})+\beta_2(\mathrm{T_{fruit}})+\beta_3(\text{weekend effect})+\beta_4(\text{sequnece effect})+\beta_5(\text{Hispanic})+\beta_6(\text{non- Hispanic Black})+\text{person specific effect}+\text{within- person variability}$$

where C_λ = Box-Cox transformed cup equivalents of fruits consumed from all sources, $T_{fruit\ juice}$ and T_{fruit} = Number of times 100% fruit juice and fruit consumed on each 24HR, respectively, and the person-specific effect and within-person random variability are normally distributed

The estimated model parameters from the fitted one- and two-part models above are used to simulate the usual intake distributions of fruits and vegetables, separately, for a pseudo-population with the same characteristics and between-person variability as the sample on which the model was fit. The usual intakes were then used as the dependent variable in the final step of deriving the prediction models described below.

Prediction Model

The final step of developing the scoring algorithm involves generating the sex-specific logistic regression prediction equations to apply to YRBSS from the simulated usual intake amounts calculated above, frequency of intake of fruits and vegetables, and participant race/ ethnicity. A generalized linear model was used to predict the logit of the expected probability of meeting the intake recommendations, the dependent variable in the final prediction model. Simulated intake amounts were first classified as meeting or not meeting federal recommendations. For fruit, the log odds of meeting the recommendation was modeled by the reported daily frequencies of fruit juice and fruit intake and participant race/ ethnicity (shown below). For vegetables, the log odds of meeting recommendations was modeled by the frequency of intake of the 4 vegetable subgroups and race/ethnicity. For these analyses, the minimum recommended amounts of fruits and vegetables were used for 14–18 year olds (i.e. amounts recommended for sedentary individuals, Table 1). [4;5] The resulting regression parameters form the prediction models used to apply to YRBSS (Online Supplementary Table 2).

Logistic regression prediction equation for fruit:

$$log\frac{p(meeting\ fruit\ intake\ recommendation)}{1-p(meeting\ fruit\ intake\ recommendation)}=\beta_{i0}+\beta_{i1}(T_{fruit\ juice})+\beta_{i2}(T_{fruit})+\beta_{i3}(Hispanic)+\beta_{i4}(non-Hispanic\ Black)$$

where p(meeting fruit intake recommendation)= probability of meeting the fruit intake recommendation for sex group i and $T_{fruitjuice}$ and T_{fruit} = Number of times per day participants reported consuming 100% fruit juice and fruit, respectively

Application of Scoring Algorithms to YRBSS

The above derived logistic prediction equations were applied to YRBSS to obtain percentages of each state’s high school student population meeting fruit and vegetable intake recommendations. Using the 2013 YRBSS data, the times per day each student reported eating each fruit and vegetable group and each student’s race/ethnicity were substituted for the frequency and race/ethnicity covariates in the prediction equations, respectively, to obtain the student’s log odds of meeting recommendations. Weighted averages of the predicted probabilities from the equations were computed to obtain the national and state-specific estimates of the percentage of high school students meeting recommendations.

Before entering YRBSS participants’ frequencies of intake into the prediction models, YRBSS frequencies were examined to determine whether unadjusted frequencies may overinflate estimates of percentages meeting recommendations because YRBSS has been shown to overestimate mean intake in prior work.[9] To test this, YRBSS mean daily frequencies of intake were compared to the mean extracted daily frequencies of intake from the NHANES 24HRs. Prior work demonstrated that frequencies of intake can be up to twice as high and still produce reasonable estimates of percentages meeting recommendations.[7] YRBSS fruit and vegetable frequencies of intake were 2–7 times higher than extracted frequencies (Online Supplementary Figure 1); consequently, multiplicative correction factors were derived and applied to YRBSS estimates. Correction factors were calculated by dividing reported mean servings per day from multiple 24HRs for each fruit and vegetable group by mean daily frequencies of intake as reported in a 2010 study of 610 high school students (see Online Supplementary Table 3).[9] Correction factors were 0.73, 0.36, 0.08, 0.34, 0.16, and 1.34 for 100% juice, fruit, salad, potatoes, carrots, and other vegetables respectively.

Statistical Analysis

Analyses were conducted using SAS[24] and SAS-Callable SUDAAN[25] to account for YRBSS's complex, multistage, probability sample design. Confidence intervals for the percentages meeting recommendations were calculated using standard errors that reflect variation from the combination of both survey sources. Specifically, standard errors were calculated using the Balanced Repeated Replication technique and replicate weights to account for variation in the models from NHANES[26] and using Taylor linearization to account for variation due to the YRBSS sampling design.[27] Negative values for lower confidence interval bounds were truncated at zero. Median YRBSS frequencies of fruit and vegetable intake nationally and for the 33 states were also calculated for display purposes.

Results

Median frequency of intake and cup equivalents consumed for the NHANES variables used to derive the prediction models are shown in Table 2 by sex and race/ethnicity. Median cup equivalents of fruit and vegetables consumed was 0.5 and 0.8, respectively (dependent variables in models). NHANES participants consumed fruit a median of 0.2 times per day and vegetables 0.1 times per day (independent variables in models).

Median frequency of fruit intake among students in the YRBSS national sample was 0.9 times per day, ranging from 0.7 to 1.0 times per day in the 33 states included in the state-by-state analysis (Table 3). Median vegetable intake was 1.1 times per day, nationally, ranging from 0.9 to 1.4 times per day across the 33 states. Based on estimates from the prediction equations, 8.5% of high school students nationwide met fruit recommendations (95% confidence interval 4.9%, 12.1%) and 2.1% met vegetable recommendations (95% confidence interval 0.0%, 8.1%). Percentages of each the 33 state's high school student population meeting recommendations ranged from 5.3% in Nebraska and Missouri to 8.9% in Florida for fruit and 1.0% in New Jersey, North Dakota, and South Carolina to 3.3% in New Mexico for vegetables.

Discussion

Ongoing collection of state-level fruit and vegetable intake and relevant program data are needed to help identify public health nutrition issues and support the design, evaluation, and management of nutrition intervention programs in addition to catalyzing local interest in nutrition programs and policies.[28] This analysis enhances current surveillance efforts by providing state level estimates of percentages of high school students meeting fruit and vegetable intake recommendations. To do so, previously developed methods[7;29] were used to derive scoring algorithms for high school students in YRBSS that could also be used with other screeners with similar questions. When calculating the total cup equivalents of fruits and vegetables from NHANES (the dependent variables), foods often not considered by participants when they respond to brief screeners like YRBSS, such as mixtures and condiments were included. By including intake of these foods as background intake via the intercept, the prediction equation may give a better estimate of total fruit and vegetable intake than not including them.

In 2013 most high school students consumed too few fruits and vegetables with some variation by state. In this analyses, 8.5% of a nationally representative sample of high school students met the federal fruit recommendation and 2.1% met the vegetable recommendation, based on prediction equations and national YRBSS frequency data. Fruit estimates were lower than those estimated by NCI using 2007–2010 NHANES 24HR data (14–15% of 14–18 year olds met fruit recommendations) but similar for vegetables (NCI: 2–4% met vegetable recommendations).[2] These differences may be due to various methodological differences between the NHANES and YRBSS.

There were several important differences in the YRBSS and NHANES survey methods. The two surveys used different instruments; information elicited from a screener like YRBSS is inherently different from and less accurate than that generated from 24HRs.[30] Furthermore, they had different recall timeframes (24 hours versus 7 days), and were collected in different years: 2007–10 for NHANES and 2013 for YRBBS. Another difference is that YRBSS-derived estimates do not include contributions from non-100% fruit juice or fried potatoes because YRBSS specifically instructs respondents not to include these items. Including these food and beverage sources results in higher YRBSS estimates for fruit (9.8% versus 8.5%) and vegetables (2.3% vs. 2.1%).

In this analysis, intake recommendations for sedentary individuals, those engaging in less than 30 minutes of moderate activities daily,[4;5] were used. Consequently, results likely overestimate the proportion of adolescents meeting recommendations given that nationwide, 47.3% of students were estimated to be physically active at least 60 minutes per day on 5 or more days based on self-report, and active youth should eat more fruits and vegetables while staying within calories limits.[31] A second limitation of this analysis is that results may not be generalizable to the entire US adolescent population because it only surveys adolescents who attend public and private high schools, and not those home-schooled or not in school.[12] In 2013, 85% of 14–17 year olds were enrolled in high school.[32] Also, national NHANES 24HRs were used to derive the prediction equations because state-specific 24HRs were not systematically available; thus separate scoring algorithms for each state were not derived. It is also important to note that the national sample is not an aggregation of the state surveys and data in the national sample may come from states that are not included in the state-specific analysis.[12] Likewise, the NHANES is designed to be representative of the whole country, not any particular state. Finally, even though the data are weighted to account for nonresponse and to reflect the national population, both NHANES and YRBSS may be subject to selection bias. In 2007–2010, NHANES had an interview response rate of 78–79% and an examination response rate of 75–77%.[33] Overall response rates for the national component of the YRBSS was 68% and ranged from 60%–87% for all states included in this study.[13;34]

Multiplicative correction factors were used to compensate for overestimation in YRBSS; YRBSS daily frequencies were 2–7 times higher than frequencies extracted from NHANES. In prior work, BRFSS daily frequencies were up to 2 times higher than extracted frequencies but predicted estimates of percentages of each state population meeting recommendations were comparable to published estimates using 24HRs.[7] Not applying correction factors yielded estimates of 18.6% for fruit and 22.9% for vegetables. Estimating the tail ends of distributions using this methodology may be less precise than estimating mean intake, however, estimates may still be useful for tracking change over time within a state and making comparisons across states. Ideally, prediction equations would be derived from a population that has both YRBSS questions and 24HRs available (i.e. direct calibration) to establish their internal validity. In the absence of this type of direct calibration, correction factors derived from a population of high school students who answered the YRBSS fruit and vegetable frequency of intake questions and multiple 24HRs measured in servings were used to account for overestimation. While extracted times per day from the 24 hour dietary recalls were similar to servings per day for four of the six fruit and vegetable groups (Online Supplementary Figure 1), utilizing data from this external study to derive correction factors allows for direct comparisons of the amounts individuals consumed to frequencies of intake rather than relying on intake estimates from very different survey populations. While intake measured in servings and intake in cups are not equivalent, the consistency of predicted intake with other national estimates indicate this method produces reasonable estimates.

With less than 10% of high school student consuming enough fruit and only 2% consuming enough vegetables, efforts to improve low fruit and vegetable intake are needed because food preferences track from childhood later into life.[3;35;36] Implementing nutrition standards that meet or exceed federal regulations for meals and snacks in early care and education centers and schools where approximately 60 million children and adolescents [37;38] spend a significant share of their day may help set a healthy trajectory to adulthood.[39] School-based interventions have been shown to significantly improve fruit consumption but have minimal impact on vegetable intake.[40] This disparity in intake may be due to stronger preferences for fruits than vegetables.[41] Recent changes to school meal standards have improved the nutritional quality of meals selected by adolescents driven primarily by the increase in variety, portion size, and number of servings of fruits and vegetables.[42] In elementary and middle school children, recent improvements have also improved students' overall diet quality with students consuming significantly more fruits and vegetables.[43] However, opportunities exist to improve school meal standard implementation.[44] Interventions targeting the home environment have also been shown to increase fruit and vegetable intake among adolescents.[45;46]

Conclusions

With less than 10% of the youth across 33 states consuming the recommended amount of fruits and less than 3% consuming the recommended amount of vegetables, concerted efforts to improve the environments to which youth are exposed may be needed to substantially change dietary behavior, especially for vegetables. Modifications to the home, child care, school, and community environments as well as complementary strategies including parental modeling of healthy eating behavior, improved nutrition education and social marketing may be helpful.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The authors have no conflicts of interest to disclose. LVM designed research and performed statistical analysis; LVM, FET, and ZD wrote the paper; all authors read and approved of the final manuscript and have primary responsibility for final content. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

References

1. U.S.Department of Agriculture, U.S.Department of Health and Human Services. Dietary Guidelines for Americans, 2015–2020. Washington, DC: U.S. Government Printing Office; 2015.
2. Usual Dietary Intakes: Food Intakes, US Population, 2007–10. National Cancer Institute, Division of Cancer Control and Population Sciences, Epidemiology and Genomics Research Program; 2015. http://epi.grants.cancer.gov/diet/usualintakes/pop/2007-10/ [Accessed July 15, 2016]
3. Due P, Krolner R, Rasmussen M, et al. Pathways and mechanisms in adolescence contribute to adult health inequalities. Scandinavian Journal of Public Health. 2011; 39:62–78.
4. All about the Vegetable Group. [Accessed July 15, 2016] United States Department of Agriculture. 2016. http://www.choosemyplate.gov/vegetables
5. All about the Fruit Group. [Accessed July 15, 2016] United States Department of Agriculture. 2016. http://www.choosemyplate.gov/fruit
6. Grimm KA, Blanck HM, Scanlon KS, Moore L, Grummer-Strawn LM, Foltz JL. State-Specific Trends in Fruit and Vegetable Consumption Among Adults --- United States, 2000–2009. Morbidity and Mortality Weekly Report (MMWR). 2010; 59:5.
7. Moore LV, Dodd KW, Thompson FE, Grimm KA, Kim SA, Scanlon KS. Using Behavioral Risk Factor Surveillance System data to estimate the percent of the population meeting USDA Food Patterns fruit and vegetable intake recommendations. Am J Epidemiol. 2015; 181:979–988. [PubMed: 25935424]
8. Healthy People 2020: Nutrition and Weight Status Objectives. U S Department of Health and Human Services, Office of Disease Prevention and Health Promotion; 2016. https://www.healthypeople.gov/2020/topics-objectives/topic/nutrition-and-weight-status/objectives [Accessed July 15, 2016]
9. Eaton DK, Olsen EO, Brener ND, et al. A Comparison of Fruit and Vegetable Intake Estimates from Three Survey Question Sets to Estimates from 24-Hour Dietary Recall Interviews. J Acad Nutr Diet. 2013
10. Median Portion Size (Pk) in Cup Equivalents**per Mention by Gender and Age for Fruits and Vegetables Analyses. National Cancer Institute, Division of Cancer Control and Population Sciences, Epidemiology and Genomics Research Program; 2015. Diet Screener in the 2005 CHIS: Scoring Procedures: Table 1b. http://epi.grants.cancer.gov/chis/dietscreener/scoring.html [Accessed January 16, 2016]
11. National Health and Nutrition Examination Survey Data. Centers for Disease Control and Prevention (CDC) National Center for Health Statistics (NCHS); 2014. http://www.cdc.gov/nchs/nhanes/about_nhanes.htm [Accessed September 16, 2016]
12. Brener ND, Kann L, Shanklin S, et al. Methodology of the Youth Risk Behavior Surveillance System-2013. Mmwr Recommendations and Reports. 2013; 62:1–20.

13. 2013 YRBS Data User's Guide. Division of Adolescent and School Health, National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention, CDC; 2014. ftp://ftp.cdc.gov/pub/data/yrbs/2013/YRBS_2013_National_User_Guide.pdf [Accessed Accessed July 15, 2016]
14. Kann L, Kinchen S, Shanklin SL, et al. Youth risk behavior surveillance--United States, 2013. MMWR Surveill Summ. 2014; 63(Suppl 4):1–168.
15. Krebs-Smith SM, Guenther PM, Subar AF, Kirkpatrick SI, Dodd KW. Americans Do Not Meet Federal Dietary Recommendations. Journal of Nutrition. 2010; 140:1832–1838. [PubMed: 20702750]
16. Thompson FE, Subar AF, Smith AF, et al. Fruit and vegetable assessment: Performance of 2 new short instruments and a food frequency questionnaire. J Am Diet Assoc. 2002; 102:1764–1772. [PubMed: 12487538]
17. Thompson FE, Willis GB, Thompson OM, Yaroch AL. The meaning of 'fruits' and 'vegetables'. Public Health Nutr. 2011; 14:1222–1228. [PubMed: 21272414]
18. Wolfe WS, Frongillo EA, Cassano PA. Evaluating brief measures of fruit and vegetable consumption frequency and variety: cognition, interpretation, and other measurement issues. J Am Diet Assoc. 2001; 101:311–318. [PubMed: 11269609]
19. Food Patterns Equivalents Database 2009–2010. United States Department of Agriculture,Agricultural Research Service; 2014. http://www.ars.usda.gov/Services/docs.htm?docid=23869 [Accessed July 15, 2016]
20. Food Patterns Equivalents Database 2007–2008. United States Department of Agriculture,Agricultural Research Service; 2014. http://www.ars.usda.gov/Services/docs.htm?docid=23869 [Accessed July 15, 2016]
21. National Cancer Institute. Usual dietary intakes: SAS macros for the NCI method. National Cancer Institute; 2015. http://riskfactor.cancer.gov/diet/usualintakes/macros.html [Accessed September 13, 2016]
22. Food and Nutrition Board, Institute of Medicine. DRI Dietary Reference Intakes: Applications in Dietary Assessment. A report of the Subcommittee on Interpretation and Uses of Dietary Reference Intakes and the Standing Committee on the Scientific Evaluation of Dietary Reference Intakes. Washington DC: National Academy Press; 2000.
23. Tooze JA, Midthune D, Dodd KW, et al. A new statistical method for estimating the usual intake of episodically consumed foods with application to their distribution. J Am Diet Assoc. 2006; 106:1575–1587. [PubMed: 17000190]
24. SAS [Computer Program]. Version 9.3.2. Cary, NC: SAS Institute Inc; 2012.
25. SAS-Callable SUDAAN [Computer Program]. Version 11. Research Triangle Park, NC: RTI International; 2012.
26. Task 4: Using Balanced Repeated Replication to Estimate Standard Errors. Centers for Disease Control and Prevention, National Center for Health Statistics; 2011. Modeling Usual Intake Using Dietary Recall Data. http://www.cdc.gov/nchs/tutorials/dietary/Advanced/ModelUsualIntake/Info4.htm [Accessed September 13, 2016]
27. Software for Analysis of YRBS Data. Centers for Disease Control and Prevention; 2014. http://www.cdc.gov/healthyyouth/data/yrbs/pdf/yrbs_analysis_software.pdf [Accessed September 13, 2016]
28. Trowbridge F, Wong F, Byers T, Serdula MK. Methodological Issues in Nutrition Surveillance: The CDC Experience. J Nutr. 1990; 120:1512–1518. [PubMed: 2173743]
29. Dietary Screener in the 2005 CHIS: Scoring Procedures. National Cancer Institute, Applied Research Cancer Control and Population Sciences; 2015. http://appliedresearch.cancer.gov/surveys/chis/dietscreener/scoring.html [Accessed September 13, 2016]
30. Dietary Assessment Primer, Screeners at a Glance. National Institutes of Health, National Cancer Institute; 2015. http://dietassessmentprimer.cancer.gov/profiles/screeners/index.html [Accessed September 13, 2016]
31. Kann L, Kinchen S, Shanklin SL, et al. Youth risk behavior surveillance--United States, 2013. MMWR Surveill Summ. 2014; 63(Suppl 4):1–168.
32. Enrollment Status of the Population 3 Years Old and Over, by Sex, Age, Race, Hispanic Origin, Foreign Born, and Foreign-Born Parentage: October 2013. U S Census Bureau, Current Population

Survey; 2013. http://www.census.gov/hhes/school/data/cps/2013/Tab01-01.xls [Accessed September 13, 2016]

33. Centers for Disease Control and Prevention. NHANES Response Rates and Population Totals. National Center for Health Statistics; 2013. http://www.cdc.gov/nchs/nhanes/response_rates_CPS.htm [Accessed July 15, 2016]
34. YRBS Participation, Data Quality, and Data Availability. Division of Adolescent and School Health National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention, CDC; 2015. http://www.cdc.gov/healthyyouth/data/yrbs/pdf/2013_hs_participation_history.pdf [Accessed September 13, 2016]
35. Kelder SH, Perry CL, Klepp KI, Lytle LL. Longitudinal tracking of adolescent smoking, physical activity, and food choice behaviors. Am J Public Health. 1994; 84:1121–1126. [PubMed: 8017536]
36. Resnicow K, Smith M, Baranowski T, Baranowski J, Vaughan R, Davis M. 2-year tracking of children's fruit and vegetable intake. J Am Diet Assoc. 1998; 98:785–789. [PubMed: 9664920]
37. Who's minding the kids? Child care arrangements: spring 2011. US Department of Commerce, US Census Bureau; 2013. http://www.census.gov/prod/2013pubs/p70-135.pdf [Accessed July 15, 2016]
38. National Center for Education Statistics. Enrollment in educational institutions, by level and control of institution: selected years, 1869–70 through fall 2023. Washington, DC: US Department of Education, Institute of Education Sciences; 2012. Digest of education statistics. Table 105.30. https://nces.ed.gov/programs/digest/d13/tables/dt13_105.30.asp [Accessed July 15, 2016]
39. Kim SA, Moore LV, Galuska D, et al. Vital Signs: Fruit and Vegetable Intake Among Children - United States, 2003–2010. Mmwr-Morbidity and Mortality Weekly Report. 2014; 63:671–676. [PubMed: 25102415]
40. Evans CEL, Christian MS, Cleghorn CL, Greenwood DC, Cade JE. Systematic review and meta-analysis of school-based interventions to improve daily fruit and vegetable intake in children aged 5 to 12 y. Am J Clin Nutr. 2012; 96:889–901. [PubMed: 22952187]
41. Blanchette L, Brug J. Determinants of fruit and vegetable consumption among 6–12-year-old children and effective interventions to increase consumption. Journal of Human Nutrition and Dietetics. 2005; 18:431–443. [PubMed: 16351702]
42. Johnson DB, Podrabsky M, Rocha A, Otten JJ. Effect of the healthy hunger-free kids act on the nutritional quality of meals selected by students and school lunch participation rates. JAMA Pediatrics. 2016; 170:e153918. [PubMed: 26747076]
43. Cohen JFW, Richardson S, Parker E, Catalano PJ, Rimm EB. Impact of the New U.S. Department of Agriculture School Meal Standards on Food Selection, Consumption, and Waste. Am J Prev Med. 2014; 46:388–394. [PubMed: 24650841]
44. Merlo C, Brener N, Kann L, McManus T, Harris D, Mugavero K. School-Level Practices to Increase Availability of Fruits, Vegetables, and Whole Grains, and Reduce Sodium in School Meals - United States, 2000, 2006, and 2014. MMWR Morb Mortal Wkly Rep. 2015; 64:905–908. [PubMed: 26313472]
45. Pearson N, Atkin AJ, Biddle SJ, Gorely T. A family-based intervention to increase fruit and vegetable consumption in adolescents: a pilot study. Public Health Nutr. 2010; 13:876–885. [PubMed: 20196908]
46. Pearson N, Biddle SJ, Gorely T. Family correlates of fruit and vegetable consumption in children and adolescents: a systematic review. Public Health Nutr. 2009; 12:267–283. [PubMed: 18559129]

Author Manuscript
Author Manuscript
Author Manuscript

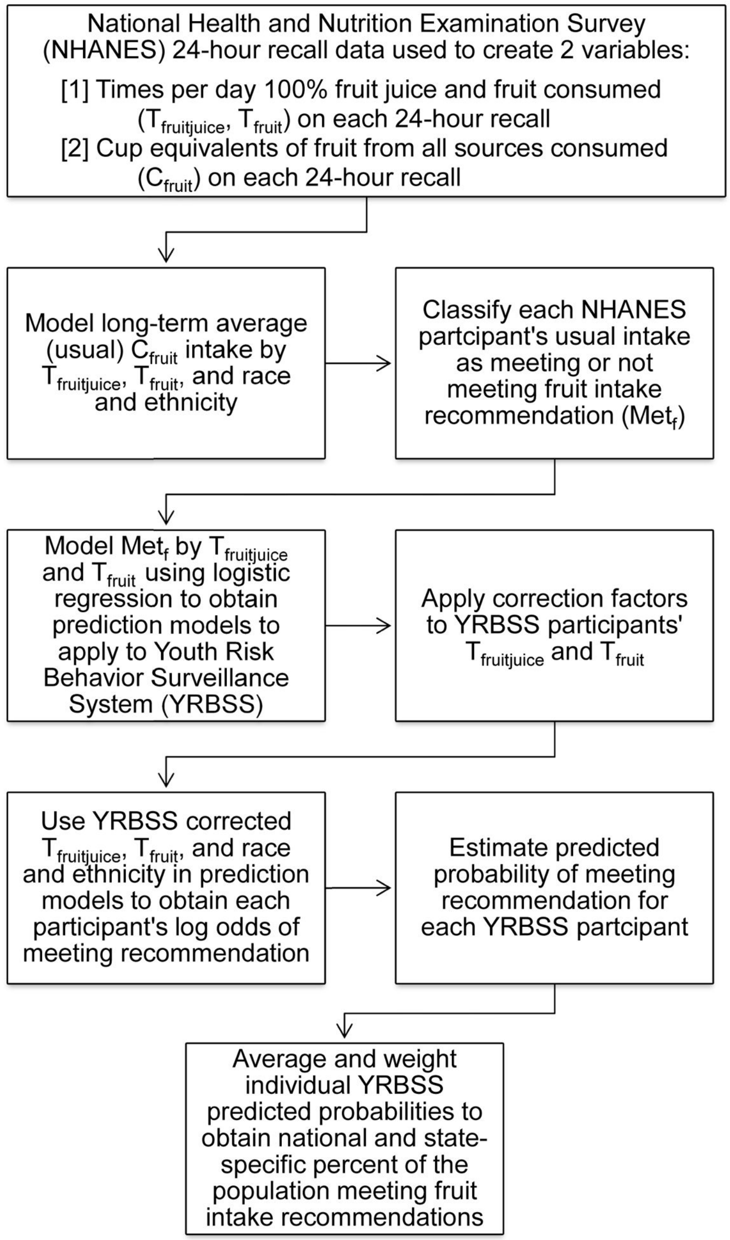

Figure 1.

Overview of method to estimate percent of the population meeting fruit intake recommendations National Health and Nutrition Examination Survey, United States, 2007–2010, and Youth Risk Behavior Surveillance System, United States and 33 states, 2013.

Table 1

Amounts of fruits and vegetables 14–18 year olds need daily per US Department of Agriculture fruit and vegetable intake recommendations

Sex	Recommended servings (cups equivalents/day)[a]	
	Vegetables	**Fruit**
Females	2½ cups	1 ½ cups
Males	3 cups	2 cups

[a]Amounts appropriate for individuals who get less than 30 minutes per day of moderate physical activity, beyond normal daily activities.[4,5] Physically active individuals may be able to consume more while staying within calorie needs.[4,5]

[b]One cup is approximately equal to 1 small apple (149 g), 8 large strawberries (144 g), 12 baby carrots (120 g), or 1 large tomato (182 g).[4,5]

Table 2

Fruit and vegetable intake from 24-hour dietary recalls of 14–18 year olds by sex and race/ethnicity, National Health and Nutrition Examination Survey, 2007–2010[a]

		Median times per day[b]		Median cup equivalents[c]	
Characteristic	**No.[d]**	**Fruit**	**Vegetable**	**Fruit**	**Vegetable**
Total	1,535	0.2	0.1	0.5	0.8
Sex					
Females	727	0.2	0.2	0.5	0.7
Males	808	0.2	0.0	0.5	0.8
Race/ethnicity					
Hispanic	575	0.4	0.0	0.7	0.8
Non-Hispanic Black	364	0.3	0.0	0.4	0.5
Non-Hispanic Other[e]	596	0.2	0.2	0.5	0.8

[a]Estimates are weighted to account for complex sampling using SUDAAN except where noted. Fruit consists of 100% fruit juice and whole fruit. Vegetables include green salad, potatoes, carrots, and other vegetables.

[b]Only foods that parallel Youth Risk Behavior Surveillance System questions were counted; averaged over number of recall days

[c]Total cup equivalents per day of fruits and vegetables from all sources except fried potatoes and beverages other than 100% fruit juice. Estimates were averaged over number of recall days.

[d]No.= Unweighted number of participants

[e]Non-Hispanic other includes non-Hispanic white and all other racial ethnic groups

Table 3

Fruit and vegetable intake – national and 33 states, 2013 Youth Risk Behavior Surveillance System[a]

		Median times per day		Percent meeting recommendations[b]			
				Fruit		Vegetable	
State	No.[c]	Fruit	Vegetable	%	95% CI[d]	%	95% CI[d]
National	12,829	0.9	1.1	8.5%	(4.9% , 12.1%)	2.1%	(0.0%, 8.1%)
Alabama	1,475	0.8	1.0	6.8%	(2.7% , 10.8%)	1.3%	(0.0%, 7.6%)
Alaska	1,152	0.9	1.2	6.4%	(2.4% , 10.5%)	1.9%	(0.0%, 8.4%)
Arkansas	1,415	0.7	1.0	6.7%	(2.7% , 10.6%)	1.2%	(0.0%, 7.6%)
Connecticut	2,178	0.9	1.2	7.1%	(3.1% , 11.0%)	1.2%	(0.0%, 7.3%)
Florida	5,639	0.9	1.0	8.9%	(5.2% , 12.6%)	2.2%	(0.0%, 8.3%)
Georgia	1,832	0.8	1.0	7.3%	(2.9% , 11.8%)	1.3%	(0.0%, 7.6%)
Idaho	1,807	0.9	1.2	5.4%	(1.5% , 9.3%)	1.9%	(0.0%, 8.1%)
Illinois	2,994	0.9	1.1	7.5%	(3.4% , 11.6%)	1.4%	(0.0%, 7.5%)
Kansas	1,863	0.9	1.2	5.4%	(1.5% , 9.3%)	1.5%	(0.0%, 7.8%)
Kentucky	1,549	0.8	1.0	6.5%	(2.6% , 10.4%)	1.4%	(0.0%, 7.6%)
Maryland	47,564	0.9	1.2	7.6%	(4.2% , 10.9%)	1.6%	(0.0%, 7.6%)
Michigan	4,001	0.9	1.1	6.2%	(2.3% , 10.2%)	1.2%	(0.0%, 7.2%)
Mississippi	1,552	0.7	1.0	8.6%	(4.1% , 13.0%)	2.5%	(0.0%, 9.6%)
Missouri	1,514	0.8	1.0	5.3%	(0.8% , 9.7%)	1.3%	(0.0%, 7.6%)
Montana	4,612	0.9	1.2	5.8%	(2.1% , 9.5%)	1.4%	(0.0%, 7.4%)
Nebraska	1,752	0.9	1.1	5.3%	(1.5% , 9.1%)	1.6%	(0.0%, 7.8%)
Nevada	1,996	0.9	1.1	6.8%	(3.2% , 10.5%)	1.9%	(0.0%, 8.2%)
New Jersey	1,619	0.9	1.1	6.4%	(2.2% , 10.7%)	1.0%	(0.0%, 7.2%)
New Mexico	5,084	0.9	1.2	8.1%	(4.7% , 11.5%)	3.3%	(0.0%, 9.6%)
North Carolina	1,756	0.8	1.1	7.2%	(2.9% , 11.4%)	1.3%	(0.0%, 7.7%)
North Dakota	1,885	0.9	1.2	5.5%	(1.3% , 9.7%)	1.0%	(0.0%, 7.1%)
Ohio	1,359	0.9	1.1	6.1%	(1.9% , 10.3%)	1.2%	(0.0%, 7.6%)
Oklahoma	1,452	0.7	1.0	6.3%	(2.6% , 10.0%)	1.7%	(0.0%, 7.9%)
Rhode Island	2,262	0.9	1.2	7.9%	(4.1% , 11.8%)	1.2%	(0.0%, 7.2%)
South Carolina	1,503	0.8	0.9	8.2%	(3.9% , 12.5%)	1.0%	(0.0%, 7.5%)

		Median times per day		Percent meeting recommendations[b]			
				Fruit		Vegetable	
State	**No.[c]**	**Fruit**	**Vegetable**	**%**	**95% CI[d]**	**%**	**95% CI[d]**
South Dakota	1,232	0.9	1.2	6.4%	(1.5% , 11.4%)	1.7%	(0.0%, 7.6%)
Tennessee	1,757	0.8	0.9	8.2%	(3.7% , 12.7%)	1.7%	(0.0%, 8.0%)
Texas	2,974	0.9	0.9	7.3%	(4.0% , 10.7%)	1.9%	(0.0%, 8.2%)
Utah	2,099	1.0	1.2	5.6%	(1.7% , 9.6%)	1.9%	(0.0%, 8.1%)
Vermont	20,165	1.0	1.4	6.6%	(3.2% , 10.1%)	2.0%	(0.0%, 7.7%)
Virginia	6,386	0.9	1.1	7.4%	(3.8% , 11.0%)	1.8%	(0.0%, 8.0%)
West Virginia	1,715	0.9	1.2	8.3%	(3.9% , 12.7%)	2.5%	(0.0%, 9.2%)
Wyoming	2,863	0.9	1.3	6.7%	(3.0% , 10.4%)	2.3%	(0.0%, 8.3%)

[a] Estimates are weighted to account for complex sampling using SUDAAN except where noted. Fruit consists of 100% fruit juice and whole fruit. Vegetables include green salad, potatoes, carrots, and other vegetables. 17 states were excluded that deviated from the standard 6 fruit and vegetable items in the national survey, did not participate in YRBSS in 2013, or did not have weighted state data

[b] Recommendations are age- and sex-specific and appropriate for individuals who get less than 30 minutes per day of moderate physical activity, beyond normal daily activities. Percentages are derived from age- and sex-specific models that account for the usual intake of foods and race/ethnicity.

[c] Number of respondents (unweighted) with complete data for fruit and vegetable intake and demographic information.

[d] 95% confidence limits for percentages of the population meeting recommendations. Negative lower bounds were truncated at 0%.