Economic Research Service
U.S. DEPARTMENT OF AGRICULTURE

Economic Research Service

Economic Research Report Number 311

April 2023

Trends in U.S. Whole-Grain Intakes 1994–2018: The Roles of Age, Food Source, and School Food

Biing-Hwan Lin, Travis A. Smith, and Joanne F. Guthrie

Economic Research Service
U.S. DEPARTMENT OF AGRICULTURE

Recommended citation format for this publication:

Lin, Biing-Hwan, Travis A. Smith, and Joanne F. Guthrie. April 2023. *Trends in U.S. Whole-Grain Intakes 1994–2018: The Roles of Age, Food Source, and School Food,* ERR-311, U.S. Department of Agriculture, Economic Research Service.

USDA Economic Research Service
U.S. DEPARTMENT OF AGRICULTURE

Economic Research Service

Economic Research Report Number 311

April 2023

Trends in U.S. Whole-Grain Intakes 1994–2018: The Roles of Age, Food Source, and School Food

Biing-Hwan Lin, Travis A. Smith, and Joanne F. Guthrie

Abstract

Since 2005, the Dietary Guidelines for Americans (DGA) has recommended that whole grains comprise at least half of total grain consumption. This study used nationally representative food consumption datasets (spanning 1994–2018) to examine trends in whole-grain intakes before and after the establishment of this recommendation. Trends were examined by age group and food source; that is, food purchased at grocery stores and other retailers to be eaten either at home or away (as a brown bag lunch) versus food purchased at restaurants, fast-food establishments and similar sources, and schools. Across the entire time period studied, the diets of older U.S. consumers (65 years old and over) were richest in whole grains on a per-1,000 calorie basis—but only among children (2–19 years old) did intakes, measured on a per-1,000 calorie basis, increase during 1994–2018. Multivariate analyses indicate this finding was largely attributable to changes in whole-grain consumption from foods obtained at school. Since 2013 (following the implementation of new standards requiring school meals subsidized by the U.S. Department of Agriculture (USDA) to offer more whole-grain-rich foods), approximately one in two children who ate school food consumed whole grains on the survey day, whereas previously, fewer than one in five of such children consumed whole grains. Children who selected whole grains when eating food obtained at school also ate larger amounts, measured as ounce equivalents consumed per 1,000 calories, with 2013–18 levels more than double those of 1994–2010.

Keywords: whole grains, diet quality, consumption trends, food away from home, National School Lunch Program, School Breakfast Program, children's diets

About the Authors

Biing-Hwan Lin is a senior economist and Joanne Guthrie is a senior nutritionist with the Food Economics Division, USDA, Economic Research Service. Travis Smith is an associate professor, Agriculture and Applied Economics Department, University of Georgia.

Acknowledgments

For technical peer review, the authors thank Hayden Stewart of USDA, Economic Research Service (ERS); Pamela Starke-Reed, Alanna Moshfegh, and Shanthy Bowman of USDA, Agricultural Research Service; TusaRebecca Pannucci of USDA, Food and Nutrition Service's (FNS) Center for Nutrition Policy and Promotion; Joseph Cooper of the USDA, Office of Chief Economist; Juliana Cohen of Merrimack College; and an anonymous reviewer at USDA, FNS. The authors also thank USDA, ERS's Chris Whitney, Jeff Chaltas, and Grant Wall for editorial assistance and Xan Holt for layout and design. The contributions from Travis Smith, University of Georgia, were partially funded under the cooperative agreement 58-4000-6-0009.

Contents

USDA Economic Research Service
U.S. DEPARTMENT OF AGRICULTURE

A report summary from the Economic Research Service *April 2023*

Trends in U.S. Whole-Grain Intakes 1994–2018: The Roles of Age, Food Source, and School Food

Biing-Hwan Lin, Travis A. Smith, and Joanne F. Guthrie

What Is the Issue?

Since 2005, the Dietary Guidelines for Americans (DGA), the Federal Government's statement on what to eat to be healthy, has recommended that people eat at least half of their grain intake in the form of whole grains. This change has been encouraged via nutrition education, food product reformulation, and new product development—and through public policy changes such as the requirement, beginning in 2012, that whole grains be included in meals provided through the USDA's National School Lunch and School Breakfast Programs. This study examines trends in whole-grain intakes of U.S. residents by age and food source using national datasets spanning 1994–2018. Food sources include food at home (FAH)—food purchased at grocery stores and other retailers to be eaten either at home or away (as a brown bag lunch)—versus food away from home (FAFH), which includes food purchased at restaurants, fast-food establishments and similar sources, and at schools.

What Did the Study Find?

DGA-based guidance recommends whole grain intake amounts based on an individual's caloric intake. For example, the recommendation for a 2,000-calorie diet is 6-ounce equivalents of grains, with at least half being whole grains. Because caloric needs vary by age, gender, and physical activity, the authors assessed intakes using a density measure (whole-grain ounce equivalents per 1,000 calories). During the years studied, U.S. consumers 2 years old and over consumed an average of approximately 2,000 calories daily; therefore, the authors compared whole grain density of diets to a benchmark standard of 1.5-ounce equivalents of whole grains per 1,000 calories to represent the whole grain recommended amounts across all calorie levels. In 1994–98, whole-grain intakes by U.S. residents 2 years old and over were 0.4-ounce equivalents per 1,000 calories; in 2017–18, intakes were 0.43-ounce equivalents per 1,000 calories, an increase of less than 0.05-ounce equivalents per 1,000 calories over two decades.

Adults 65 years old and above consumed the most whole-grain-dense diets across all time periods. However, there was no upward intake trend, with a whole-grain density of approximately 0.6-ounce equivalents at the beginning

(1994) and end (2018) of this period. Whole-grain densities of the diets of younger adults (20–64 years old) also did not change significantly (0.38 in 1994–98 and 0.37-ounce equivalents per 1,000 calories in 2017–18, respectively). A significant increase occurred only among children 2–19 years old; their diets were more whole-grain dense in 2015–16 and 2017–18, compared with 1994–98 (0.5 and 0.47 versus 0.34-ounce equivalents per 1,000 calories, respectively).

Further analysis of children's diets revealed the role of school meals and other food obtained at school (school food) in the change in children's whole-grain intakes. Comparing FAH with all FAFH, FAH was more whole-grain dense. However, when FAFH was disaggregated into restaurants, fast-food establishments, schools, and other sources after 2013, school food became the most whole grain-dense food source.

After 2013–14, more of the children who ate school food ate whole grains and ate larger amounts of them. Almost 50 percent of children who ate school food ate whole grains from school foods; previously, this figure had never topped 24 percent. Among children eating whole grains as part of their school food, amounts consumed in 2013–18 were more than double those of 1994–2010. A decomposition analysis indicated that 34 percent of schoolchildren's increased whole-grain intake from school food between 2005–10 and 2013–18 could be attributed solely to children's increased likelihood of consuming whole grains; 22 percent solely to increased amounts consumed by those consuming; and 43 percent to the interaction of the two effects.

There were age and ethnicity-related disparities in children's consumption of whole grains from school foods. Groups less likely to consume whole grains from school food included older children compared with those children 5–10 and 11–14 years old and non-Hispanic-White children compared with non-Hispanic-Black and Hispanic children. Among those schoolchildren who did consume whole grains, non-Hispanic-White schoolchildren also consumed smaller amounts of whole grains from school food than other children.

How Was the Study Conducted?

Nationally representative food consumption survey datasets used include the USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals (CSFII) and the What We Eat in America component of the National Health and Nutrition Examination Survey (WWEIA/NHANES) conducted by USDA and the U.S. Department of Health and Human Services (HHS) over 2003–18. All analyses were conducted using methods that adjust for complex survey design effects and sample weights.

Descriptive analyses of grain consumption were conducted for the U.S. population 2 years old and above. Analyses were conducted for the total population for the following subgroups: a) adults 65 years old and above, b) adults 20–64 years old, and c) children 2–19 years old. Multivariate regression analyses examining the contribution of school food to children's whole-grain intakes include children 5–19 years old who were attending school at the time of data collection.

Glossary

Key Concepts and Terms

Decomposition analysis: This analysis approach assumes that differences in intake can be assessed by examining differences in:

- Propensity of consumption: the likelihood that an individual will consume any amount of a food.
- Intensity of consumption: the amount of a food consumed by those who are consuming it.
- For a mathematical explanation, see box B.

Food Patterns Equivalents Database (FPED): This USDA database converts the foods and beverages in the Food and Nutrient Database for Dietary Studies to their USDA Food Patterns components (for example, a bowl of pasta with tomato sauce would be disaggregated into appropriate amounts of vegetable and grains) (USDA, ARS, 2019c and 2019d).

Food source: This is defined by where the food was acquired. In this study, food acquisition sources were grouped as:

- Food at home (FAH), which is acquired from grocery stores, convenience stores, and similar retailers.
- Food away from home (FAFH), which is further separated into four subcategories:
- Restaurant: food from full-service restaurants (i.e., with wait staff).
- Fast food: food from fast-food/pizza establishments.
- School food: Includes meals served through USDA's National School Lunch Program and School Breakfast Program, as well as other foods and beverages sold at school (often termed "competitive foods"); does not include food prepared at home and brought to school for consumption ("brown bag").
- Other FAFH.

For more information, see appendix table A.1.

Whole grains and their measurement: Whole grains are defined as grain foods (or the grain component of a mixed food) in which the principal components of the grain (i.e., the starchy endosperm, germ, and bran) are present in the same relative proportions as the components in the intact grain. The Federal Dietary Guidelines for Americans (DGA) expresses recommendations for grain consumption in terms of "ounce equivalents," with a 1-ounce slice of bread as an example of a 1-ounce equivalent item. In the USDA FPED, total-grain, whole-grain, and refined-grain values for foods are measured in terms of ounce equivalents.

Whole-grain density: A measurement of whole-grain ounce equivalents per 1,000 calories.

Trends in U.S. Whole-Grain Intakes 1994–2018: The Roles of Age, Food Source, and School Food

Introduction

Grain products are available in two basic forms: whole and refined. Whole grains contain all three key parts of the kernel—the bran, the germ, and the endosperm (Ferruzzi et al., 2014). Refining the grain normally removes most of the bran and some of the germ. In the United States, most refined grains are enriched—that is, some vitamins (thiamin, riboflavin, niacin, and folic acid) and iron are added at levels specified by Federal regulations (U.S. Department of Health and Human Services (HHS), 2015). Nevertheless, the Federal Dietary Guidelines for Americans recommend the consumption of whole grains as important sources of under-consumed nutrients such as zinc, magnesium, and dietary fiber (USDA/HHS, 2020; USDA, Center for Nutrition Policy and Promotion (CNPP), 2019).

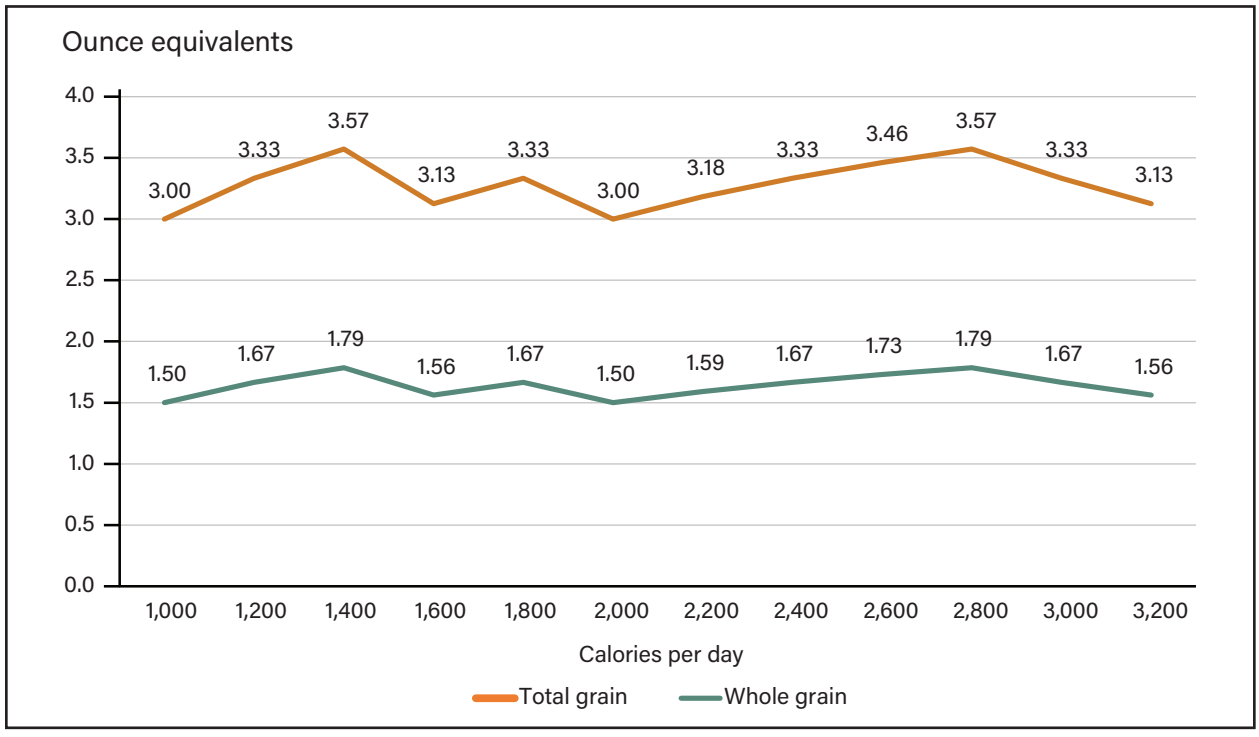
In addition, a considerable body of research has found low whole-grain consumption to be associated with an increased risk of obesity and several chronic disease conditions (Chen et al., 2016; Dietary Guidelines Advisory Committee, 2005; Lieffers et al., 2018; Ludwig et al., 2018). A comprehensive scientific review of the evidence conducted by an independent Federal Advisory Committee (as part of the development of the Federal Dietary Guidelines for Americans 2020–2025) concluded that—among adults—there was strong evidence of a relationship between whole-grain consumption and reduced cardiovascular disease risk. There was moderate evidence of reduced risk of obesity, type 2 diabetes, bone health, colorectal cancer, and post-menopausal breast cancer, and limited evidence of reduced risk of lung cancer. Among children and adolescents, there was limited evidence of a reduced risk of obesity in adolescence and of cardiovascular disease in adulthood (Dietary Guidelines Advisory Committee, 2020).

The Dietary Guidelines for Americans (DGA) gives advice about what to eat for a healthy diet. The publication's advice also forms the basis for Federal nutrition policies such as dietary standards for Federal food assistance programs, public nutrition information campaigns, and nutrition labeling of foods. Since its first issuance in 1980, the DGAs have been updated every 5 years to ensure consistency with up-to-date scientific knowledge. In a comprehensive review of scientific evidence, the National Research Council (1989) concluded that "diets high in plant foods—i.e., fruits, vegetables, legumes, and whole-grain cereals—are associated with a lower occurrence of coronary heart disease and cancers of the lung, colon, esophagus, and stomach." Responding to this conclusion, the 1995 DGA recommended Americans to "choose a diet with plenty of grain products, vegetables, and fruits (USDA/HHS, 1995)." Recognizing the distinct advantages of consuming grains and fruits/vegetables, separate recommendations for the consumption of these broad categories of plant foods appeared in the 2000 DGA. Although previous editions of the DGA encouraged whole grain consumption, the 2005 and subsequent editions have provided more specific recommendations (USDA/HHS, 2005, 2015; USDA/HHS, 2010).

Total, Whole-, and Refined-Grain Dietary Recommendations

DGA guidance on grain consumption uses the term "ounce equivalents" rather than "servings" when describing recommendations. The DGA report gives a 1-ounce slice of bread as an example of a 1-ounce equivalent item. Foods can be disaggregated into subgroups; for example, a 1-ounce slice of a multigrain bread that is 50 percent whole grain and 50 percent refined grain would contain 0.5-ounce equivalent whole grain, 0.5-ounce equivalent refined grain, and 1-ounce equivalent total grains (Bowman et al., 2017). The 2005 and subsequent editions of the DGA included two major changes from previous guidelines in the recommendations for grain consumption. First, the recommendation for total grain consumption was revised slightly downward. For example, recommended total grain consumption is now five 1-ounce equivalents (servings) per day for a 1,600-calorie diet, compared with the six servings recommended in the 2000 edition. Second, it was specifically recommended that at least half of the total grain intake be whole grains. The recommendations on total grains and whole grains are specified for 12 energy-intake levels, ranging from 1,000 to 3,200 calories per day.[1] Figure 1 displays the benchmark densities of total grains and whole grains (i.e., ounce equivalents of grains for each 1,000 calories in food) based on these recommendations. These range from 3- to 3.57-ounce equivalents for total grains and 1.5- to 1.79-ounce equivalents for whole grains per 1,000 calories (referred to as whole-grain density). The average daily caloric consumption during the time period studied was approximately 2,000 calories per day; therefore, the authors use 1.5-ounce equivalents per 1,000 calories as their benchmark standard for assessing whole-grain density.

Figure 1
Benchmark grain density (ounce equivalents/1,000 calories) by energy level



Note: The benchmark density for total grains represents the upper limit, and the benchmark for whole grains represents the lower limit at a given calorie intake level.

Source: USDA, Economic Research Service calculations based on recommendations of the Dietary Guidelines for Americans, 2020–2025.

[1] Recommended grain amounts at each calorie level can be found in table A3-2 of the DGA (USDA/HHS, 2020).

Response to Whole-Grain Recommendations

DGA recommendations have spurred public and private efforts to encourage whole-grain consumption. Federal nutrition education materials encourage increased whole-grain consumption (USDA, CNPP, 2019a), as do educational efforts from some private-sector groups (Whole Grain Council, 2005; American Heart Association, 2021). These efforts could encourage consumers to shift purchasing and consumption from refined grains to whole grains. Changes in consumer behavior could also spur a supply-side response, such as food companies creating new whole-grain products and reformulating existing products to include whole grains, and restaurants could offer more whole-grain items. Indeed, previous research has shown the food industry responded with new food products and reformulation in anticipation of increasing demand for whole grains (Mancino and Kuchler, 2012; Mancino et al., 2008; Vocke et al., 2008; Whole Grain Council, 2005). Offering some insight into the overall impact, Vocke et al. (2008) reported that whole-wheat flour's share of total flour production grew from 2.1 percent in 2002–03 to 4.1 percent in 2006–07—double the amount before the publication of the 2005 DGA but still a small share of overall production.

Importantly, because the DGA is a statement of Federal nutrition policy, its guidance can impact whole-grain consumption via Federal food program regulations. In 2009, the USDA Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) began including whole grains (such as whole-wheat bread) in food packages for pregnant, breastfeeding, and postpartum women and for children 1 to 5 years old (National Academy of Sciences, Engineering and Medicine, 2017). In 2010, Congress passed the Healthy, Hunger-Free Kids Act, which mandated that the USDA update school meal regulations to conform to the 2005 DGA (USDA, FNS, 2012).

Implementation of the updated regulations began in the 2012–13 school year, requiring at least one-half of all grain offerings in school lunches be whole grain-rich (i.e., at least 50 percent whole grains). Breakfasts were required to meet this standard in 2013–14, and beginning 2014–15, both meals—breakfast and lunch—were expected to serve only whole-grain-rich grains. However, because some school-foodservices reported difficulty procuring whole-grain-rich items that appealed to students, USDA offered schools flexibility that returned the requirement to the initial 50 percent of offerings, beginning in school year 2017. At USDA school-meal-participating schools, USDA also updated nutrition standards for any foods and beverages sold outside of the program—whether in the cafeteria, school store, snack bar, or vending machine(s). Primarily grain items (e.g., a granola bar) were required to be at least 50 percent whole grain or have whole grain as the first ingredient, with these changes required to take place by school year 2014–15 (Guthrie and Newman, 2013). A summary of relevant policies during the time period of this study can be found in box A.

Box A: Whole-grain requirements for the USDA National School Lunch Program, School Breakfast Program, and other foods sold by participating schools, 1994–2018

School year	Requirement
Before 2012	No requirement for whole grains
2012–13	At least one-half of all grain offerings in NSLP lunches must be whole grain-rich (i.e., at least 50 percent whole grains).
2013–14	At least one-half of all grain offerings in SBP breakfasts must be whole grain-rich (i.e., at least 50 percent whole grains).
2014–15	Both NSLP lunches and SBP breakfasts were required to serve only whole grain-rich meals.
2014–15	At all USDA-school meal participating schools, non-USDA foods sold (snack bar, vending machine(s), etc.) that were primarily grain, were required to be at least 50 percent whole grain or have whole grain as the first ingredient.
2017–18	State agencies were allowed to exempt local school foodservices from serving specific whole-grain products if the foodservices found it difficult to procure acceptable products. However, it was required that at least half of the grain products the foodservices offered be whole grain-rich.
2018–19	The rule on menu planning flexibilities set a requirement for whole grain-rich offerings for lunches and breakfasts, at 50 percent of all grain offerings.

NSLP = National School Lunch Program; SBP = School Breakfast Program.

Source: USDA, Economic Research Service, using information from USDA, Food and Nutrition Service (FNS), National School Lunch Program and School Breakfast Program: Nutrition Standards in the National School Lunch and School Breakfast Programs, Federal Register. 2012. USDA, FNS, National School Lunch Program and School Breakfast Program: Nutrition Standards for All Foods Sold in School as Required by the Healthy, Hunger-Free Kids Act of 2010, Federal Register. 2016. USDA, FNS, Child Nutrition Programs: Flexibilities for Milk, Whole Grains, and Sodium Requirements: Interim Final Rule, Federal Register, 2017. USDA, FNS, Child Nutrition Programs: Flexibilities for Milk, Whole Grains, and Sodium Requirements: Final Rule, Federal Register, 2018.

These changes in consumer information, whole grain-food availability, and Federal program guidelines are intended to promote increased whole-grain consumption. Nevertheless, whole-grain intake continues to fall below recommendations (DGAC, 2020). To better understand whole-grain consumption and any changes that may have occurred since promoting whole-grain consumption became a larger focus of the DGA, the authors examined changes over time using federally collected large national surveys of food and nutrient intakes of U.S. residents. The authors also analyzed differences by age group, given that consumers may respond differently to information by age and that some interventions (such as a change in school meal patterns and nutrition standards) may impact some age groups and not others.

Because the food preparation source—either food at home or away from home—has been shown by previous research to have important associations with diet quality (Guthrie et al., 2002; Saksena et al., 2018; Poti et al., 2013; Smith, 2017), the authors also examined whole-grain consumption trends by source. Finally, trends in whole-grain intakes of school-aged children by source were examined using multivariate approaches to better understand how the required inclusion of whole-grain-rich foods in USDA school meals is associated with whole-grain intakes of U.S. children.

Data

The study sample was drawn from eight nationally representative food intake recall survey datasets spanning 1994–2018: USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals (CSFII, 1994–98) and the continuous collections of information from the What We Eat in America component of the National Health and Nutrition Examination Survey (WWEIA/NHANES), conducted by USDA and HHS during 2003–18 (USDA, ARS, 2019a and 2019b).[2] Infants under the age of 2 were excluded from this report's sample because, until 2020, the DGAs applied only to individuals age 2 and above. Therefore, it would not be appropriate to include younger age groups in an assessment of adherence to guidelines during the time period studied (1994–2018).

Both the CSFII and WWEIA/NHANES surveys used comparable data collection methods, instruments, and other survey procedures to collect 24-hour food intake recall data for 2 nonconsecutive days.[3] For this study, only data from the first day of data collection were used. Respondents listed which foods they ate, how much of each food they ate, where they obtained the food, and whether the food was eaten at home. Respondents also described various economic, social, and demographic characteristics for themselves and their households, including the following: age, gender, race and ethnicity, household income, and parental educational achievement.

USDA's Agricultural Research Service (ARS) provides a technical database that can be used with intake data for food group analysis. For each food, USDA's Food Patterns Equivalents Database (FPED) (USDA, ARS, 2019c and 2019d) shows the number of servings from 37 food groups, including refined and whole grains. For grains, servings are reported as ounce equivalents consistent with Federal dietary guidance; therefore, that measurement is used in this report.

[2] Detailed documentation of the surveys can be found on the Food Surveys Research Group web page of USDA's Agricultural Research Service.

[3] USDA conducted dietary intake surveys prior to 1994, such as the 1989–1991 CSFII and 1977–1978 Nationwide Food Consumption Survey (NFCS). These earlier survey data are excluded in this study because the data don't have corresponding technical databases that translate foods into food groups specified in the Dietary Guidelines for Americans. The National Center for Health Statistics (NCHS) also conducted its own food intake surveys prior to 2003, using different survey designs and questionnaires so that the NCHS data collected before 2003 are not compatible with the 1994–98 CSFII and 2003–16 WWEIA/NHANES data. For example, prior to 2003, NCHS asked whether the food was eaten at home but not the location where the food was acquired, such as a supermarket, restaurant, or school.

Definition of Food Source

In the 1994–98 CSFII and the 2003–18 WWEIA, survey respondents reported whether a food was eaten at home and where it was acquired (food consumption survey data collected in 2001–02 included information on where food was eaten but not where it was obtained; therefore, these years of data were not included in this report's analysis). Food-source coding differs slightly between the CSFII and different years of WWEIA, but major sources—such as grocery stores, restaurants with waiter/waitress service, fast-food establishments, and school cafeterias—are common to all surveys. In this study, there are two main categories of food sources: food at home (FAH) and food away from home (FAFH), with the latter separated into four subcategories: full-service restaurants, fast-food establishments, schools, and other FAFH (for more information, see appendix table A.1).

Foods obtained at school are primarily those served through the USDA National School Lunch Program (NSLP) and the School Breakfast Program (SBP) but may also include foods sold outside of USDA programs, as described in appendix table A.1. Whole-grain standards for both school meals and other foods sold at school were implemented during the period studied (see box A).

Statistical Methods

The authors conducted descriptive analyses of trends in average intakes and densities of total grains and whole grains by age group for the U.S. population aged 2 and above. Age groups included adults 65 years old and above, adults 20–64 years old, and children 2–19 years old. Descriptive analyses of trends by food source were also conducted. The significance of differences was tested statistically by t-test.

A more in-depth analysis of trends in children's diets was conducted because initial descriptive analyses suggested more change in whole grain-intake trends among children than in adult groups and that this seemed to be associated with school food sources. For these analyses, the sample was limited to children aged 5 to 19 years who reported attending school at the time when they participated in the survey. In these analyses, full-service and fast-food establishments were combined into a single group called "restaurant" because of sample size limitations.

A challenge of this analysis is that only a subset—representing 29 percent of schoolchildren—reported eating any whole grains at school. More insight into behavior, such as whole-grain consumption, can be extracted from analyses that provide information on those people who choose to eat a target food (e.g., whole grains) versus those who do not, as well as information on the amount consumed by those who choose to consume the food. Economists studying food demand have proposed several approaches to these types of analyses based on different assumptions about what drives the cases of no consumption (zeros).

One approach is to use a Heckman two-step procedure. This approach serves as a statistical correction for potential bias in deciding to engage in the behavior studied (in this report's case, to consume a whole-grain food), commonly known as selection bias. The approach allows different factors to determine the level and probability of consumption. Heckman two-step models were estimated (using both Stata and SAS), both of which conduct the first step analysis via probit regression, with sampling design effects incorporated. The results indicated the Inverse Mills Ratio was insignificant, signaling that the procedure for correcting selection bias did not improve parameter estimates. Therefore, three regression analyses were conducted to examine the intake of whole grains from school foods among schoolchildren and conduct a decomposition analysis.

The first regression analysis examined changes in the whole grain to total grain ratio for school foods over time while controlling for the following demographic characteristics: age, gender, race and ethnicity, household income, and education of the household head. The second and third regression analyses examined two potential drivers of change in whole-grain consumption: change in consumption propensity (the decision to eat any of the food at all) and changes in consumption intensity (consumption amounts among those who consume). Propensity to consume was estimated by conducting a logistic regression that identified the percentage of the students who ate school foods who consumed whole grains (in any amount). Using the same sample of students, a consumption intensity regression examined the amount (intensity) of whole grain consumption (ounce equivalents per day) from school food.

Finally, decomposition analysis (see box B) was employed to assess the effects of consumption propensity and intensity. In this study, the decomposition analysis was applied to differences between two periods—before and after the change in school meal patterns and nutrition standards. The period of 2005–10 represents the period before the implementation of the whole grain requirements for school meals, while the intakes after the standards were implemented were analyzed for each of the 2013–14, 2015–16, and 2017–18 time periods of the WWEIA/NHANES. The 2011–2012 data were excluded from the decomposition analysis because the changes in school meal patterns and nutrition standards were implemented in the 2012 school year (i.e., in the fall of 2012). As a result, the 2011–2012 dietary data overlap with the 2012 school meal pattern and nutrition standards for only a few months and span the periods before and after the 2012 school meal standards.

Box B: Mathematical derivation of decomposition between two periods, 0 and 1, before and after implementation of school meal patterns and nutrition standards for whole grains

Mean intake of the population: Q0 and Q1

Propensity to consume: P0 and P1

Intensity of consumption (i.e., mean intake among eaters): C0 and C1

Change in mean intake among population between the two periods: Q1 - Q0

$= P1\ C1 - P0\ C0$

$= (P0 + (P1 - P0))\ (C0 + (C1 - C0)) - P0\ C0$

$= P0\ (C1 - C0) + C0\ (P1 - P0) + (P1 - P0)\ (C1 - C0)$

= change due to intensity + change due to propensity + interaction effect

The predicted propensity to consume is calculated from the results of a logistic regression (tables 5) by converting the log-odds coefficients into probabilities. The consumption intensity is obtained by regressing intakes on survey years and demographics among those individuals who reported eating whole grains. The propensity effect is measured as the change in consumption probability at the consumption amount before implementation of new school meal patterns and nutrition standards. The intensity effect is calculated as the change in consumption amount among consumers at the consumption probability (propensity) before the implementation of new school meal patterns and nutrition standards. The interaction effect is the product of changes in consumption probability and amount.

Both the 1994–98 CSFII and the 2003–18 WWEIA employed complex sampling designs, which include multi-stage, unequal probability, and cluster sampling methods. The complex survey design is nested within each survey wave (i.e., across surveys they are independent), making it possible to combine surveys for analysis (Mirel et al., 2013). All analyses used the Surveymeans and Surveyreg procedures in SAS version 9.4 to incorporate complex survey-design effects and sample weights (SAS Institute Inc., 2004).

Findings

Over the Time Period Measured, Imbalance Between Refined-Grain and Whole-Grain Consumption Continued

Daily intakes of food energy, total grains, refined grains, and whole grains for the U.S. population aged 2 and above by food source are reported in tables 1a and 1b. In tables 2a and 2b, the density of total grains, refined grains, and whole grains by food source for the U.S. population is reported. During the period studied, U.S. consumers consumed an average of slightly more than 2,000 calories a day (tables 1a and 1b). Hence, for each 1,000 calories, the intakes of total grains and refined grains should be limited to no more than 3- and 1.5-ounce equivalents, respectively. The intake of whole grains should be at least 1.5-ounce equivalents for an average consumer, and the ratio of the whole to total grains should be at least 50 percent. As shown in tables 2a and 2b and figures 2 and 3, U.S. consumers consistently over-consumed refined grains and under-consumed whole grains during 1994–2018. In 1994–98, refined-grain intake comprised 89 percent of the total grain intake, whereas whole-grain intake comprised 11 percent. Beginning in 2011–2012, whole-grain intake increased to approximately 0.9-ounce equivalents daily or 13–14 percent of total grain intake, still well below the 50-percent recommendation. Expressed on the basis of caloric density, refined-grain intake is 2.77-ounce equivalents per 1,000 calories in 2017–18, while whole-grain intake never reaches one-third of the 1.5-ounce equivalents per 1,000 calorie benchmark.

Table 1a

Per capita daily intake of calories and grains by food source: U.S. population aged 2 years and above, 1994–2010

Means and standard errors (SE) of the means										
		1994–98		2003–04		2005–06		2007–08		2009–10	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Energy (calories)		2033.93	16.20	2194.78	15.59	2158.47	28.85	2069.79	24.55	2080.56	12.91
	At home	1380.76	14.93	1458.96	21.46	1430.04	17.96	1396.89	23.87	1460.34	16.85
	Away from home	653.17	14.97	735.83	16.47	728.43	24.68	672.91	15.81	620.22	13.11
	Restaurant	163.75	5.39	203.32	7.29	195.28	13.03	192.91	12.22	159.58	6.72
	Fast food	286.52	8.80	388.88	18.18	359.90	17.81	316.26	15.15	299.26	8.07
	School	46.05	2.11	38.91	4.80	35.12	3.56	39.74	3.81	39.24	5.25
	Others	156.85	8.46	104.71	6.33	138.14	9.03	124.00	8.05	122.14	5.29
Total grains (ounce-equivalents)		6.67	0.05	6.91	0.10	6.71	0.10	6.37	0.09	6.57	0.08
	At home	4.63	0.06	4.43	0.11	4.23	0.09	4.19	0.11	4.51	0.06
	Away from home	2.04	0.05	2.48	0.06	2.48	0.08	2.18	0.05	2.07	0.06
	Restaurant	0.48	0.02	0.62	0.03	0.64	0.04	0.59	0.04	0.50	0.03
	Fast food	0.97	0.03	1.43	0.08	1.32	0.06	1.10	0.05	1.07	0.04
	School	0.14	0.01	0.13	0.01	0.12	0.01	0.13	0.01	0.14	0.02
	Others	0.45	0.02	0.30	0.02	0.41	0.03	0.37	0.02	0.35	0.02
Refined grains (ounce-equivalents)		5.92	0.05	6.31	0.09	6.03	0.10	5.73	0.07	5.78	0.09
	At home	3.98	0.05	3.90	0.10	3.62	0.08	3.61	0.09	3.78	0.06
	Away from home	1.95	0.05	2.42	0.07	2.42	0.08	2.12	0.05	2.00	0.06
	Restaurant	0.46	0.02	0.61	0.03	0.62	0.04	0.57	0.04	0.48	0.03
	Fast food	0.94	0.03	1.40	0.08	1.30	0.06	1.08	0.05	1.05	0.04
	School	0.13	0.01	0.12	0.01	0.11	0.01	0.12	0.01	0.13	0.02
	Others	0.41	0.02	0.29	0.02	0.39	0.03	0.35	0.02	0.33	0.02
Whole grains (ounce-equivalents)		0.75	0.02	0.59	0.03	0.68	0.03	0.64	0.04	0.79	0.03
	At home	0.66	0.02	0.53	0.03	0.61	0.03	0.58	0.04	0.73	0.03
	Away from home	0.09	0.01	0.06	0.01	0.07	0.01	0.07	0.01	0.06	0.01
	Restaurant	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.01	0.02	0.00
	Fast food	0.03	0.00	0.02	0.01	0.03	0.00	0.02	0.00	0.02	0.00
	School	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00
	Others	0.04	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00

Source: USDA, Economic Research Service, using data from USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals and the continuous waves of What We Eat in America/National Health and Nutrition Examination Survey conducted by USDA and U.S. Department of Health and Human Services during 2003–18.

Table 1b

Per capita daily intake of calories and grains by food source: U.S. population aged 2 years and above, 2011–2018

Means and standard errors (SE) of the means									
		2011–12		2013–14		2015–16		2017–18	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Energy (calories)		2139.06	12.30	2079.32	17.17	2048.24	18.25	2093.14	14.12
	At home	1399.10	31.55	1368.60	15.84	1369.60	20.87	1402.55	22.45
	Away from home	739.97	28.67	710.73	13.83	678.64	17.65	690.60	25.02
	Restaurant	171.07	10.81	177.04	8.86	178.61	6.64	173.28	10.87
	Fast food	362.34	23.83	352.13	9.36	330.94	11.75	360.90	17.92

Continues on next page >

	School	40.53	4.59	38.76	2.93	34.62	3.56	28.21	4.88
	Others	166.03	10.17	142.80	8.32	134.47	7.81	128.20	6.27
Total grains (ounce-equivalents)		6.81	0.07	6.61	0.06	6.44	0.05	6.64	0.11
	At home	4.37	0.11	4.20	0.07	4.15	0.06	4.28	0.13
	Away from home	2.44	0.10	2.42	0.06	2.29	0.06	2.36	0.10
	Restaurant	0.54	0.04	0.55	0.03	0.57	0.03	0.54	0.04
	Fast food	1.28	0.08	1.30	0.04	1.21	0.05	1.32	0.07
	School	0.14	0.02	0.15	0.01	0.12	0.01	0.11	0.02
	Others	0.48	0.03	0.42	0.02	0.39	0.02	0.40	0.02
Refined grains (ounce-equivalents)		5.89	0.08	5.74	0.07	5.53	0.06	5.79	0.09
	At home	3.57	0.09	3.47	0.07	3.39	0.05	3.55	0.10
	Away from home	2.31	0.10	2.27	0.06	2.14	0.06	2.24	0.10
	Restaurant	0.51	0.04	0.52	0.03	0.54	0.03	0.52	0.04
	Fast food	1.24	0.08	1.24	0.04	1.16	0.05	1.28	0.07
	School	0.13	0.01	0.11	0.01	0.09	0.01	0.08	0.01
	Others	0.43	0.03	0.40	0.02	0.35	0.02	0.37	0.02
Whole grains (ounce-equivalents)		0.92	0.04	0.87	0.03	0.91	0.04	0.84	0.05
	At home	0.79	0.04	0.73	0.03	0.76	0.04	0.73	0.04
	Away from home	0.13	0.01	0.15	0.01	0.15	0.01	0.12	0.01
	Restaurant	0.03	0.00	0.03	0.00	0.04	0.01	0.02	0.00
	Fast food	0.04	0.01	0.05	0.01	0.04	0.01	0.04	0.01
	School	0.01	0.00	0.03	0.00	0.04	0.00	0.03	0.01
	Others	0.05	0.00	0.03	0.00	0.04	0.00	0.02	0.00

Source: USDA, Economic Research Service, using data from USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals and the continuous waves of What We Eat in America/National Health and Nutrition Examination Survey conducted by USDA and U.S. Department of Health and Human Services during 2003–18.

Table 2a

Density of grains intake by food source: U.S. population aged 2 years and above, 1994–2010

Means and standard errors (SE) of the means: ounce-equivalents per 1,000 calories										
		1994–98		2003–04		2005–06		2007–08		2009–10	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Total grains		3.35	0.02	3.18	0.04	3.14	0.03	3.11	0.03	3.22	0.03
	At home	3.37	0.02	3.02	0.06	2.93	0.04	2.97	0.05	3.08	0.03
	Away from home	3.13	0.03	3.24	0.06	3.31	0.05	3.15	0.04	3.23	0.06
	Restaurant	3.09	0.07	3.09	0.13	3.29	0.10	3.06	0.08	3.18	0.10
	Fast food	3.37	0.06	3.41	0.12	3.41	0.08	3.39	0.06	3.46	0.08
	School	3.02	0.08	3.08	0.15	3.35	0.12	3.33	0.17	3.33	0.12
	Others	2.63	0.06	2.52	0.10	2.67	0.09	2.50	0.08	2.49	0.11
Refined grains		2.95	0.01	2.88	0.04	2.79	0.03	2.76	0.03	2.79	0.03
	At home	2.86	0.02	2.61	0.05	2.46	0.04	2.51	0.04	2.54	0.03
	Away from home	2.96	0.03	3.13	0.06	3.20	0.05	3.03	0.04	3.09	0.06
	Restaurant	2.95	0.06	3.00	0.12	3.19	0.10	2.95	0.08	3.06	0.10
	Fast food	3.25	0.06	3.33	0.12	3.32	0.07	3.29	0.06	3.35	0.08
	School	2.84	0.08	2.96	0.16	3.19	0.13	3.18	0.17	3.16	0.13
	Others	2.32	0.06	2.32	0.10	2.48	0.08	2.32	0.09	2.30	0.10

Continues on next page >

Whole grains		0.40	0.01	0.29	0.01	0.34	0.02	0.35	0.02	0.43	0.01
	At home	0.51	0.02	0.41	0.02	0.47	0.02	0.46	0.02	0.55	0.02
	Away from home	0.17	0.01	0.11	0.02	0.11	0.01	0.13	0.01	0.14	0.01
	Restaurant	0.14	0.02	0.09	0.02	0.09	0.01	0.11	0.02	0.12	0.02
	Fast food	0.12	0.02	0.08	0.02	0.09	0.02	0.10	0.01	0.11	0.02
	School	0.18	0.02	0.12	0.02	0.16	0.03	0.15	0.02	0.17	0.03
	Others	0.31	0.03	0.20	0.03	0.19	0.02	0.18	0.01	0.19	0.03

Source: USDA, Economic Research Service, using data from USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals and the continuous waves of What We Eat in America/National Health and Nutrition Examination Survey conducted by USDA and U.S. Health and Human Services during 2003–18.

Table 2b

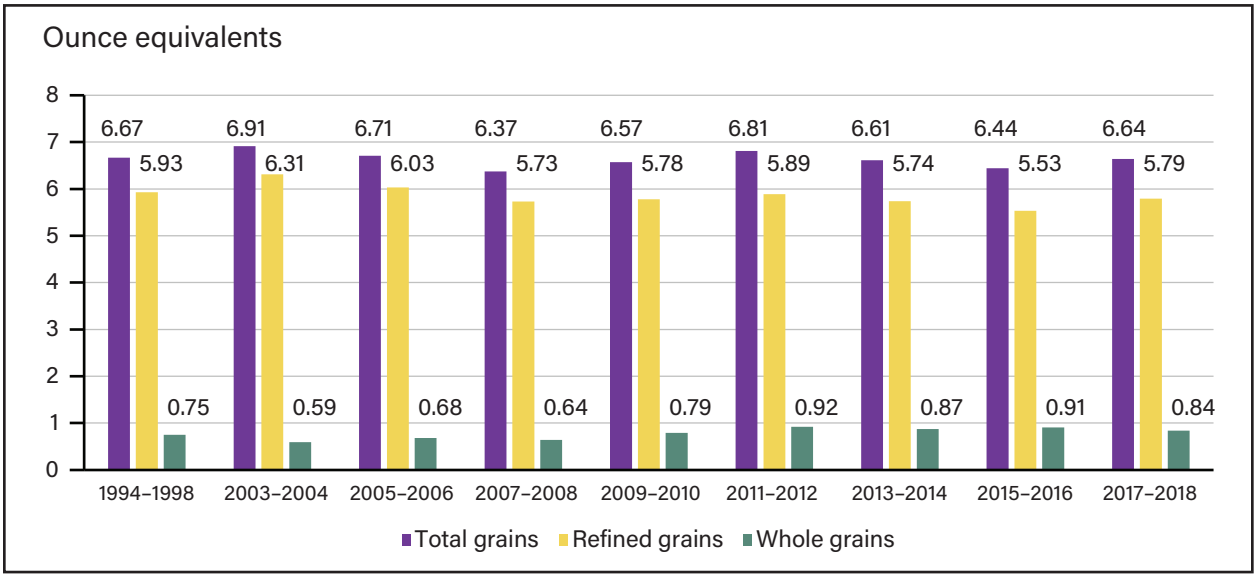
Density of grains intake by food source: U.S. population aged 2 years and above, 2011–2018

Means and standard errors (SE) of the means: ounce-equivalents per 1,000 calories									
		2011—12		2013—14		2015—16		2017—18	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Total grains		3.21	0.03	3.22	0.03	3.17	0.03	3.20	0.04
	At home	3.07	0.03	3.00	0.04	2.96	0.03	2.97	0.04
	Away from home	3.16	0.06	3.30	0.04	3.24	0.03	3.24	0.05
	Restaurant	3.18	0.11	3.12	0.07	3.29	0.07	3.23	0.12
	Fast food	3.25	0.10	3.52	0.07	3.44	0.06	3.47	0.07
	School	3.48	0.13	3.67	0.15	3.46	0.15	3.59	0.14
	Others	2.42	0.09	2.44	0.06	2.37	0.07	2.41	0.09
Refined grains		2.74	0.03	2.76	0.03	2.70	0.03	2.77	0.03
	At home	2.48	0.03	2.42	0.04	2.38	0.04	2.45	0.04
	Away from home	2.96	0.06	3.06	0.05	2.97	0.04	3.05	0.06
	Restaurant	3.01	0.11	2.94	0.07	3.08	0.08	3.10	0.12
	Fast food	3.11	0.10	3.32	0.07	3.28	0.08	3.35	0.07
	School	3.18	0.11	2.84	0.13	2.31	0.13	2.55	0.13
	Others	2.12	0.08	2.21	0.05	2.07	0.08	2.21	0.10
Whole grains		0.47	0.02	0.46	0.01	0.48	0.02	0.43	0.02
	At home	0.59	0.02	0.59	0.03	0.58	0.03	0.52	0.02
	Away from home	0.20	0.01	0.25	0.02	0.26	0.02	0.19	0.01
	Restaurant	0.17	0.02	0.18	0.03	0.21	0.03	0.13	0.01
	Fast food	0.15	0.02	0.20	0.02	0.16	0.03	0.12	0.01
	School	0.30	0.04	0.83	0.05	1.15	0.08	1.04	0.08
	Others	0.30	0.02	0.24	0.03	0.30	0.04	0.20	0.02

Source: USDA, Economic Research Service, using data from USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals and the continuous waves of What We Eat in America/National Health and Nutrition Examination Survey conducted by USDA and U.S. Health and Human Services during 2003–18.

Figure 2

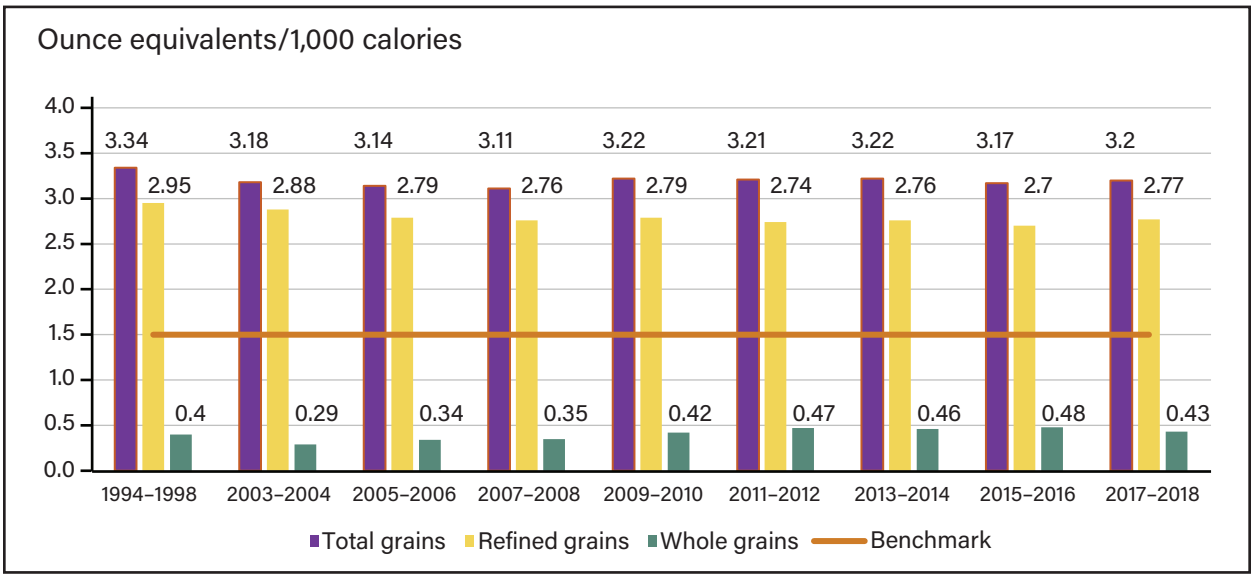
Mean daily intake (ounce equivalents) of total grains, refined grains, and whole grains, U.S. population aged 2 years and above, 1994–2018



Source: USDA, Economic Research Service, using data from USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals and the continuous waves of What We Eat in America /National Health and Nutrition Examination Survey conducted by USDA and U.S. Department of Health and Human Services during 2003–18.

Figure 3

Density of grains intake (ounce equivalents/1,000 calories), U.S. population aged 2 years and above, 1994–2018



Source: USDA, Economic Research Service, using data from USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals and the continuous waves of What We Eat in America /National Health and Nutrition Examination Survey conducted by USDA and U.S. Department of Health and Human Services during 2003–18.

Diets of Older Adults Are the Most Whole-Grain Dense, but Only Children's Diets Show an Increase

At all time periods, diets of adults 65 years and over were more whole grain dense than diets of children and younger adults (figure 4, tables 3a and 3b). Although the mean whole grain density of children's diets appears to have surpassed that of adults aged 20–64 since 2013–14, the whole grain density of children's diets was not statistically significantly higher than the whole grain density in young adults' diets. It is noteworthy that children were the only group among whom the whole grain density of the diet increased significantly over the time period studied, going from 0.34 ounces per 1,000 calories in 1994–98 to 0.50 and 0.47 ounces per 1,000 calories in 2015–16 and 2017–18, respectively, while the whole grain densities of the diets of young adults were not significantly different in 2017–18 from 1994–98, and neither were the whole grain densities of the seniors' diets.

Table 3a

Density of grains intake by food source among children, adults, and seniors, 1994–2010

Means and standard errors (SE) of the means: ounce-equivalents per 1,000 calories											
		1994–98		2003–04		2005–06		2007–08		2009–10	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Children aged 2–19 years											
Total grains		3.36	0.02	3.30	0.05	3.31	0.06	3.28	0.04	3.46	0.04
	At home	3.35	0.03	3.12	0.08	3.13	0.07	3.21	0.05	3.37	0.06
	Away from home	3.32	0.05	3.40	0.07	3.46	0.10	3.24	0.06	3.32	0.12
	Restaurant	3.25	0.15	3.44	0.19	3.90	0.27	3.29	0.17	3.29	0.15
	Fast food	3.61	0.09	3.55	0.11	3.39	0.14	3.26	0.08	3.43	0.18
	School	3.02	0.08	3.08	0.15	3.35	0.12	3.33	0.17	3.33	0.12
	Others	2.84	0.09	2.89	0.20	3.00	0.19	2.92	0.18	2.71	0.17
Refined grains		3.02	0.02	3.07	0.05	3.05	0.05	2.98	0.04	3.10	0.04
	At home	2.91	0.03	2.80	0.08	2.77	0.06	2.82	0.06	2.89	0.06
	Away from home	3.17	0.05	3.30	0.07	3.36	0.10	3.14	0.06	3.20	0.12
	Restaurant	3.18	0.14	3.41	0.19	3.87	0.28	3.26	0.18	3.23	0.15
	Fast food	3.55	0.09	3.47	0.12	3.32	0.14	3.18	0.08	3.34	0.18
	School	2.84	0.08	2.96	0.16	3.19	0.13	3.18	0.17	3.16	0.13
	Others	2.54	0.09	2.66	0.19	2.81	0.17	2.79	0.19	2.55	0.15
Whole grains		0.34	0.01	0.23	0.01	0.26	0.02	0.30	0.02	0.36	0.01
	At home	0.44	0.02	0.32	0.02	0.36	0.03	0.39	0.02	0.48	0.02
	Away from home	0.15	0.01	0.11	0.01	0.11	0.02	0.10	0.01	0.13	0.01
	Restaurant	0.07	0.02	0.03	0.01	0.03	0.01	0.03	0.02	0.06	0.02
	Fast food	0.06	0.02	0.08	0.03	0.06	0.02	0.08	0.02	0.09	0.02
	School	0.18	0.02	0.12	0.02	0.16	0.03	0.15	0.02	0.17	0.03
	Others	0.30	0.04	0.23	0.04	0.19	0.04	0.13	0.02	0.16	0.03
Adults aged 20–64 years											
Total grains		3.24	0.02	3.07	0.06	3.04	0.03	2.99	0.04	3.08	0.04
	At home	3.32	0.03	2.94	0.06	2.84	0.06	2.87	0.06	2.97	0.03
	Away from home	3.09	0.04	3.31	0.10	3.39	0.06	3.22	0.05	3.33	0.09
	Restaurant	2.97	0.07	3.00	0.11	3.21	0.13	3.06	0.07	3.11	0.10
	Fast food	3.34	0.06	3.61	0.18	3.67	0.10	3.48	0.11	3.62	0.13
	School										
	Others	2.74	0.07	2.80	0.11	2.86	0.14	2.83	0.11	2.85	0.12
Refined grains		2.89	0.02	2.81	0.05	2.73	0.03	2.69	0.03	2.70	0.04
	At home	2.86	0.03	2.58	0.05	2.42	0.05	2.47	0.05	2.47	0.04
	Away from home	2.95	0.04	3.24	0.10	3.30	0.06	3.12	0.05	3.22	0.09
	Restaurant	2.84	0.06	2.93	0.10	3.14	0.13	2.95	0.07	3.01	0.10
	Fast food	3.24	0.06	3.55	0.18	3.59	0.09	3.40	0.11	3.54	0.13
	School										
	Others	2.47	0.07	2.68	0.11	2.72	0.13	2.67	0.11	2.67	0.11
Whole grains		0.35	0.02	0.26	0.01	0.31	0.02	0.30	0.02	0.38	0.02
	At home	0.46	0.02	0.36	0.02	0.43	0.03	0.40	0.03	0.50	0.02
	Away from home	0.15	0.01	0.07	0.01	0.09	0.01	0.10	0.02	0.11	0.01
	Restaurant	0.12	0.02	0.07	0.01	0.07	0.01	0.11	0.04	0.09	0.02
	Fast food	0.10	0.02	0.06	0.02	0.08	0.01	0.08	0.02	0.09	0.02

Continues on next page >

	School										
	Others	0.27	0.04	0.13	0.02	0.13	0.02	0.16	0.02	0.17	0.02
Seniors aged 65 years and above											
Total grains		3.50	0.03	3.29	0.05	3.11	0.06	3.16	0.04	3.07	0.05
	At home	3.60	0.04	3.31	0.05	3.17	0.06	3.16	0.06	3.10	0.05
	Away from home	2.91	0.08	3.05	0.14	3.15	0.12	3.03	0.11	2.98	0.09
	Restaurant	2.92	0.14	3.06	0.20	3.22	0.25	2.92	0.13	3.07	0.17
	Fast food	3.50	0.16	3.35	0.27	3.27	0.23	3.57	0.20	3.26	0.13
	School										
	Others	2.58	0.14	2.54	0.16	2.86	0.21	2.42	0.19	2.44	0.16
Refined grains		2.88	0.03	2.80	0.06	2.57	0.06	2.65	0.06	2.51	0.05
	At home	2.85	0.03	2.71	0.06	2.49	0.07	2.51	0.06	2.40	0.06
	Away from home	2.72	0.08	2.91	0.14	2.94	0.12	2.87	0.11	2.86	0.09
	Restaurant	2.71	0.15	2.84	0.22	3.02	0.25	2.79	0.16	2.91	0.18
	Fast food	3.29	0.15	3.33	0.27	3.08	0.17	3.49	0.20	3.20	0.14
	School										
	Others	2.33	0.11	2.38	0.16	2.63	0.21	2.19	0.19	2.33	0.17
Whole grains		0.62	0.02	0.48	0.02	0.55	0.03	0.51	0.02	0.56	0.03
	At home	0.75	0.03	0.60	0.03	0.68	0.04	0.64	0.03	0.70	0.03
	Away from home	0.19	0.03	0.14	0.02	0.21	0.06	0.16	0.02	0.11	0.02
	Restaurant	0.21	0.04	0.22	0.07	0.20	0.05	0.14	0.06	0.17	0.04
	Fast food	0.21	0.05	0.02	0.01	0.19	0.14	0.08	0.03	0.06	0.04
	School										
	Others	0.25	0.05	0.16	0.03	0.24	0.04	0.24	0.04	0.11	0.04

Source: USDA, Economic Research Service, using data from USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals and the continuous waves of What We Eat in America/National Health and Nutrition Examination Survey conducted by USDA and U.S. Department of Health and Human Services during 2003–18.

Table 3b

Density of grains intake by food source among children, adults, and seniors, 2011–2018

Means and standard errors (SE) of the means: ounce-equivalents per 1,000 calories									
		2011—12		2013—14		2015—16		2017—18	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Children aged 2–19 years									
Total grains		3.42	0.03	3.55	0.04	3.60	0.05	3.59	0.05
	At home	3.32	0.04	3.38	0.06	3.51	0.06	3.44	0.05
	Away from home	3.33	0.08	3.63	0.07	3.51	0.09	3.54	0.08
	Restaurant	3.48	0.22	3.51	0.16	3.85	0.21	3.45	0.15
	Fast food	3.38	0.17	3.84	0.17	3.69	0.09	3.63	0.13
	School	3.48	0.13	3.67	0.15	3.46	0.15	3.59	0.14
	Others	2.68	0.12	2.60	0.10	2.67	0.17	2.90	0.18
Refined grains		3.03	0.04	3.09	0.03	3.10	0.05	3.11	0.05
	At home	2.81	0.05	2.84	0.05	2.92	0.07	2.91	0.05
	Away from home	3.13	0.09	3.28	0.09	3.13	0.10	3.22	0.10

Continues on next page >

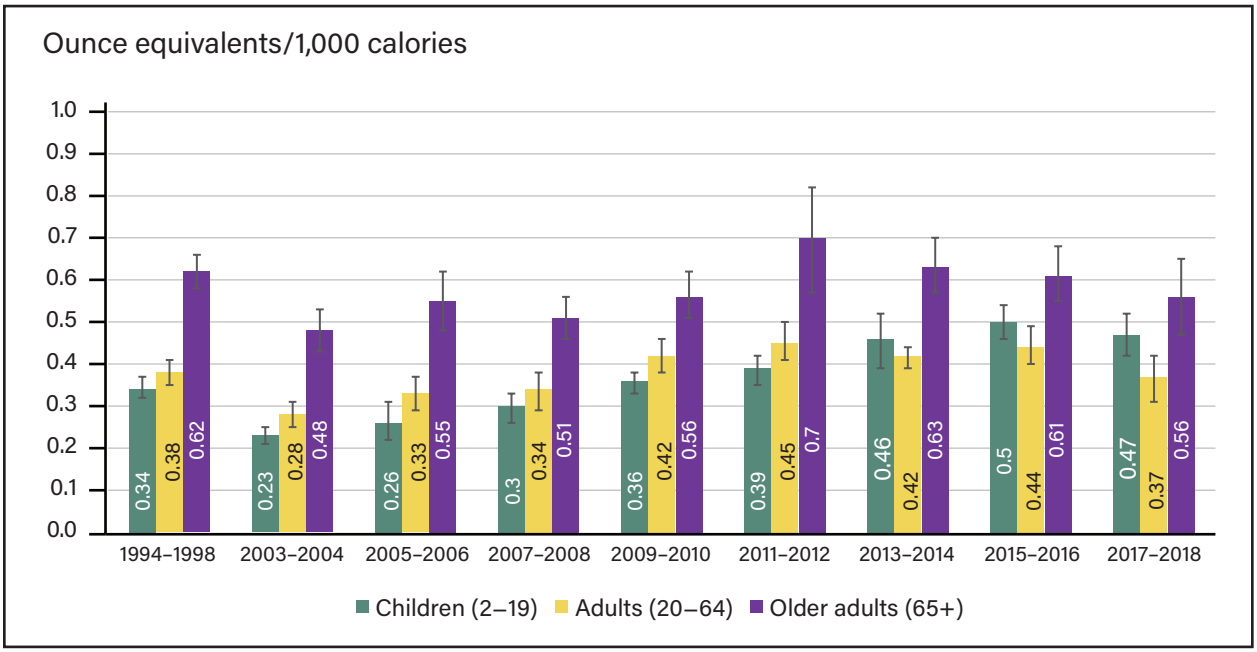
	Restaurant	3.38	0.21	3.39	0.15	3.76	0.21	3.32	0.15
	Fast food	3.28	0.17	3.69	0.18	3.63	0.09	3.53	0.13
	School	3.18	0.11	2.84	0.13	2.31	0.13	2.55	0.13
	Others	2.36	0.12	2.36	0.10	2.34	0.16	2.70	0.18
Whole grains		0.39	0.02	0.46	0.03	0.50	0.02	0.47	0.02
	At home	0.51	0.03	0.55	0.05	0.59	0.04	0.53	0.03
	Away from home	0.20	0.02	0.35	0.03	0.38	0.04	0.33	0.04
	Restaurant	0.10	0.02	0.12	0.04	0.09	0.02	0.12	0.04
	Fast food	0.11	0.03	0.15	0.03	0.06	0.01	0.10	0.03
	School	0.30	0.04	0.83	0.05	1.15	0.08	1.04	0.08
	Others	0.33	0.05	0.24	0.04	0.33	0.07	0.20	0.03
Adults aged 20–64 years									
Total grains		3.10	0.04	3.09	0.03	3.01	0.03	3.10	0.05
	At home	3.02	0.05	2.95	0.04	2.86	0.03	2.79	0.06
	Away from home	3.27	0.06	3.33	0.04	3.29	0.06	3.16	0.07
	Restaurant	3.14	0.12	3.10	0.07	3.12	0.09	3.15	0.13
	Fast food	3.53	0.08	3.62	0.06	3.55	0.07	3.40	0.08
	School								
	Others	2.79	0.12	2.88	0.09	2.82	0.11	2.19	0.13
Refined grains		2.69	0.04	2.71	0.03	2.60	0.04	2.72	0.04
	At home	2.47	0.05	2.45	0.05	2.35	0.04	2.32	0.05
	Away from home	3.10	0.06	3.17	0.03	3.09	0.06	3.02	0.08
	Restaurant	2.98	0.13	2.92	0.08	2.89	0.10	3.02	0.14
	Fast food	3.41	0.09	3.49	0.06	3.40	0.07	3.27	0.09
	School								
	Others	2.51	0.11	2.69	0.07	2.50	0.11	2.02	0.14
Whole grains		0.42	0.02	0.38	0.01	0.41	0.02	0.37	0.03
	At home	0.55	0.03	0.50	0.02	0.51	0.03	0.46	0.03
	Away from home	0.17	0.02	0.16	0.02	0.20	0.02	0.14	0.01
	Restaurant	0.16	0.03	0.18	0.03	0.22	0.03	0.13	0.01
	Fast food	0.12	0.02	0.14	0.02	0.15	0.03	0.13	0.02
	School								
	Others	0.28	0.03	0.20	0.04	0.32	0.04	0.17	0.03
Seniors aged 65 years and above									
Total grains		3.15	0.06	3.06	0.04	3.06	0.05	3.01	0.05
	At home	3.17	0.07	2.95	0.07	2.97	0.05	2.72	0.06
	Away from home	2.82	0.12	3.17	0.15	3.09	0.15	3.00	0.08
	Restaurant	2.56	0.22	2.83	0.19	3.25	0.30	4.20	0.20
	Fast food	3.13	0.22	3.63	0.24	3.25	0.21	2.57	0.09
	School								
	Others	2.44	0.20	2.57	0.20	2.53	0.24	2.22	0.14
Refined grains		2.45	0.06	2.43	0.04	2.46	0.05	2.30	0.05
	At home	2.32	0.07	2.19	0.08	2.20	0.07	1.83	0.07
	Away from home	2.60	0.13	2.89	0.16	2.88	0.18	2.53	0.07
	Restaurant	2.37	0.23	2.68	0.18	2.97	0.32	3.69	0.18
	Fast food	2.91	0.19	3.26	0.24	3.13	0.21	2.25	0.10
	School								
	Others	2.11	0.24	2.32	0.20	2.23	0.20	1.41	0.12

Continues on next page >

Whole grains		0.70	0.06	0.63	0.03	0.61	0.03	0.76	0.05
	At home	0.85	0.06	0.76	0.05	0.76	0.07	0.60	0.06
	Away from home	0.23	0.05	0.28	0.03	0.21	0.07	0.78	0.05
	Restaurant	0.19	0.10	0.15	0.05	0.27	0.14	1.20	0.14
	Fast food	0.22	0.09	0.37	0.07	0.12	0.04	0.62	0.06
	School								
	Others	0.33	0.08	0.25	0.02	0.30	0.09	0.47	0.08

Source: USDA, Economic Research Service, using data from USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals and the continuous waves of What We Eat in America/National Health and Nutrition Examination Survey conducted by USDA and U.S. Department of Health and Human Services during 2003–18.

Figure 4
Whole-grain density (ounce equivalent/1,000 calories) in total diet: children, adults 20–64 years, and older adults, 1994–2018



Note: The vertical line on each histogram denotes a 95-percent confidence interval of the mean value.

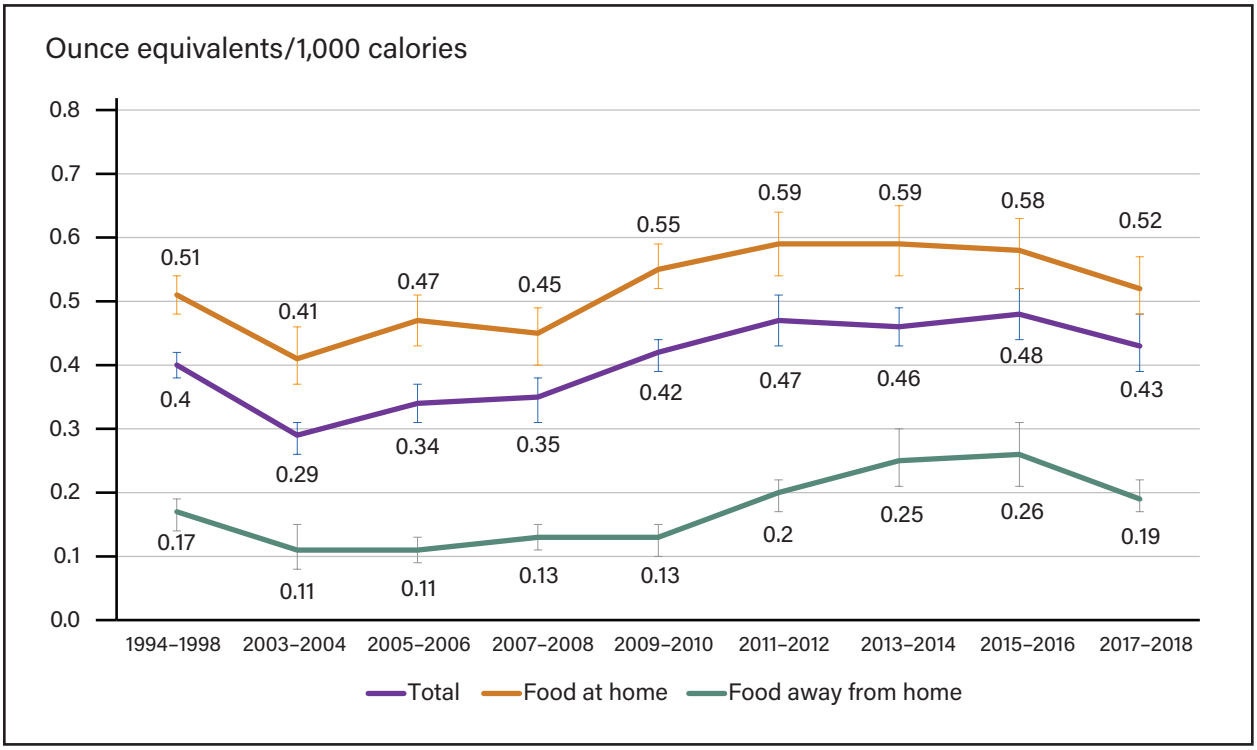
Source: USDA, Economic Research Service, using data from USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals and the continuous waves of What We Eat in America/National Health and Nutrition Examination Survey conducted by USDA and U.S. Department of Health and Human Services during 2003–18.

Whole-Grain Density Varies by Food Source

As shown in figure 5 and tables 2a and 2b, FAH is significantly more whole-grain dense than FAFH at all time points for the U.S. population. However, between 2009–10 and 2013–14, the whole-grain density of FAFH noticeably increased, but that of FAH did not. When disaggregated into more specific sources, it becomes apparent that this change is attributable to one FAFH source—school food.

Figure 5

Whole-grain density (ounce equivalent/1,000 calories) by food source: U.S. population aged 2 years and above, 1994–2018



Note: The vertical line on each data point denotes a 95-percent confidence level of the mean value.

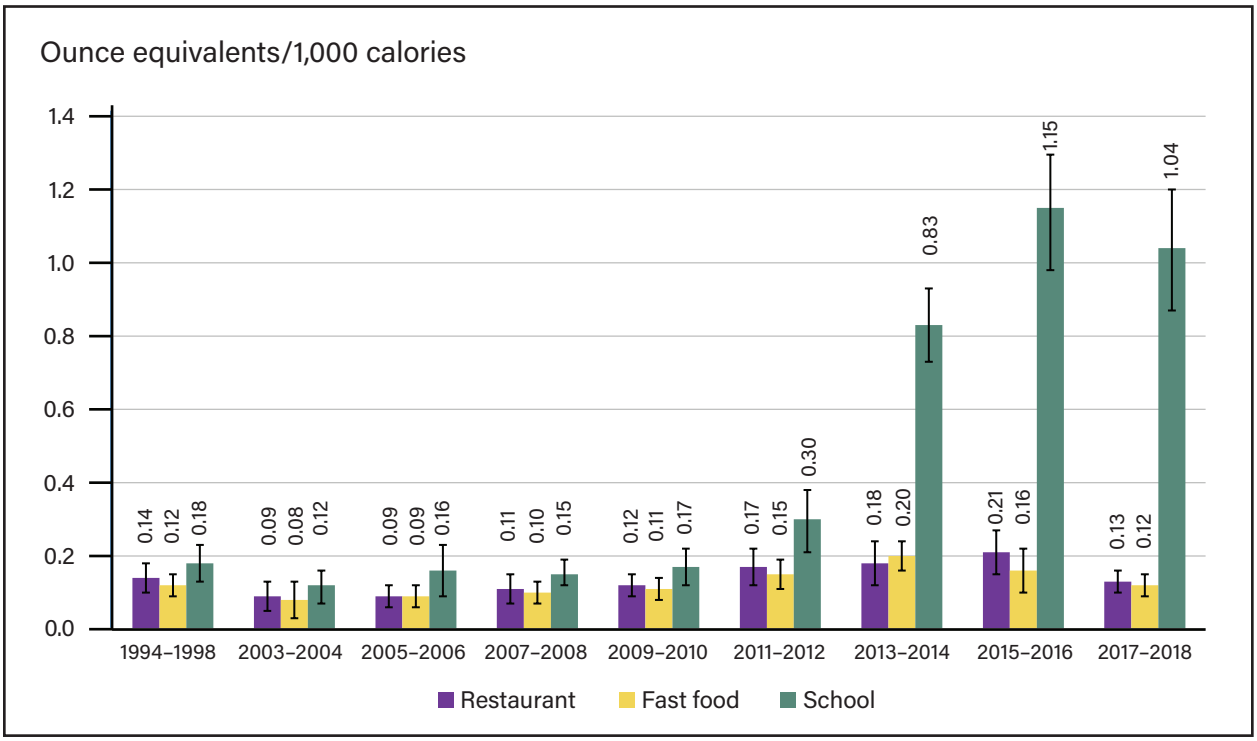
Source: USDA, Economic Research Service, using data from USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals and the continuous waves of What We Eat in America/National Health and Nutrition Examination Survey conducted by USDA and U.S. Health and Human Services during 2003–18.

Beginning in 2013, School Foods Eaten by Children Were More Whole-Grain Dense

As shown in figure 6, when FAFH was disaggregated into restaurants, fast food, and school food, it became apparent that the whole-grain density from school food rose sharply and surpassed the density from FAH during 2013–18 (1.04 versus 0.52 ounces per 1,000 calories in 2017–18). This increase in the whole-grain density from school food coincided with updated school meal standards becoming effective in the 2012–13 school year.

Figure 6

Whole-grain density (ounce equivalents/1,000 calories) of food from restaurant, fast food, and school, U.S. population aged 2 years and above, 1994–2018



Note: The vertical line on each histogram denotes a 95-percent confidence interval of the mean value.

Source: USDA, Economic Research Service, using data from USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals and the continuous waves of What We Eat in America /National Health and Nutrition Examination Survey conducted by USDA and U.S. Health and Human Services during 2003–18.

Examination of How School Food Is Related to Increases in Children's Whole-Grain Intakes

The authors explored the association of school food with the increase in children's wholegrain intakes via a series of multivariate analyses. For these analyses, the sample was limited to schoolchildren, defined as children 5–19 years old who were attending school at the time of data reporting. Food source was defined as in the glossary (a more detailed description of categories is found in appendix table A.1), except the restaurant and fast-food groups are combined because of sample size limitations. Descriptive statistics for this group are found in tables 4a and 4b, as well as mean whole grain intakes by source.

Table 4a

Descriptive statistics of the sample and grain consumption among schoolchildren, 1994–2010

Survey years										
Variable	1994–98		2003–04		2005–06		2007–08		2009–10	
	Mean		Mean		Mean		Mean		Mean	
Demographics										
Male (percent)	51.71		52.39		52.15		49.11		49.20	
	(49.72, 53.71)		(49.38, 55.39)		(48.00, 56.29)		(45.03, 53.19)		(45.75, 52.66)	
Age										
5–10 (percent)	45.37		44.39		43.80		41.44		43.36	
	(43.28, 47.46)		(39.12, 49.65)		(39.89, 47.70)		(36.83, 46.05)		(40.93, 45.79)	
11–14 (percent)	32.20		30.76		29.85		31.24		29.67	
	(29.88, 34.52)		(28.28, 33.23)		(27.46, 32.25)		(27.24, 35.23)		(27.06, 32.28)	
15–19 (percent)	22.43		24.86		26.35		27.32		26.97	
	(20.56, 24.29)		(20.02, 29.70)		(22.83, 29.87)		(24.05, 30.60)		(24.14, 29.80)	
Race and ethnicity										
Non-Hispanic White (percent)	66.16		62.37		61.73		59.72		57.67	
	(61.37, 70.95)		(53.26, 71.48)		(52.73, 70.72)		(51.94, 67.51)		(48.81, 66.54)	
Non-Hispanic Black (percent)	15.67		15.37		14.54		15.22		14.20	
	(12.87, 18.48)		(10.13, 20.60)		(8.52, 20.55)		(10.08, 20.36)		(11.56, 16.83)	
Hispanic (percent)	13.56		15.82		16.08		19.94		21.54	
	(9.32, 17.80)		(9.15, 22.49)		(12.52, 19.63)		(13.11, 26.76)		(13.03, 30.04)	
Other race/ethnicity (percent)	4.60		6.44		7.66		5.12		6.59	
	(3.42, 5.78)		(3.58, 9.30)		(4.27, 11.05)		(2.98, 7.26)		(4.47, 8.72)	
Household income										
< 185% poverty line (percent)	38.50		41.03		36.15		43.26		45.70	
	(35.10, 41.91)		(35.44, 46.63)		(29.88, 42.42)		(36.48, 50.04)		(39.97, 51.43)	
185–300% poverty line (percent)	21.11		20.76		21.17		17.27		15.86	
	(18.51, 23.71)		(16.60, 24.92)		(17.13, 25.21)		(13.12, 21.42)		(12.86, 18.85)	
> 300% poverty line (percent)	40.39		38.20		42.68		39.47		38.45	
	(36.81, 43.96)		(31.65, 44.75)		(34.75, 50.61)		(32.00, 46.94)		(32.71, 44.18)	
Weekend (percent)	28.66		28.91		29.08		30.01		30.25	
	(25.76, 31.56)		(24.41, 33.42)		(25.71, 32.45)		(25.92, 34.19)		(25.31, 35.18)	
Education of household reference person										
< high school (percent)	14.98		18.70		17.93		20.28		20.87	
	(12.70, 17.25)		(14.45, 22.95)		(13.98, 21.88)		(14.94, 25.62)		(16.53, 25.21)	
High school diploma (percent)	57.29		62.08		58.75		53.52		50.23	
	(53.49, 61.97)		(57.06, 67.09)		(52.81, 64.69)		(47.13, 59.92)		(45.25, 55.21)	
College degree (percent)	27.73		19.15		23.32		26.13		28.81	
	(23.38, 32.07)		(15.70, 22.59)		(17.33 29.30)		(19.49, 32.77)		(22.89, 34.74)	

Continues on next page >

Daily intake of total grains by source (ounce-equivalents per day)										
Means and confidence intervals of the mean										
All Sources	7.09		**7.45**	a	7.25		6.67	a,b	7.01	
	(6.90, 7.29)		(7.16, 7.75)		(6.93, 7.56)		(6.36, 6.98)		(6.64, 7.38)	
FAH	4.82		4.64		4.6		**4.33**	a	4.71	
	(4.60, 5.04)		(4.28, 5.01)		(4.22, 4.97)		(4.02, 4.64)		(4.42, 5.00)	
FAFH	**2.28**	b	**2.81**	a	**2.65**	a	2.34		2.30	
	(2.15, 2.40)		(2.57, 3.06)		(2.39, 2.91)		(2.20, 2.48)		(2.01, 2.60)	
Restaurant/fast food	**1.14**	b	**1.92**	a,b	**1.69**	a	**1.35**	a	1.29	
	(1.05, 1.24)		(1.71, 2.12)		(1.44, 1.94)		(1.23, 1.46)		(1.10, 1.49)	
School	0.63		0.62		**0.50**	a	0.61		0.65	
	(0.57, 0.69)		(0.46, 0.78)		(0.39, 0.60)		(0.45, 0.76)		0.47, 0.83)	
Daily intake of whole grains by source (ounce-equivalents per day)										
Means and confidence intervals of the mean										
All Sources	**0.66**	b	**0.49**	a,b	**0.51**	a,b	**0.52**	a,b	**0.59**	b
	(0.59, 0.73)		(0.43, 0.56)		(0.41, 0.60)		(0.44, 0.59)		(0.55, 0.63)	
FAH	0.58		**0.42**	a,b	**0.44**	a,b	**0.46**	a,b	**0.53**	b
	(0.52, 0.65)		(0.35, 0.49)		(0.35, 0.53)		(0.38, 0.53)		(0.48, 0.57)	
FAFH	**0.08**	b	**0.07**	b	**0.07**	b	**0.06**	b	**0.06**	b
	(0.06, 0.09)		(0.05, 0.10)		(0.05, 0.09)		(0.05, 0.07)		(0.04, 0.08)	
Restaurant/fast food	**0.02**	b	0.03		**0.02**	b	0.02		0.02	
	(0.01, 0.02)		(0.01, 0.06)		(0.02, 0.03)		(0.01, 0.03)		(0.01, 0.03)	
School	**0.02**	b	**0.02**	b	**0.02**	b	**0.02**	b	**0.03**	b
	(0.02, 0.03)		(0.01, 0.03)		(0.01, 0.03)		(0.01, 0.04)		(0.02, 0.05)	
Whole-grain share of total grain (percent)										
Means and confidence intervals of the mean										
All Sources	**9.67**	b	**7.45**	a,b	**7.60**	a,b	**8.67**	b	**9.34**	b
	(8.81, 10.52)		(6.65, 8.24)		(6.15, 9.05)		(7.07, 10.27)		(8.73, 9.95)	
FAH	**3.08**	b	**11.38**	b	**11.61**	b	**12.29**	b	**13.69**	b
	(1.84, 14.32)		(9.62, 13.13)		(9.41, 13.80)		(10.08, 14.50)		(12.34, 15.04)	
FAFH	**4.01**	b	**3.88**	b	**3.57**	b	**3.66**	b	**3.56**	b
	(3.25, 4.76)		(2.44, 5.32)		(2.50, 4.63)		(2.93, 4.38)		(2.87, 4.25)	
Restaurant/fast food	1.59		2.43		2.41		2.55		3.01	
	(1.02, 2.17)		(0.48, 4.37)		(1.30, 3.52)		(1.34, 3.77)		(1.27, 4.74)	
School	**4.02**	b	**4.35**	b	**4.51**	b	**4.82**	b	**5.65**	b
	(2.84, 5.20)		(1.35, 7.35)		(2.11, 6.91)		(3.69, 5.95)		(3.61, 7.69)	
Sample size	3617		2540		2641		2016		2118	

FAH = food at home; FAFH = food away from home. a = values are different from those for 1994–98, $p < 0.05$; b = values are different from those for 2017–18, $p < 0.05$.

Note: Numbers in parentheses are the 95-percent confidence intervals for the means. Differences in grain consumption and shares were tested for significance by utilizing both variance and covariance, the latter is not incorporated in the confidence interval. The numbers in boldface indicate significance at $p < 0.05$.

Only the differences from the 1994–98 data and the 2017–18 data, the beginning and ending surveys covered in the study, were tested.

Source: USDA, Economic Research Service, using data from USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals and the continuous waves of What We Eat in America/National Health and Nutrition Examination Survey conducted by USDA and U.S. Department of Health and Human Services during 2003–18.

Table 4b

Descriptive statistics of the sample and grain consumption among schoolchildren, 2011–2018

Survey years								
Variable	2011–12		2013–14		2015–16		2017–18	
	Mean		Mean		Mean		Mean	
Demographics								
Male (percent)	49.40		52.52		50.32		51.04	
	(45.33, 53.46)		(48.84, 56.19)		(46.56, 54.08)		(46.40, 55.69)	
Age								
5–10 (percent)	44.62		42.85		41.79		45.27	
	(41.60, 47.63)		(38.90, 46.81)		(38.57, 45.00)		(40.66, 49.87)	
11–14 (percent)	29.92		29.01		31.57		29.25	
	25.62, 34.22)		(26.04, 31.97)		(29.48, 33.67)		(25.59, 32.91)	
15–19 (percent)	25.46		28.14		26.64		25.49	
	(21.51, 29.41)		(24.21, 32.07)		(23.62, 29.66)		(21.76, 29.21)	
Race and ethnicity								
Non-Hispanic White (percent)	55.59		53.10		51.46		51.17	
	(44.31, 66.86)		(41.09, 65.10)		(38.64, 64.28)		(43.44 58.90)	
Non-Hispanic Black (percent)	13.63		14.40		14.12		12.66	
	(7.24, 20.02)		(9.14, 19.66)		(6.58, 21.67)		(8.21, 17.10)	
Hispanic (percent)	22.65		23.14		24.07		22.53	
	(15.46, 29.85)		(14.64, 31.64)		(14.12, 34.02)		(15.40, 29.66)	
Other race/ethnicity (percent)	8.13		9.37		10.35		13.65	
	(5.30, 10.96)		(6.73, 12.00)		(7.08, 13.62)		(9.24, 18.06)	
Household income								
< 185% poverty line (percent)	49.17		45.78		43.63		43.78	
	(39.85, 58.50)		(36.30, 55.26)		(35.79, 51.46)		(37.02, 48.54)	
185–300% poverty line (percent)	18.27		16.81		20.13		17.32	
	(13.17, 23.38)		(12.89, 20.72)		(15.38, 24.89)		(14.29, 20.36)	
> 300% poverty line (percent)	32.56		37.41		36.24		39.89	
	(26.31, 38.80)		(26.96, 47.87)		(27.34, 45.14)		(32.19, 47.60)	
Weekend (percent)	30.53		29.77		35.87		31.44	
	(27.90, 33.15)		(26.65, 32.88)		(32.18, 39.56)		(27.45, 35.42)	
Education of household reference person								
< high school (percent)	24.30		16.53		17.83		15.24	
	(20.26, 28.34)		(12.63, 20.43)		(10.89, 24.77)		(10.92, 19.55)	
High school diploma (percent)	49.17		54.96		52.63		54.5	
	(43.84, 54.50)		(50.50, 59.33)		(48.25, 57.01)		(47.23, 61.77)	
College degree (percent)	26.53		28.41		28.7		30.26	
	(21.04, 32.01)		(21.94, 34.88)		(20.91, 36.48)		(22.12, 38.41)	

Continues on next page >

Daily intake of total grains by source (ounce-equivalents per day)								
Means and confidence intervals of the mean								
All Sources	7.07		6.98		7.11		7.24	
	(6.75, 7.39)		(6.70, 7.26)		(6.80, 7.43)		(6.94, 7.54)	
FAH	**4.26**	a	**4.36**	a	**4.32**	a	4.63	
	(4.08, 4.45)		(4.10, 4.63)		(4.03, 4.61)		(4.25, 5.00)	
FAFH	**2.81**	a	**2.62**	a	**2.79**	a	**2.61**	a
	(2.55, 3.07)		(2.40, 2.84)		(2.54, 3.05)		(2.33, 2.89)	
Restaurant/fast food	**1.58**	a	**1.41**	a	**1.68**	a	**1.52**	a
	(1.41, 1.75)		(1.23, 1.58)		(1.47, 1.89)		(1.30, 1.74)	
School	0.71		0.80		0.64		0.56	
	(0.57, 0.86)		(0.63, 0.97)		(0.52, 0.77)		(0.35, 0.78)	
Daily intake of whole grains by source (ounce-equivalents per day)								
Means and confidence intervals of the mean								
All Sources	**0.74**	b	**0.86**	a	**0.93**	a	**0.89**	a
	(0.68, 0.80)		(0.76, 0.96)		(0.84, 1.01)		(0.78, 1.00)	
FAH	0.62		0.61		0.66		0.68	
	(0.56, 0.67)		(0.50, 0.72)		(0.57, 0.75)		(0.57, 0.78)	
FAFH	**0.13**	a,b	**0.25**	a	**0.27**	a	**0.22**	a
	(0.09, 0.16)		(0.21, 0.30)		(0.21, 0.33)		(0.15, 0.28)	
Restaurant/fast food	0.03		**0.06**	a,b	**0.03**	a	0.02	
	(0.01, 0.04)		(0.03, 0.08)		(0.02, 0.04)		(0.01, 0.03)	
School	**0.06**	a,b	**0.18**	a	**0.20**	a	**0.17**	a
	(0.04, 0.08)		(0.13, 0.22)		(0.15, 0.26)		(0.09, 0.24)	
Whole-grain share of total grain (percent)								
Means and confidence intervals of the mean								
All Sources	**11.43**	a,b	**13.48**	a	**14.33**	a	**13.15**	a
	(10.10, 12.77)		(11.69, 15.27)		(12.91, 15.75)		(12.00, 14.29)	
FAH	**16.72**	a	**17.16**	a	**17.81**	a	**15.79**	a
	(14.29, 19.14)		(14.14, 20.17)		(14.67, 20.96)		(14.07, 17.51)	
FAFH	**5.75**	a,b	**10.72**	a	**12.39**	a	**9.76**	a
	(4.33, 7.17)		(8.55, 12.90)		(9.65, 15.13)		(7.04, 12.47)	
Restaurant/fast food	2.95		**5.17**	a,b	2.47		2.56	
	(1.43, 4.47)		(3.83, 6.50)		(1.59, 2.35)		(1.06, 4.06)	
School	**8.63**	a,b	**21.48**	a,b	**32.93**	a	**29.04**	a
	(6.43, 10.84)		(18.51, 24.45)		(28.47, 37.38)		(24.36, 33.73)	
Sample size	2035		2049		1983		1543	

FAH = food at home; FAFH = food away from home. a = values are different from those for 1994–98, $p < 0.05$; b = values are different from those for 2017–18, $p < 0.05$.

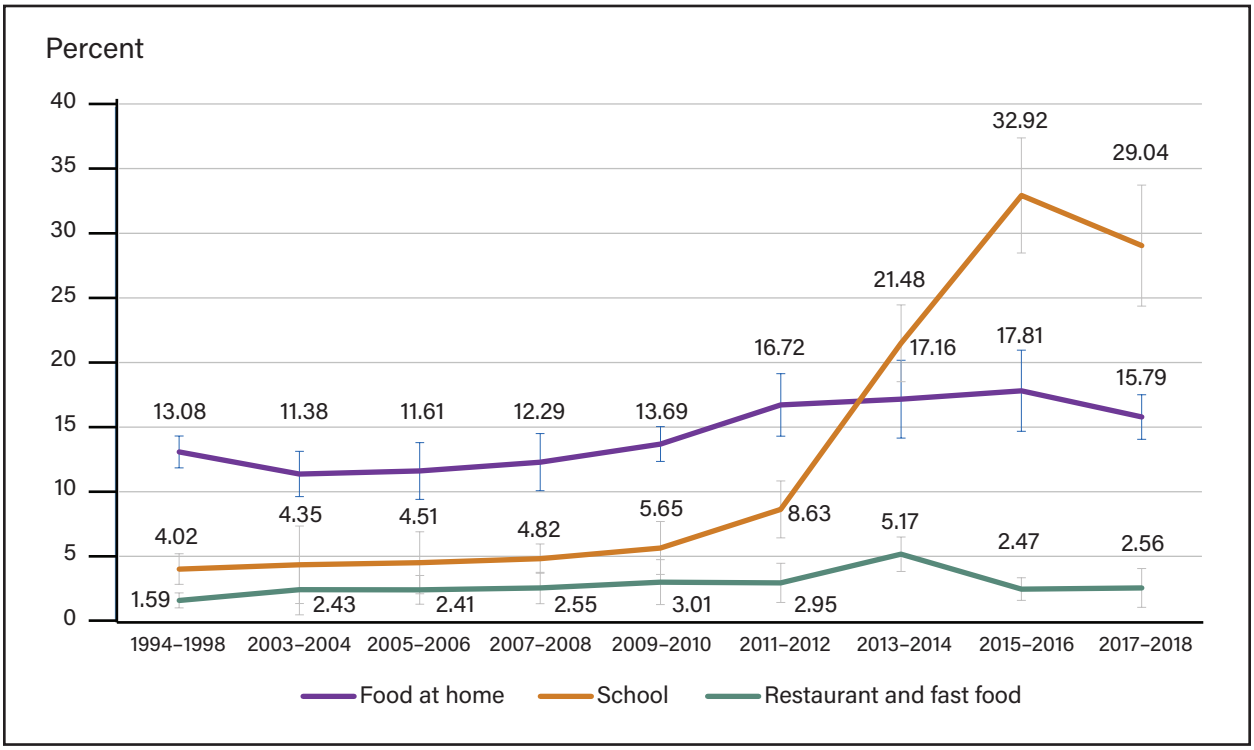
Note: Numbers in parentheses are the 95-percent confidence intervals for the means. Differences in grain consumption and shares were tested for significance by utilizing both variance and covariance, the latter is not incorporated in the confidence interval. The numbers in boldface indicate significance at $p < 0.05$.

Only the differences from the 1994–98 data and the 2017–18 data, the beginning and ending surveys covered in the study, were tested.

Source: USDA, Economic Research Service, using data from USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals and the continuous waves of What We Eat in America/National Health and Nutrition Examination Survey conducted by USDA and U.S. Department of Health and Human Services during 2003–18.

Among schoolchildren, FAH consumption of whole grains dropped significantly from 1994–98 to 2003–08 ($p < 0.05$) but recovered to a level comparable to 1994–98 for the remaining years (tables 4a and 4b). At the beginning of the study period (1994–98), most of the whole grains in children's diets were obtained from home-prepared food (0.58 ounces of a total of 0.66 ounces per day). Whole-grain consumption from restaurants/fast food was small—0.02 ounces per day. The average consumption of whole grains from school among all schoolchildren was also small at the beginning of the period, at 0.02 ounces per day in 1994–2008 but rose to 0.06 ounces per day in 2011–2012; then to 0.17-0.20 ounces per day in 2013–18. Consequently, the share of whole grain to total grain consumption from school food rose sharply—from 4.02 percent in 1994–98 to 8.63 percent in 2011–2012, before reaching 21.48 percent in 2013–14, 32.93 percent in 2015–16, and 29.04 percent in 2017–18—the closest of any food source to reaching the 50-percent share of total grains recommended by the DGA (figure 7, tables 4a and 4b).

Figure 7
Whole-grain share (percent) of total grain intake among schoolchildren by food source, 1994–2018



Note: The vertical line on each data point denotes a 95-percent confidence level of the mean value.

Source: USDA, Economic Research Service, using data from USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals and the continuous waves of What We Eat in America /National Health and Nutrition Examination Survey conducted by USDA and U.S. Department of Health and Human Services during 2003–18.

Multivariate Analyses Delineate the Role of School Foods

The preceding descriptive statistics reveal the association between the changes in school food standards for whole grains beginning in 2012 and rising whole grain intakes from school foods. It is known that food intakes are influenced by socioeconomic and demographic factors (Dunford and Popkin, 2018; Lin et al., 2003; Lin and Yen, 2007; Ng et al., 2016; Powell et al., 2016); therefore, multivariate regression analyses were

conducted to shed more light on the underlying factors contributing to increasing whole grain intakes in the school setting and identify potential disparities in intakes.

Regression results (table 5) show that after controlling for demographics, the whole-grain share of children's grain intakes from school foods was much greater after the implementation of the new school meal patterns and nutrition standards, reaching 29.66 percent of total grain intake in 2017–18, down from 34.2 percent in 2015–16 but up from 9.9 percent in 2011–12 and 22.76 percent in 2013–14. At the 5-percent significance level, the whole-grain share of the total grains from school foods varies by race/ethnicity and age but not by gender, household income, and parental education attainment.[4] Compared with children who are non-Hispanic Black, Hispanic, or of other races/ethnicities, the school food consumption of non-Hispanic White children was characterized by a lower whole grain to total grain ratio.

[4] Schoolchildren aged 15–19 have a lower share than those aged 5–10 at the 10-percent significance level. An identical regression model based on 1994–2014 data found that the share is significantly correlated with age and race/ethnicity (Lin et al., 2019).

Table 5

School meals whole-grain intake: whole-grain ratio, intensity, and propensity

	Whole-grain ratio			Intensity (conditional intake)			Propensity			Odds ratio		
											95%	
Parameter	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|	Estimate	Confidence Interval	
Survey wave												
Year 1994–98	5.592	3.37	<.0001	0.398	11.62	<.0001	-1.679	-8.00	<.0001	0.187	0.12	0.28
Year 2003–04	5.809	2.62	0.01	0.340	38.10	<.0001	-1.460	-4.52	<.0001	0.232	0.12	0.44
Year 2005–06	5.504	2.82	0.01	0.386	41.40	<.0001	-1.818	-7.24	<.0001	0.162	0.10	0.27
Year 2007–08	6.611	3.87	<.0001	0.389	42.76	<.0001	-1.571	-7.01	<.0001	0.208	0.13	0.32
Year 2009–10	6.997	3.85	<.0001	0.444	47.15	<.0001	-1.430	-5.95	<.0001	0.239	0.15	0.39
Year 2011–12	9.851	4.93	<.0001	0.632	64.21	<.0001	-1.198	-4.56	<.0001	0.302	0.18	0.51
Year 2013–14	22.762	11.09	<.0001	0.956	103.71	<.0001	-0.052	-0.23	0.82	0.950	0.61	1.47
Year 2015–16	34.236	12.92	<.0001	1.083	118.25	<.0001	0.332	1.54	0.12	1.394	0.91	2.13
Year 2017–18	29.656	11.20	<.0001	1.190	122.98	<.0001	-0.101	-0.44	0.66	0.904	0.58	1.42
Gender												
Female (base)												
Male	-0.054	-0.06	0.95	0.143	36.99	<.0001	0.021	0.22	0.82	1.021	0.85	1.23
Age												
5–10 (base)												
11–14	-0.578	-0.55	0.59	0.036	9.77	<.0001	-0.351	-3.35	0.00	0.704	0.57	0.87
15–19	-2.272	-2.07	0.04	-0.010	-3.41	0.00	-0.290	-2.32	0.02	0.748	0.58	0.96
Race and ethnicity												
Non-Hispanic white (base)												
Non-Hispanic black	2.233	2.48	0.01	0.067	11.40	<.0001	0.440	3.57	0.00	1.552	1.22	1.98
Hispanics	2.052	2.06	0.04	0.193	41.81	<.0001	0.260	2.19	0.03	1.297	1.03	1.64
Other race/ ethnicity	5.342	2.38	0.02	0.184	15.84	<.0001	0.304	1.76	0.08	1.355	0.96	1.91
Weekend	9.739	2.33	0.02	0.018	0.57	0.57	-0.065	-0.19	0.85	0.937	0.47	1.87
Household income												
< 185% pov erty level	-2.039	-1.40	0.16	-0.047	-8.31	<.0001	0.144	1.08	0.28	1.155	0.89	1.50
185–300% poverty level (base)												
> 300% pov erty level	-2.447	-1.40	0.16	-0.008	-0.88	0.38	-0.179	-0.98	0.33	0.836	0.58	1.20
Education of household respondent												
Less than high school (base)	-1.939											
High school diploma	0.113	0.11	0.9156	-0.007	-1.30	0.20	-0.001	-0.01	0.99	0.999	0.79	1.26
College degree	-1.747	-1.00	0.3172	-0.091	-8.67	<.0001	-0.138	-0.77	0.44	0.871	0.61	1.24
N	5,043			1,661			5,647					
R-Square	0.40			0.62								

Pr = probability; t = t-value; N = number of observations.

Note: The t-value measures the size of the difference in estimate relative to the standard error. Pr > [t] indicates the probability of no difference from the overall estimate (the null hypothesis.

Source: USDA, Economic Research Service, using data from USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals and the continuous waves of What We Eat in America/National Health and Nutrition Examination Survey conducted by USDA and U.S. Health and Human Services during 2003–18.

How Intake Propensity and Intensity Act To Increase Whole-Grain Intakes

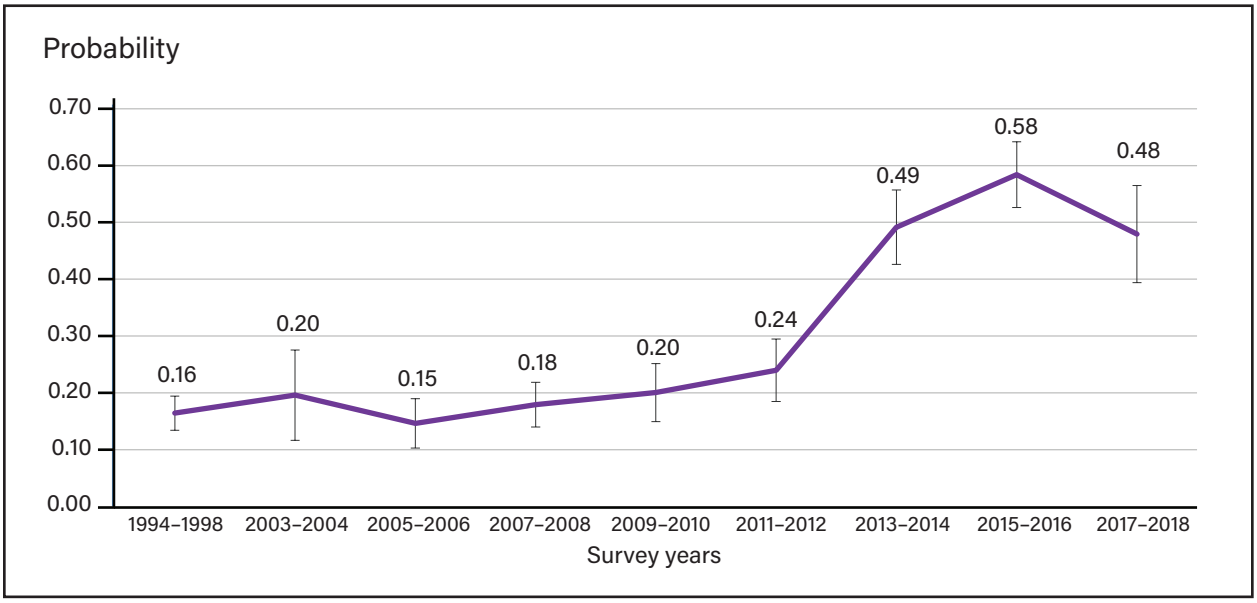
Changes in schoolchildren's average whole-grain consumption from school food could arise from: (1) changes in consumption propensity (the share of children who eat any whole-grain food at all); (2) changes in consumption intensity (the amount consumed by those who consume); and (3) the interaction of propensity and intensity (see the mathematical derivation of decomposition in box B). The effects of intake propensity, intensity, and their interaction on increased whole-grain intake from school foods was estimated as described below.

Beginning in 2013, More Children Ate Whole Grains at School

Changes in school meal regulations meant that all participating schools would be offering whole grain-rich items as part of their meals. Although offering such foods does not guarantee that children will consume the foods, the availability could be plausibly hypothesized to increase the likelihood of consumption. The authors' analysis of the propensity (likelihood) of consuming whole grains from school foods among those schoolchildren who ate school foods provides evidence to support this hypothesis.

The propensity for children eating school foods to consume whole grains is shown in figure 8. These consumption propensity estimates were derived by fitting estimated logistic coefficients (table 5) into the cumulative logistic probability function and evaluated at the mean values of the socio-demographic variables. There was no significant change in the propensity to consume whole grains from school foods during 1994–2010, the period before the adoption of updated school meal patterns and nutrition standards, with propensities ranging from 0.15 to 0.24. However, after 2013, students were more than twice as likely to consume whole grains from school as in any previous survey period, with a propensity of 0.48–0.58—that is, when students ate school foods, one in every two students ate whole grains from school foods. Whole grains from school were less likely to be consumed by older children compared with those 5–10 years old ($p < 0.05$) and by non-Hispanic-White children compared with non-Hispanic-Black and Hispanic children ($p < 0.05$) (table 5).

Figure 8
Schoolchildren's propensity (probability) to consume whole grain from school foods, 1994–2018



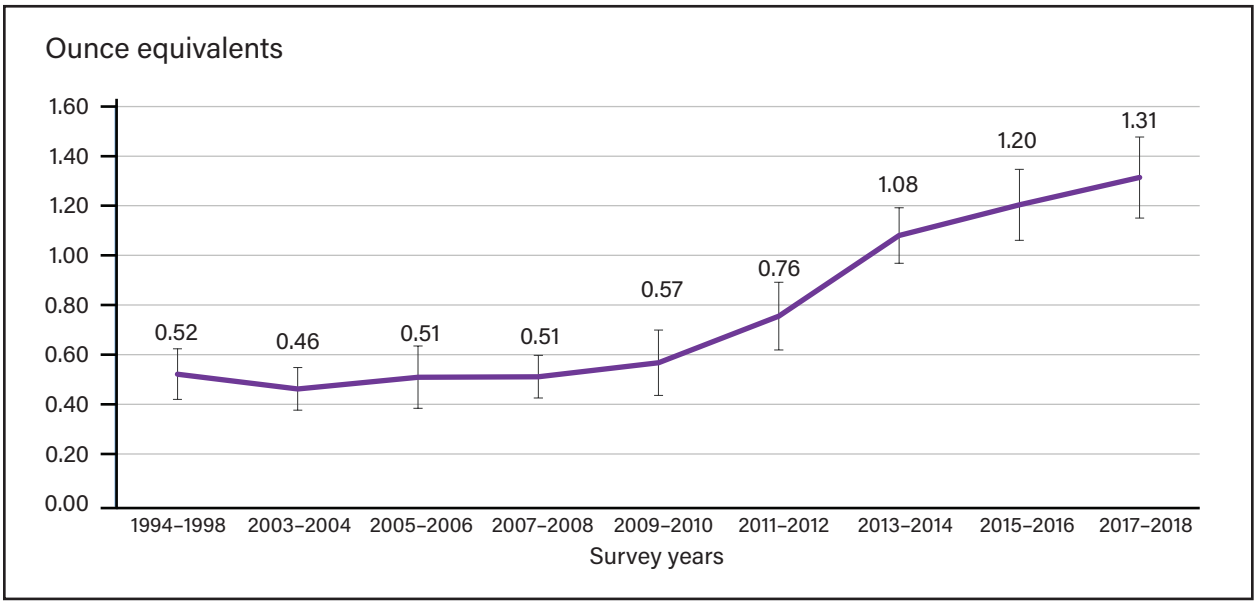
Note: The vertical line on each data point denotes a 95-percent confidence level of the mean value.

Source: USDA, Economic Research Service, using data from USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals and the continuous waves of What We Eat in America /National Health and Nutrition Examination Survey conducted by USDA and U.S. Department of Health and Human Services during 2003–18.

Intensity of Whole-Grains Consumption, Among Those Who Ate Whole Grains as Part of School Food

Among those who consumed whole grains from school, their average whole-grain intake remained relatively stable over 1994–2010 (0.34–0.44 ounce equivalents per day) before significantly ($p < 0.05$) increasing to 0.96–1.19 ounce equivalents per day during 2013–18 among the base group (table 5). The base group is defined as female, younger (5–10 years old), non-Hispanic White, with household income 185–300 percent of poverty level, and parental education of less than high school (table 5). For those who ate whole grains as a part of school-prepared food, compared with their respective counterparts, a larger average amount was consumed among males, those 11–14 years old, and those from households with incomes falling between 185 and 300 percent of the poverty line (table 5). Non-Hispanic White schoolchildren consumed a smaller amount of whole grains from school food than other children. The consumption intensity of a representative schoolchild (i.e., intensity evaluated at the mean values of the socio-demographic variables) is shown in figure 9, which indicates the amount of whole grains consumed by those schoolchildren who ate school foods rose significantly ($p < 0.05$) after 2011–12.

Figure 9
Schoolchildren's whole-grain consumption amounts (ounce equivalents) among those who consume whole grains from school foods, 1994–2018



Note: The vertical line on each data point denotes a 95-percent confidence level of the mean value.

Source: USDA, Economic Research Service, using data from USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals and the continuous waves of What We Eat in America /National Health and Nutrition Examination Survey conducted by USDA and U.S. Department of Health and Human Services during 2003–18.

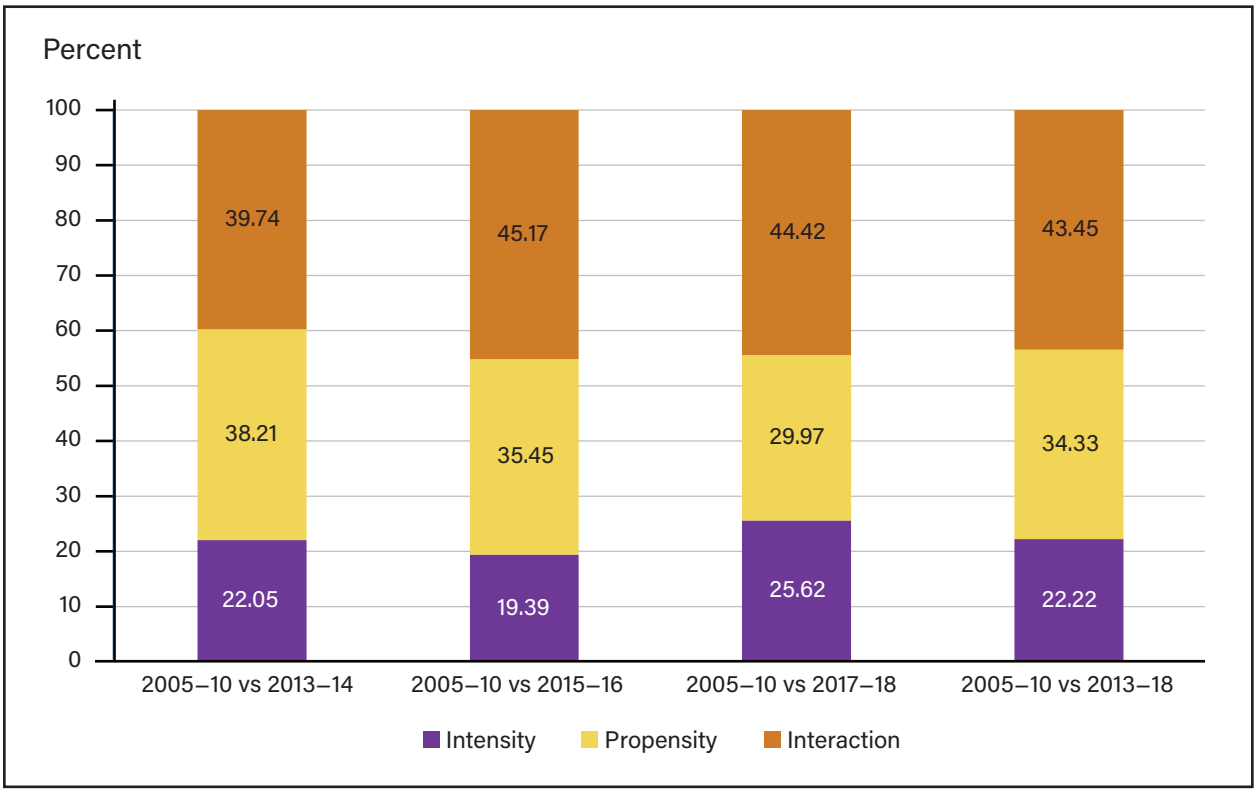
Decomposing the Effects of Propensity, Intensity, and Their Interaction

Decomposition analyses delineated the relative impacts of propensity, intensity, and their interaction on whole-grain intakes from school food before and after the implementation of new school meal patterns and nutrition standards. Whole-grain consumption in 2005–10 (i.e., before new standards) was compared with 2013–14, 2015–16, 2017–18, and 2013–18 (since the 2011–12 survey overlapped with the 2012 new school meal patterns and standards for a few months, 2011–12 was excluded from this analysis). The sample statistics

reported in tables 4a and 4b were combined with the regression coefficients reported in table 5 to calculate the decomposition effects for all students who ate school meals. Both the consumption propensity and intensity increased between 2005–10 and 2013–16; all three effects—intensity, propensity, and interaction—were positive. These three effects were summed to estimate their percent contributions to the increased ratio of whole-grain to total-grain consumption (figure 10).

Using the mean values of consumption propensity and intensity, the propensity effect outweighed the intensity effect for the comparison of 2005–10 versus 2013–14 and beyond, resulting in a ratio of 1.55 (34.33 percent to 22.22 percent) between 2005–10 and 2013–18. The interaction effect—the joint effect of propensity and intensity—was greater than the individual effects of propensity and intensity effect between 2005–10 and 2013–18. Because both the propensity and intensity effects were positive (i.e., more children ate whole grains, and those who ate them also ate larger amounts), the interaction had a compounding effect on intakes.

Figure 10
The relative effects (percentage) of propensity, intensity, and interaction on increased whole-grain consumption from school food



vs = versus.

Source: USDA, Economic Research Service, using data from USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals and the continuous waves of What We Eat in America /National Health and Nutrition Examination Survey conducted by USDA and U.S. Department of Health and Human Services during 2003–18.

Discussion

What Do These Trends Suggest for Meeting Whole-Grain Recommendations?

These analyses examined whole grain intakes of U.S. consumers over a roughly 20-year span, starting with data from 1994–98 and continuing through 2017-18. The analysis was able to leverage the Federal Government's investments in large, national surveys of food consumption and databases that permit analysis of the whole grain content of foods consumed. As with any study, limitations must be acknowledged. Although the surveys' dietary intake methodology has been validated, recalls may be limited by an individual's ability to describe consumed foods accurately. The Food Patterns Equivalents Database (FPED) may not perfectly capture the whole-grain content of all foods. The descriptive analyses in this study compare intakes in terms of density—that is, amounts consumed per 1,000 calories rather than by total amounts consumed. The density approach allows qualitative comparisons across groups that differ widely in amounts consumed, but it could be affected by individuals eating very low amounts or very unbalanced diets (e.g., almost nothing except grains). Finally, the cross-sectional nature of the data does not permit causal inference. Nevertheless, the analysis yields insights into how whole-grain intakes have changed—or have not changed—over time that may be of interest to nutrition policymakers, program officials, educators, and other public health leaders.

At the beginning of the study period for this report, the Dietary Guidelines for Americans (DGA)—the Federal Government's official statement about what to eat and drink to be healthy—provided general dietary guidance to eat a diet rich in plant foods, including whole grains. At roughly the midpoint of this time span (2005), the DGA published stronger, more specific recommendations, stating that those individuals 2 years of age and older should obtain half of all their grain consumption from whole grains. Subsequent DGA editions have continued to stress the importance of whole-grain consumption, emphasizing its association with decreased risk of cancer, diabetes, and other chronic diseases (DGAC, 2020). This association is particularly important now, as diabetes has been identified as a risk factor for more severe disease resulting from COVID-19 (Zhou et al., 2021).

The whole-grain recommendation was followed by the development and delivery of nutrition education messaging by both public and private organizations (USDA, CNPP, 2019; American Heart Association, 2021; Whole Grains Council, 2005), development of new whole-grain products and reformulation of existing products that increased whole-grain options for the home food supply (Mancino et al., 2008), and by new product offerings in restaurants and fast-food locations (Whole Grain Council, 2019). Additionally, changes were made in USDA food assistance and nutrition programs, including new requirements to include whole grain-rich products in the daily menus of school meals offered through USDA's National School Lunch and School Breakfast Programs. Industry responded by creating whole grain-rich products specifically for the school foodservice market (Whole Grain Council, 2018).

Nevertheless, U.S. consumers (as a whole) have not made much progress toward recommended grain consumption patterns. In 1994–98, the U.S. population averaged whole-grain intakes of 0.4 ounce per 1,000 calories, well short of the 1.5 ounces-per-1,000 calories benchmark. In 2015–18, whole-grain intakes were 0.43–0.48 ounce equivalents per 1,000 calories—still less than one-third of the benchmark level of 1.5-ounce equivalents per 1,000 calories, while refined-grain intakes were 2.77-ounce equivalents per 1,000 calories. Consistent with these self-reported data, whole wheat flour production was 5 percent of total flour production in 2019, only 1 percent higher than in 2006–07 (Sosland, 2021). Although consumption of other whole grains (such as brown rice or oats) may have increased, this information supports the authors' finding that average consumption remains below recommended levels.

At all measured-time points, adults 65 years and older consumed a more whole grain-dense diet than younger adults and children. However, the diets of older adults did not become more whole-grain dense over time, and at 0.56 ounce per 1,000 calories, the whole-grain density of older adults' diets in 2017–18 was less than half of the benchmark level. Under the Older Americans Act, the U.S. Department of Health and Human Services provides States with grants to operate congregate meals and home-delivered meal services for older adults. These programs serve approximately 900,000 meals daily, targeting the most economically and socially vulnerable of older Americans.[5] Federal guidelines state that the meals should adhere to the DGA. However, States operating congregate meals and home-delivered meal services for older Americans have more flexibility on menu planning than in the USDA school meal programs, and an evaluation of the nutritional quality of meals served indicated that the average meal served through these State programs for older Americans did not meet the DGA's whole-grain recommendations (Niland et al., 2017). Increasing the whole-grain content of those meals (as was done with USDA school meal programs) could increase intakes of participating older adults. However, the more limited reach of these programs suggests the programs would be less likely to have broad population impacts than the USDA school meal programs.

In no time period studied did the whole-grain density of the diets of younger adults (aged 20–64) reach one-third of the benchmark level of 1.5-ounce equivalents per 1,000 calories. These findings suggest that despite the range of public and private initiatives, more effective strategies to increase whole-grain intakes of adults are needed if the intakes are to meet DGA recommendations. Changing grain consumption habits is not uniquely difficult—the typical U.S. diet also does not meet recommendations for other healthful food groups, such as fruits, vegetables, and dairy (DGA 2020–2025). However, food preferences develop early in life (Birch, 1999) and, once developed, may be difficult to change. While many factors influence long-term food habits, earlier interventions that shape initial preferences may be more likely to have success.

Previously, Lin et al. (2019) documented a significant increase in children's whole-grain intakes in 2013–14 and identified the key role of school foods in this change. This study reaffirms and extends the findings of the previous study. The authors' descriptive analyses show that whole-grain intakes by schoolchildren were even higher in 2015–18, and the consumption of school food was once again the major factor in the increase. In 1994–98, the whole-grain to total-grain ratio of school food was 4 percent. Following the implementation of new USDA school meal patterns and nutrition standards that required the inclusion of whole grain-rich menu items, the whole-grain to total-grain ratio of school food climbed to 21.48–32.93 percent in 2013–18. The further increase in whole-grain intake seen in 2015–18 may be attributed to one or more of these factors: (1) increased acceptance by schoolchildren, (2) the additional requirement that USDA-subsidized school breakfasts must include whole grain-rich foods beginning in school year 2014–15, and (3) the requirement that non-USDA foods sold at schools that are primarily grain must contain whole grains as a first ingredient. The authors' analyses indicate that in the later time periods, more schoolchildren ate whole grains as part of school foods (propensity), and those schoolchildren who ate whole grains consumed larger amounts (intensity). These two factors worked in tandem to increase the overall consumption of whole grains at school, as indicated by the large interaction effect shown in the authors' decomposition analysis.

Although the authors' analyses can only demonstrate an association, not a causal relationship, the analyses are consistent with those of other studies. In one small local study, Cullen et al. (2015) found increased whole-grain selection among school lunch participants, while a national study of 5,106 children found school breakfast participation to be positively associated with whole-grain intakes (Au, 2018). Most notably, the USDA's School Nutrition and Meal Cost Study, which collected data on the intakes of students who participated in

[5] Information provided by the Administration for Community Living (ACL), an operating division of the U.S. Department of Health and Human Services (HHS).

USDA's NSLP and SBP in school year 2014–15, found that both lunch and breakfast participants ate more whole grains at these meals than nonparticipants (Fox et al., 2019).

In school year 2014–15, meal patterns originally required all grains offered as part of school meals to be whole grain-rich. As discussed previously, concerns about product availability and student acceptance led USDA to permit school foodservices to continue with whole grain-rich foods as part of at least half of grain offerings (box A). Menu data from USDA's School Nutrition and Meal Cost Study indicate that whole grain-rich items comprised at least half of grain offerings in 87 percent of lunches and 94 percent of breakfasts, but only 27 percent of lunches and 47 percent of breakfasts offered only whole grain-rich grains (Gearan et al., 2019). Moreover, plate waste data from that study indicate children did not eat all the grain foods served to them (Fox et al., 2019). These menu data suggest that, although children's whole-grain intake from school foods increased substantially after changes in school food standards, more improvement could still have been made. Further improvement may depend not only on whole grain-rich foods being made available but also on children's acceptance of those foods. Improving acceptance and consumption of whole grain-containing school foods could be particularly important to low-income children and children from food-insecure households, who may rely more on school meals (Smith, 2017; Forrestal et al., 2021).

Food preferences are shaped by repeated exposure to a given food (Pliner, 1982). School meals can provide whole grain-rich foods on a daily basis, offering the opportunity for repeated exposure. This opportunity may particularly benefit low-income children whose parents may be reluctant to risk spending scarce dollars on new foods their children may reject (Daniel, 2016). Such repeated exposure could prompt a greater acceptance of whole grain-rich foods both at school and when offered in other settings, potentially resulting in lasting improvements in whole-grain intake for these children as they reach adulthood. At the same time, offering foods does not guarantee acceptance. Although the authors' results show improvements in whole-grain intake at school, the results still fall short of the 50:50 ratio recommended by the DGA. Further research on strategies to encourage whole-grain intake may be helpful, particularly strategies targeting subgroups less likely to consume whole grains from school foods, such as older children (teenagers) and non-Hispanic White children.

On a typical school day in 2019, more than 29 million children ate a school lunch, and almost 15 million ate a school breakfast (Tiehen, 2020). The size of this market may incentivize further development of whole grain-rich products that appeal to children's tastes (Whole Grain Council, 2018). Behavioral strategies such as taste tests, modeling by teachers and other role models, and promotion of social norms favoring healthy foods may further encourage acceptance (Birch, 1999). Coupling appealing products with health promotion while serving foods in an attractive environment with adequate time to eat (Goss et al., 2019) may help move children further toward accomplishing the DGA's goals for whole-grain intake.

References

American Heart Association. "Whole Grains, Refined Grains, and Dietary Fiber," American Heart Association, Dallas, TX (accessed 2021).

Au, L., K. Gurzo, W. Gosliner, K.L. Webb, P.B. Crawford, and L.D. Ritchie. 2018. "Eating School Meals Daily is Associated With Healthier Dietary Intakes: The Healthy Communities Study," *Journal of the Academy of Nutrition and Dietetics* 118(8):1474–1481.

Birch, L.L. 1999. "Development of Food Preferences," *Annual Review of Nutrition* 19(1):41–62.

Bowman, S.A., J.C. Clemens, J. Friday, K.L. Lynch, and A.J. Moshfegh. 2017. *Food Patterns Equivalents Database 2013–14: Methodology and User Guide*, U.S. Department of Agriculture, Agricultural Research Service.

Chen, G., X. Tong, J. Xu, S. Han, Z. Wan, J. Qin, and L. Qin. 2016. "Whole-grain Intake and Total, Cardiovascular, and Cancer Mortality: a Systematic Review and Meta-analysis of Prospective Studies," *American Journal of Clinical Nutrition* 104:164–72.

Cullen, K., T. Chen, and J. Dave. 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(1):440–443.

Daniel C. 2016. "Economic Constraints on Taste Formation and the True Cost of Healthy Eating," *Social Science Medicine* 148(1):34–41.

Dietary Guidelines Advisory Committee, 2005. *Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans, 2005, to the Secretary of Agriculture and the Secretary of Health and Human Services,* U.S. Department of Agriculture, Agricultural Research Service.

Dietary Guidelines Advisory Committee. 2020. *Scientific Report of the 2020 Dietary Guidelines Advisory Committee: Advisory Report to the Secretary of Agriculture and the Secretary of Health and Human Services,* U.S. Department of Agriculture, Agricultural Research Service.

Dunford, E., and B. Popkin. 2018. "37-Year Snacking Trends for U.S. Children, 1977–2014," *Pediatric Obesity* 13(4):247–255.

Ferruzzi, M.G., S.S. Jonnalagadda, S. Liu, L. Marquart, N. McKeown, M. Reicks, G. Riccardi, C. Seal, J. Slavin, F. Thielecke, J. van der Kamp, and D. Webb. 2014. "Developing a Standard Definition of Whole-Grain Foods for Dietary Recommendations: Summary Report of a Multidisciplinary Expert Roundtable Discussion," *Advances in Nutrition* 5:164–176.

Forrestal, S., E. Potamites, J. Guthrie, and N. Paxton. 2021. "Associations Among Food Security, School Meal Participation, and Students' Diet Quality in the First School Nutrition and Meal Cost Study," *Nutrients* 13(2):307.

Fox, M.K., E. Gearan, C. Cabili, D. Dotter, K. Niland, L. Washburn, N. Paxton, L. Olsho, L. LeClair, and V. Tran. 2019. *School Nutrition and Meal Cost Study Final Report Volume 4: Student Participation, Satisfaction, Plate Waste, and Dietary Intakes,* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support.

Gearan, E., M.K. Fox, K. Niland, D. Dotter, L. Washburn, P. Connor, L. Olsho, and T. Wommak. 2019. *School Nutrition and Meal Cost Study Final Report Volume 2: Nutritional Characteristics of School Meals,* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support.

Goss, S., E. Biehl, B. Marshall, D.M. Paige, and K. Mmari. 2019. "Role of the Elementary School Cafeteria Environment in Fruit, Vegetable and Whole Grain Consumption by 6- to 8-Year-Old Students," *Journal of Nutrition Education and Behavior* 51(1):41–47.

Guthrie, J., B.-H. Lin, and E. Frazao. May–June 2002. "Role of Food Prepared Away from Home in the American Diets, 1977–78 versus 1994–96: Changes and Consequences," *Journal of Nutrition Education and Behavior* 34(3):140–150.

Guthrie, J., and C. Newman. 2013. "Eating Better at School: Can New Policies Improve Children's Food Choices?" *Amber Waves*, U.S. Department of Agriculture, Economic Research Service.

Lieffers, J., J. Ekwaru, A. Ohinmaa, and P.J. Veugelers. 2018. "The Economic Burden of Not Meeting Food Recommendations in Canada: The Cost of Doing Nothing," *PLOS One* 13(4):e0196333.

Lin, B.-H., J. Guthrie, and T.A. Smith. 2019. "Dietary Guidance and New School Meal Standards: Schoolchildren's Whole Grain Consumption Over 1994–2014," *American Journal of Preventive Medicine.*

Lin, B.-H., J. Variyam, J. Allshouse, and J. Cromartie. *Food and Agricultural Commodity Consumption in the United States: Looking Ahead to 2020*, AER-820, February 2003.

Lin, B.-H., and S.T. Yen. November 2007. *The U.S. Grain Consumption Landscape: Who Eats Grain, in What Form, Where, and How Much?* ERR-50, U.S. Department of Agriculture, Economic Research Service.

Ludwig, D., F. Hu, L. Tappy, and J. Brand-Miller. 2018. "Dietary Carbohydrates: Role of Quality and Quantity in Chronic Disease," *British Medical Journal* 361:k2340.

Mancino, L., and F. Kuchler. 2012. "Demand for Whole-Grain Bread Before and After the Release of Dietary Guidelines," *Applied Economic Perspectives and Policy* 34(1):76–101.

Mancino, L., F. Kucher, and E. Leiter. "Getting Consumers to Eat More Whole Grains: The Role of Policy, Information, and Food Manufacturers," *Food Policy* 2008; 33(6):489–496.

Mirel, L.B., L.K. Mohadjer, S.M. Dohrmann, J. Clark, V.L. Burt, C.L. Johnson, and L.R. Curtin. 2013. National Health and Nutrition Examination Survey: Estimation Procedures, 2007–2010. *Vital and Health Statistics. Series 2, Data Evaluation and Methods Research*, 159:1–17.

National Academies of Sciences, Engineering, and Medicine (NASEM). 2017. *Review of WIC Food Packages: Improving Balance and Choice: Final Report*, Washington, DC: The National Academies Press, Washington, DC.

National Research Council. 1989. *Diet and Health: Implications for Reducing Chronic Disease Risk*. The National Academies Press, Washington, DC.

Ng, S., J. Poti, and B. Popkin. "Trends in Racial/Ethnic and Income Disparities in Foods and Beverages Consumed and Purchased From Stores Among U.S. Households With Children, 2000–2013," *American Journal of Clinical Nutrition* 2016, 104(3):750–759.

Niland, K., Fox, M.K., and E. Gearan. 2017. Nutritional Quality of Congregate and Home-Delivered Meals Offered in the Title III-C Nutrition Services Program: An Examination Utilizing the Healthy Eating Index Tool. Mathematica-MPR Issue Brief, October.

Pliner, P. 1982. "The Effects of Mere Exposure on Liking for Edible Substances," *Appetite* 3(3):283–290.

Poti, J., M.M. Slining, and B.M. Popkin. 2013. "Solid Fat and Added Sugar Intake Among U.S. Children: The Role of Stores, Schools and Fast Food From 1994 to 2010," *American Journal of Preventive Medicine* 45(5):551–559.

Powell, E., L. Smith-Taillie, and B. Popkin. 2016. "Added Sugars Intake Across the Distribution of U.S. Children and Adult Consumers: 1977–2012," *Journal of the Academy of Nutrition and Dietetics* 116(10):1543–1550.

Saksena, M.J., A.M. Okrent, T.D. Anekwe, C. Cho, C. Dicken, A. Effland, H. Elitzak, J. Guthrie, K.S. Hamrick, J. Hyman, Y. Jo, B.H. Lin, L. Mancino, P.W. McLaughlin, I. Rahkovsky, K. Ralston, T.A. Smith, H. Stewart, J. Todd, and C. Tuttle. 2018. *America's Eating Habits: Food Away from Home*, EIB-196, U.S. Department of Agriculture, Economic Research Service.

SAS Institute Inc., SAS 9.1.3 Help and Documentation, Cary, NC: SAS Institute Inc., 2002–2004.

Smith, T. 2017. "Do School Food Programs Improve Child Dietary Quality?" *American Journal of Agricultural Economics* 99(2):339–356.

Sosland, J. 2021. *Rare Increase for Whole Wheat Flour Production*, Baking Business.com.

Tiehen, L. 2020. *Food Assistance Landscape: FY2019 Annual Report*, EIB-218, U.S. Department of Agriculture, Economic Research Service.

U.S. Department of Agriculture, Agricultural Research Service. 2019a. *Continuing Survey of Food Intakes by Individuals 1994–1996, 1998 and DHKS 1994–1996*.

U.S. Department of Agriculture, Agricultural Research Service. 2019b. *What We Eat In America*.

U.S. Department of Agriculture, Agricultural Research Service. 2019c. *MyPyramid Equivalents Food Database*.

U.S. Department of Agriculture, Agricultural Research Service. 2019d. *Food Patterns Equivalents Database*.

U.S. Department of Agriculture, Center for Nutrition Policy and Promotion. 2019. *Make Half Your Grains Whole Grains*.

U.S. Department of Agriculture, Food and Nutrition Service. 2012. *National School Lunch Program and School Breakfast Program: Nutrition Standards in the National School Lunch and School Breakfast Programs* 77(17)4088–4160.

U.S. Department of Agriculture, Food and Nutrition Service. 2017. *Child Nutrition Programs: Flexibilities for Milk, Whole Grains, and Sodium Requirements: Interim Final Rule* 82(229):56703–56723.

U.S. Department of Agriculture, Food and Nutrition Service. 2018. *Child Nutrition Programs: Flexibilities for Milk, Whole Grains, and Sodium Requirements: Final Rule* 83(238):63775–63794.

U.S. Department of Agriculture, and U.S. Department of Health and Human Services. 1995. *Dietary Guidelines for Americans, 1995, 4th Edition*, Home and Garden Bulletin Number 232, December 1995.

U.S. Department of Agriculture, and U.S. Department of Health and Human Services. 2005. *Dietary Guidelines for Americans, 2005*. 6th Edition.

U.S. Department of Agriculture, and U.S. Department of Health and Human Services. 2010. *Dietary Guidelines for Americans, 2010*. 7th Edition.

U.S. Department of Agriculture, and U.S. Department of Health and Human Services. 2015. *2015–2020 Dietary Guidelines for Americans*. 8th Edition.

U.S. Department of Agriculture, and U.S. Department of Health and Human Services. 2020. *2020–2025 Dietary Guidelines for Americans.* 9th Edition.

U.S. Department of Health and Human Services (HHS), and Food and Drug Administration Center for Food Safety and Applied Nutrition. 2015. *Questions and Answers on FDA's Fortification Policy.*

Vocke, G., J.C. Buzby, and H.F. Wells. September 2008. "Consumer Preferences Change Wheat Flour Use," *Amber Waves,* U.S. Department of Agriculture, Economic Research Service.

Whole Grains Council. 2005. "Getting Enough Whole Grains," Whole Grains Council, Boston, MA.

Whole Grains Council. 2018. "WG for School Meal Programs," Whole Grains Council, Boston, MA.

Whole Grains Council. 2019. "Eating Away From Home," Whole Grains Council, Boston, MA.

Zhou, Y., J. Chi, W. Lv, and Y. Wang. 2021. "Obesity and Diabetes as High-risk Factors for Severe Coronavirus Disease 2019 (COVID-19)," *Diabetes Metabolism Research and Reviews* 37:e3377.

Appendix

Table A.1

Food source codes and descriptions of where the food was obtained from Federal data sources and their correspondence to food source definitions used in this study

Food source code		Where the food was obtained	Food source
2003–18	1994–98		
1	1	Store	FAH
2	2	Restaurant with waiter/waitress	Restaurant
3	3	Fast food restaurant/pizza	Fast food
4	4	Bar/tavern/lounge	Fast food
5		Restaurant (no additional information)	Fast food
6	6	Cafeteria (not at school)	Fast food
7	5	School cafeteria	School
8	8	Children care center	School
9	8	Family/adult care center	Other FAFH
10	9	Soup kitchen/shelter/food pantry	FAH if eaten at home; otherwise other FAFH
11	10	Meals on Wheels	Other FAFH
12	11	Community food program - other	Other FAFH
13		Community food program no additional info	Other FAFH
14	7	Vending machine	Other FAFH
15	15	Common coffee pot or snack tray	Other FAFH
16	13	From someone else/gift	FAH
17	14	Mail order purchase	FAH
18	16	Residential dining facility	Restaurant
19	12	Grown by you or someone you know	FAH
20	71–74	Fish caught by you or someone you know	FAH
24		Sport, recreation, entertainment facility	Restaurant
25		Street vendor, vending truck	Other FAFH
		Fundraiser sales	Other FAH
		Store - convenience type	FAH
		Store - no additional info	FAH
91	96	Other, specify	Other, FAFH
99	98	Don't know	Missing

FAH = food at home; FAFH = food away from home.

Note: "Where the food was obtained" serves as the main driver in food source classification. A lunch packed at home and eaten at school is classified as FAH. In the case of "Soup kitchen/shelter/food pantry," the data for "whether or not the food was eaten at home" were used to determine food source. For instance, a loaf of bread from a food pantry eaten at home is classified as FAH. Food source variables were constructed by the authors on the basis of source information listed below.

Source: USDA, Economic Research Service, using data from USDA's 1994–96 and 1998 Continuing Survey of Food Intakes by Individuals and the continuous collections of information from the What We Eat in America component of the National Health and Nutrition Examination Survey (WWEIA/NHANES), conducted by USDA and U.S. Health and Human Services during 2003–18.