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Trends in U.S. Fruit Consumption Relative to Recommendations in the *Dietary Guidelines for Americans*

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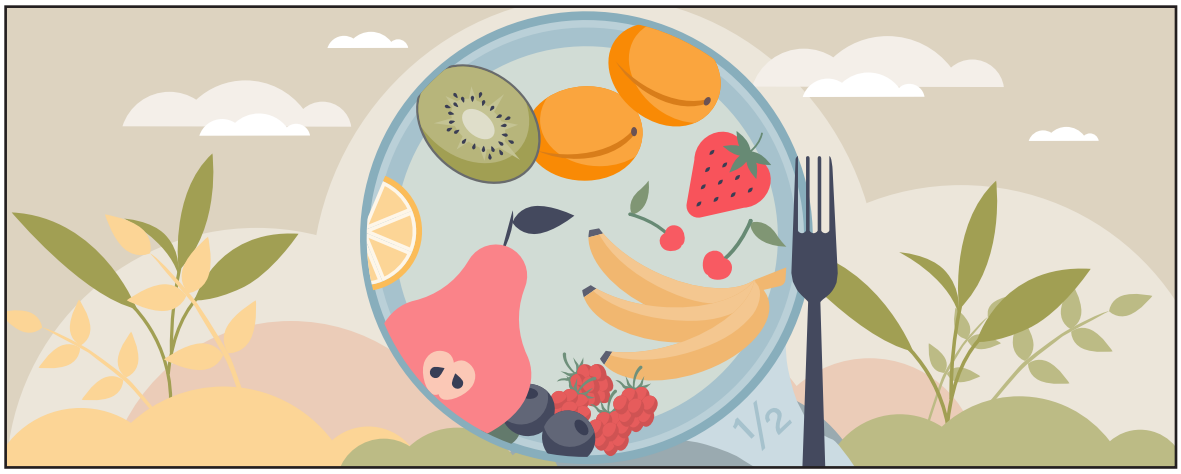

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Abstract

The average U.S. resident is consuming less fruit over time. Per capita total fruit intake, which includes fresh, frozen, canned, dried, and 100 percent juice products, decreased almost 20 percent during the 2000s and 2010s when measured in cup equivalents. Using data collected between 2005 and 2020 through the National Health and Nutrition Examination Survey, this report compares total fruit intake by adults and children to recommendations stated in the Dietary Guidelines for Americans. Results show that a stable share of the population—about 23 percent of children and 15 percent of adults–has been consuming enough fruit to satisfy recommendations since at least the mid-2000s. However, a larger and growing share of people is consuming below a quarter of the recommendations. This group totaled almost 29 percent of children and 40 percent of adults at the beginning of the 2020s. Using data on adults, this report models the probability of a consumer falling into one of these two groups. Whether a consumer fully satisfies or satisfies below 25 percent of the recommendations is associated with some key behaviors indicative of one's level of concern for health and nutrition knowledge. Fruit prices and household income have less influence.

Keywords: fruit, dietary trends, Dietary Guidelines for Americans, National Health and Nutrition Examination Surveys

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About the Authors

Hayden Stewart, Sabrina K. Young, Diansheng Dong, and Anne T. Byrne are research economists in USDA, ERS, Food Economics Division. Their research interests include food demand and diet quality.

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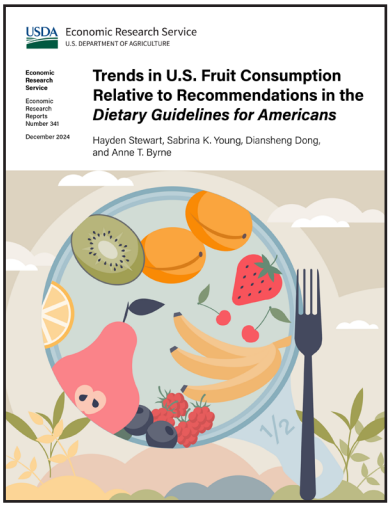
What Is the Issue?



The *Dietary Guidelines for Americans, 2020–25*, recommend choosing nutrient-dense foods, including fruit, to "Make Every Bite Count." The recommendation for a moderately active, 45-year-old female of reference height and weight is 2 cup equivalents of fruit per day, and for a moderately active, 16-year-old male of reference height and weight is 2.5 cup equivalents per day. However, despite the guideline recommendations, the average individual consumes less fruit than a typical person did 20 years ago. USDA, Economic Research Service (ERS) data reveal that U.S. per capita total fruit consumption, including fresh, frozen, canned, dried, and 100 percent juice products, has decreased about 20 percent on a cup-equivalent basis since peaking in the late 1990s and early 2000s.

Using data collected between January 2005 and March 2020 through the National Health and Nutrition Examination Survey (NHANES), this report compares total fruit consumption by U.S. children and adults to the recommendations in the *Dietary Guidelines for Americans*. The report looks at the share of individuals who consumes at least 100 percent of the recommended amount of fruit as well as the share who consumes below 25 percent of the recommendations; i.e., those who meet the recommendations and those who deviate furthest from it. The authors also used data on adults to estimate a statistical model that predicts whether someone falls into either of these two groups.

What Did the Study Find?

A stable portion of the population continues to satisfy total fruit recommendations in the *Dietary Guidelines for Americans.* With respect to these consumers, the authors found that:

- About 23 percent of all U.S. children and 15 percent of adults have been consuming the recommended amount of total fruit, including fruit juice, since at least the mid-2000s. Some mild fluctuation in the exact share was noted, but no evidence of a downward trend was found.

- Observed fruit intake among individuals who satisfied recommendations in the guidelines was consistent with consuming a small apple, a large orange, an 8-ounce glass of 100 percent juice, or a similar-sized portion of fruit on two or more occasions on most days.
- Most of these individuals have been drinking less fruit juice than consumers who satisfied recommendations 20 years ago, but they were also eating more whole and cut fruit.

On the other end of the U.S. fruit consumption spectrum is a larger and growing segment of the population that regularly consumes little or no fruit. With respect to these consumers, the authors found that:

- The share of U.S. children who habitually consumed below a quarter of the recommendations for total fruit increased by 4.8 percentage points, from 24 percent in 2005–08 to 28.8 percent in 2017–20.
- The share of U.S. adults who habitually consumed below a quarter of the recommended amount of fruit increased by 6.9 percentage points, from 33.4 percent in 2005–08 to 40.3 percent in 2017–20.
- Fruit intake among individuals in this group was consistent with consuming a small amount of fruit, possibly as an ingredient in another food, such as a blueberry muffin or cinnamon raisin bagel.
- The evidence suggests that, on most days, these individuals possibly consumed little or no fruit of any kind—juice or whole and cut fruit.

Using data on adults, estimates from statistical models revealed little association between either household income or fruit prices and the likelihood that someone met the recommendations or consumed less than 25 percent of them. Factors more closely associated with falling into one of these two groups included behaviors such as smoking, exercising, and awareness of MyPlate (USDA's official symbol of the five food groups), which indicate a consumer's level of concern for health as well as knowledge of what constitutes a healthy diet.

How Was the Study Conducted?

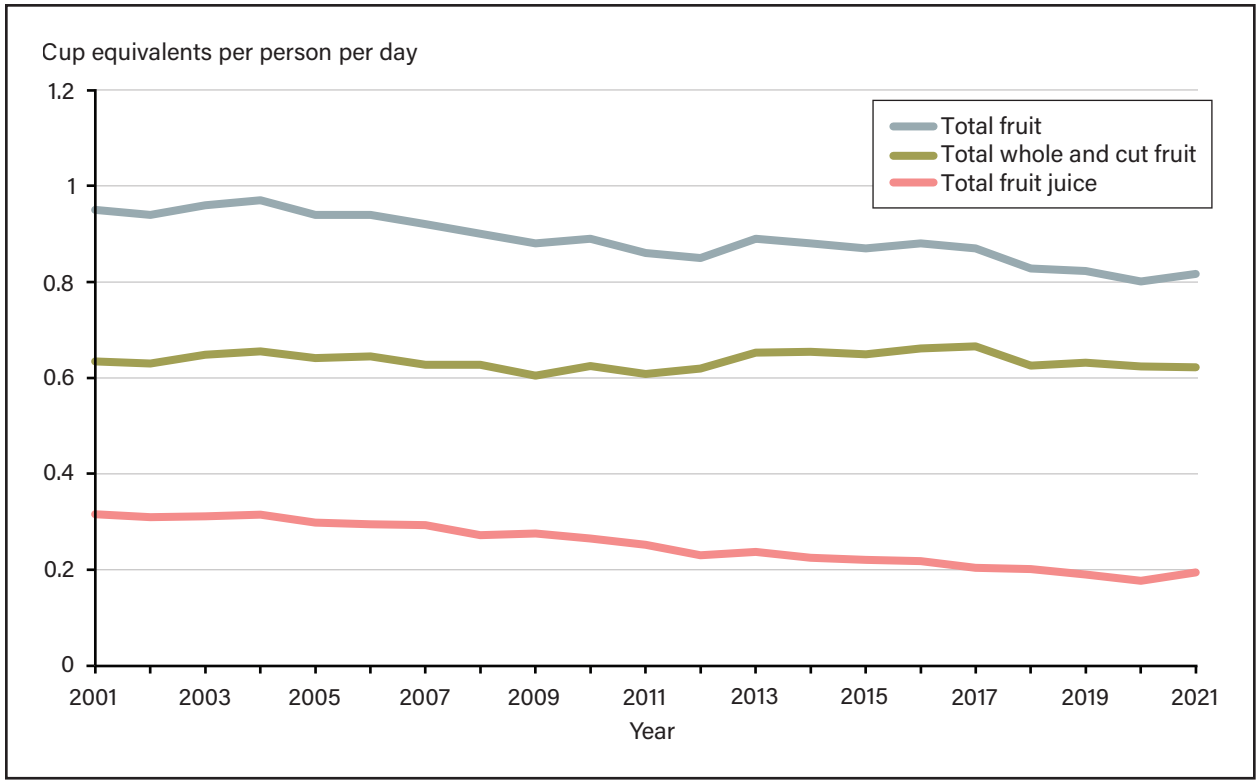
U.S. fruit consumption trends were investigated using NHANES data collected from January 2005 through March 2020. A method developed by the National Cancer Institute (NCI), an agency within the U.S. Department of Health and Human Services (HHS), was used to simulate the distribution of total fruit intake relative to recommendations in the guidelines during each of four periods: 2005–08, 2009–12, 2013–16, and 2017–March 2020. Results include the share of the U.S. population that fully met total fruit consumption recommendations during each period as well as the share that satisfied below 25 percent, below 50 percent, below 75 percent, and below 100 percent of recommendations. The authors used data on adults (individuals aged more than 19 years) to estimate a statistical model and test research hypotheses.

Introduction

A key message in the *Dietary Guidelines for Americans, 2020–25*, is to "Make Every Bite Count" by choosing nutrient-dense foods.[1] This includes consuming fruit. About 80 percent of individuals consume too little fruit to meet recommendations. Despite being encouraged to consume more, the average person consumes less fruit than they did 20 years ago. The USDA, Economic Research Service (ERS) Food Availability (Per Capita) Data System (FADS) (USDA, ERS, 2024a) notes that U.S. per capita daily total fruit intake, including fresh, frozen, canned, dried, and 100 percent juice products, peaked in the late 1990s and early 2000s at about 1 cup equivalent before falling throughout the 2000s and 2010s (figure 1). By 2021, U.S. per capita fruit intake was down almost 20 percent to 0.817 cup equivalents per day, approximately the amount of fruit in 18 seedless grapes or 6 large strawberries (see box, "Fruit Recommendations Are Measured in Cup Equivalents").

Orange and grapefruit juice are among the fruits being consumed in reduced quantities (figure 2).[2] Daily per capita orange juice consumption fell 54 percent from 0.175 to 0.083 cup equivalents between 2005 and 2021 (USDA, ERS, 2024a).[3] Daily per capita grapefruit juice consumption fell 74 percent from 0.009 to 0.002 cup equivalents (USDA, ERS, 2024a). Despite these decreases over the past 20 years, as a single category, the two citrus juice products continued to represent about 10 percent of total U.S. fruit consumption in 2021.

Figure 1
U.S. per capita total fruit consumption, 2001–21



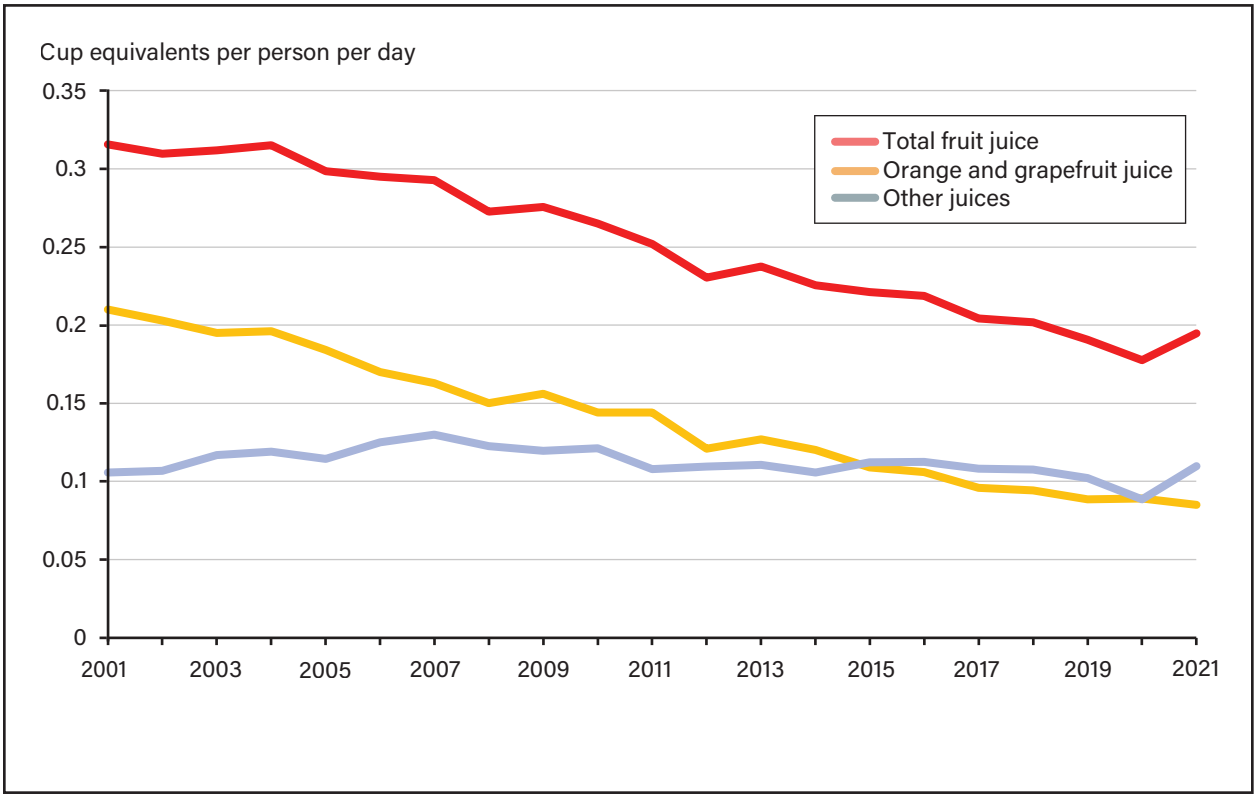
Source: USDA, Economic Research Service (ERS) using USDA, ERS Food Availability (Per Capita) Data System loss-adjusted food availability data for fruit.

[1] USDA and the U.S. Department of Health and Human Services (HHS) together publish the *Dietary Guidelines for Americans*. Each edition reflects the current body of nutrition science, helps health professionals and policymakers guide individuals and their families to make healthy food and beverage choices, and serves as the science-based foundation for vital nutrition policies and programs across the United States.

[2] Figures 1 and 2 are based on FADS. Reported decreases in U.S. per capita total fruit intake are smaller in studies based on food consumption survey data, although those studies similarly find that U.S. per capita fruit juice consumption is down, while U.S. per capita consumption of whole and cut fruit has changed relatively little over the years (e.g., Lin et al., 2023; Bowman et al., 2021a,b).

[3] Estimates include orange, temple, tangerine, and tangelo juice.

Figure 2
U.S. per capita total fruit juice consumption, 2001–21



Source: USDA, Economic Research Service (ERS) using USDA, ERS Food Availability (Per Capita) Data System loss-adjusted food availability data for fruit.

U.S. diet quality at the individual level may suffer to the extent that people are not eating and drinking enough fruit. The *Dietary Guidelines for Americans, 2020–25*, defines fruit to include fresh, canned, frozen, and dried products as well as 100 percent juice. Eating or drinking a cup equivalent of each fruit type counts equally toward recommendations, although juice should not account for more than half of total fruit intake.[4] Juice retains many of the same nutrients as whole and cut products (fresh, canned, frozen, and dried) but contains little dietary fiber. Much research shows that fruit consumption is associated with improved health outcomes, including reduced risk of cardiovascular disease, stroke, and coronary heart disease (Sun et al., 2021; Angelino et al., 2019).

Research also confirms that fruit consumption is associated with the intake of key nutrients (Stewart et al., 2023; Brauchla et al., 2021; Nicklas et al., 2020; O'Neil et al., 2012). Using data on 9,832 adult consumers, Stewart et al. (2023) found that fruit consumption is a positive marker for overall diet quality. Individuals who better adhere to total fruit recommendations typically adhere more closely to recommendations for other food groups as well. Consuming more fruit is, therefore, associated with consuming a greater amount of many different nutrients, including some not commonly found in fruit. However, fruit itself is a key source of nutrients. Individuals who consume below the recommended amount have an increased risk of vitamin C and potassium underconsumption, even if they otherwise have above average diet quality.[5]

[4] FADS data show that, in 2021, U.S. daily per capita total fruit consumption was 0.817 cup equivalents, including 0.517 cup equivalents of fresh fruit (63 percent), 0.195 cup equivalents of fruit juice (24 percent), 0.066 cup equivalents of canned fruit (8 percent), 0.026 cup equivalents of frozen fruit (3 percent), and 0.013 cup equivalents of dried fruit (2 percent).

[5] Stewart et al. (2023) examined fruit consumption and the intake of 5 out of 10 food components, including potassium, vitamin A, vitamin C, calcium, and magnesium, identified by the 2020 Dietary Guidelines Advisory Committee as being consumed in insufficient quantities by all segments of the population. Fruit may also be a key source of other food components that were not considered in that study.

In this report, the authors investigate total fruit consumption by U.S. children and adults relative to recommendations in the *Dietary Guidelines for Americans*. The authors began by examining data on fruit eating and drinking since 2005. The goal was to identify trends of potential significance to consumer diet quality and/or fruit growers. A review of economic theory and published research was then conducted to better understand any developments observed in the data. Finally, the authors propose research hypotheses and a statistical model for testing them.

Fruit Recommendations Are Measured in Cup Equivalents

Fruit recommendations in the *Dietary Guidelines for Americans, 2020–25*, are provided in cup equivalents. One cup equivalent is generally the amount of edible fruit (i.e., minus pits or peels) that will fit in a standard 1-cup measuring cup. Dried fruit is an exception. One cup equivalent of dried fruit is one-half cup by volume of dried fruit. MyPlate (USDA's official symbol of the five food groups) provides numerous examples of what constitutes 1 cup equivalent of fruit. These include a small apple, a large orange, 8 large strawberries, 22 seedless grapes, and 8 fluid ounces of 100 percent juice (USDA, Food and Nutrition Service (FNS), 2024b).

U.S. Fruit Consumption Relative to Recommendations

The *Dietary Guidelines for Americans* is designed for policymakers and nutrition and health professionals to help individuals and their families consume a healthy, nutritionally adequate diet. By law, USDA and the U.S. Department of Health and Human Services (HHS) update these recommendations every 5 years. Fairly consistent recommendations for total fruit consumption specific to a person's age, sex, and level of physical activity have been available for individuals aged 2 years and older since 2005.[6] Recommendations state, for example, that a moderately active, 45-year-old female of reference height and weight should consume 2 cup equivalents of fruit per day. The recommendation for a moderately-active, 16-year-old male of reference height and weight is 2.5 cup equivalents per day. Personalized recommendations, specific to an individual's height and weight as well as their age, sex, and level of physical activity, are available through MyPlate, which presents recommendations in the guidelines in an easy-to-understand format. Satisfying total fruit recommendations as stated in the *Dietary Guidelines for Americans* does not guarantee satisfying those in MyPlate.

Data Used in the Study

This report used the National Health and Nutrition Examination Survey (NHANES), a key source of data on U.S. consumers' food and beverage choices, to examine trends in total fruit consumption relative to recommendations stated in the *Dietary Guidelines for Americans*. The National Center for Health Statistics (NCHS), an agency within HHS, is responsible for the survey (HHS, NCHS, 2024a). Repeated samples of the U.S. population are drawn using a complex, multistage, probability cluster design that oversamples lower income and minority individuals. Survey participants report their income, demographics, and health status, among other information. They may also participate in a food consumption module, What We Eat in America (WWEIA), that includes two 24-hour dietary recalls.[7] Respondents report all foods and beverages they consumed over 2 nonconsecutive days (Day 1 and Day 2). About 5,000 individuals complete the NHANES each year. While FADS data show that average fruit consumption is trending downward (see box, "Food Availability (Per Capita) Data System (FADS) Data Reveal Consumption Trends at the Commodity

[6] In 2005, following the release of the *Dietary Guidelines for Americans, 2005,* USDA replaced the Food Guide Pyramid (FGP) with MyPyramid. Recommendations under the FGP were not tailored to one's age, sex, and level of physical activity. Individuals in general were advised to consume between 2 and 4 servings of fruit per day.

[7] WEIA is cooperatively developed by NCHS and the USDA, Agricultural Research Service (ARS) (USDA, ARS, 2024c).

Level"), NHANES data with information on individuals' food choices can be used to further identify whether such changes are evenly distributed across the population or disproportionately concentrated among certain groups.

For a cross-sectional and temporal perspective on fruit eating and fruit juice drinking, the authors used NHANES data collected between January 2005 and March 2020.[8] [9] The data set spans 15.25 years and contains information on 61,831 individuals aged 2 years and older for whom reliable dietary intake information is available for at least Day 1. Reliable dietary intake information is additionally available for Day 2 for 87 percent of these people (53,531 individuals). Total fruit intake was calculated for each person for the days for which reliable information is available.[10] Individuals were next divided into two age categories: children (individuals aged 2 through 19 years) and adults (individuals aged more than 19 years).[11] A two-part descriptive analysis of these data was then undertaken to identify trends of potential significance to consumer diet quality and/or fruit growers.

Food Availability (Per Capita) Data System (FADS) Data Reveal Consumption Trends at the Commodity Level

USDA, Economic Research Service (ERS) developed the Food Availability (Per Capita) Data System (FADS) to track consumption trends for more than 200 commodities. Annual data going back to the early 1900s are available for some commodities. Loss-adjusted data are generally available for each year since 1970. These data have been adjusted for food spoilage, plate waste, and other losses to more closely approximate actual intake.

All FADS data are available at the commodity level. To create the data series, researchers first estimated the supply of each commodity based on production, imports, and beginning stocks. For fruit products such as apples, oranges, grapefruit, and orange juice, USDA, ERS then subtracted exports and other measurable nonfood uses from its annual supply estimates. The amounts available for human consumption were next adjusted for spoilage, plate waste, and other losses to more closely approximate actual intake. U.S. per capita consumption estimates were then calculated for each commodity by dividing the amount of the commodity available for human consumption after adjustment for loss by total population size.

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[8] NCHS released NHANES data from 1999 through 2018 in continuous 2-year cycles. Each cycle was representative of the U.S. civilian, noninstitutionalized population at the time of collection. Released data include the NHANES 1999–2000, 2001–2002, 2003–04, and so on. However, NCHS suspended field operations in March 2020 because of the COVID-19 pandemic. Data collection for the NHANES 2019–2020 was still incomplete at the time. Survey administrators later combined the information they had collected with data from the NHANES 2017–2018 to create the nationally representative NHANES 2017–March 2020.

[9] For this study, the authors pooled data from seven survey cycles (NHANES 2005–06, 2007–08, 2009–10, 2011–2012, 2013–14, 2015–16, and 2017–March 2020). The NHANES 2017–18 was not included because participants in that survey cycle were included in the 2017–March 2020 sample. These were the most recent data available at the time of the study. NCHS resumed NHANES data collection in 2021. Information on the forthcoming NHANES 08/2021–08/2023 is available in Paulose-Ram et al. (2021).

[10] The authors merged the food diaries of NHANES participants with the Food Patterns Equivalents Database (FPED). This USDA data set converts the foods and beverages that NHANES respondents ingest into USDA Food Patterns components, including cup equivalents of fruit. A single-component food, such as 100 percent orange juice, is directly converted into cup equivalents. A multi-ingredient food, such as apple pie, is disaggregated into its component parts. These include cup equivalents of fruit, ounce equivalents of grains, gram equivalents of solid fats and oils, and teaspoon equivalents of added sugars.

[11] Several different cut points could have been used to separate children and adults. While a 21-year-old person is clearly an adult and a 17-year-old person is clearly a child, one could argue about where to include individuals aged 18, 19, and 20. The authors chose to define children as anyone aged 2 through 19 years because they believe using 20 years as the lower threshold for being an adult represents a middle ground among the possibilities and is consistent with how the NHANES collects questionnaire data. There are separate NHANES questions about education; for example, asked of "youth/children" aged 0 to 19 years and "adults" aged 20-plus years (HHS, NCHS, 2024b).

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Loss-adjusted estimates for fruit products reveal that the average U.S. consumer has been drinking less orange juice and less grapefruit juice over time. Per capita consumption of both products has decreased by more than 50 percent since the early 2000s. However, these two types of citrus juice still represent about 44 percent of all fruit juice intake, which is more than other popular juices, such as apple (38 percent), grape (6 percent), cranberry (4 percent), or pineapple (4 percent).

Whole and cut fruit consumption has been comparatively stable. FADS shows that increases in the consumption of some fruits, such as mandarin oranges and berries, were largely offset by decreases in the consumption of other fruits, such as grapefruit and peaches, during the 2000s and 2010s.

The Distribution of Usual Fruit Intake Relative to Recommendations

For the first part of this report's descriptive analysis, the authors used a method developed by the National Cancer Institute (NCI) to estimate the share of the U.S. population that consumes at least enough total fruit to satisfy recommendations in the guidelines, as well as the population shares that satisfy below 25 percent, below 50 percent, below 75 percent, and below 100 percent of total fruit recommendations. The authors estimated how much each of these shares has changed over time. NCI has developed a method for simulating the distribution of food and nutrient intakes across the U.S. population using data on NHANES–WWEIA respondents who completed at least Day 1 of the survey. Estimation results based on the method more closely approximate "usual" or "habitual" behavior than previous methods and were consistent with the results of studies that observe consumers over longer periods than 2 days (Herrick et al., 2018).[12] A detailed description of the method, including computer software programs, a user's guide, and examples, is available online (HHS, NCI, 2024; Herrick et al., 2018).[13]

Using data on individuals who provided at least 1 day of reliable dietary intake information between January 2005 and March 2020,[14] the authors used NCI's method to simulate the distribution of usual, habitual fruit intake relative to the recommendations during each of four periods: 2005–08, 2009–12, 2013–16, and 2017

[12] The simplest method for estimating the share of the U.S. population that fully satisfies dietary recommendations for total fruit consumption would be to estimate the proportion of all NHANES participants with 2-day average intakes equal to or greater than the recommendation for a moderately active person of the same age and sex. The same procedure could also be used to estimate the share of the population that consumes less than 25 percent of the recommended amount. However, NCI argues that this approach would likely overestimate both of these proportions. Individuals' food choices vary widely from day to day. If a group of people are observed consuming little or no fruit over 2 randomly selected days, it can be assumed that many of them have low usual intakes. Conversely, if a group of people are observed consuming large amounts of fruit over 2 randomly selected days, it can be assumed that many of them have high usual intakes. However, if the NHANES dietary intake module were collected over more than 2 days, at least some of the survey participants with very low intakes might be observed eating a piece of whole fruit or drinking a glass of 100 percent juice, effectively raising their daily average consumption levels. Other people with high reported intakes might also be observed on a day when they eat little or no fruit, effectively lowering their daily average consumption levels. A portion of the very high and very low 2-day averages reported by NHANES participants for foods such as fruit would eventually average out in this way (Herrick et al., 2018).

[13] The NCI has two models for simulating the distribution of usual, habitual food and nutrient intakes. One model is for ubiquitously consumed foods and nutrients. The second model is for episodically consumed foods and nutrients, which NCI defines to include anything eaten by less than 90 to 95 percent of survey respondents. NCI's model for episodically consumed foods, which is used in this study, consists of two equations. One equation models the probability that a consumer reported eating any amount of the food or nutrient in question. The second equation models the same consumer's conditional level of consumption. Usual or habitual intake is estimated for each NHANES participant as the product of their consumption probability and their expected conditional intake level. A Markov chain Monte Carlo (MCMC) procedure is then used to simulate the distribution of usual, habitual intakes for the entire U.S. population. Researchers can obtain information for selected cut points on the distribution (e.g., the share of all consumers who fully satisfy total fruit recommendations on a regular basis). Balanced repeated replication (BRR) weights are used to account for complex survey design.

[14] Given the significant changes made to total fruit recommendations in 2005 (see footnote 6), the authors began their analysis with the NHANES 2005–06 data, excluding earlier survey cycles from the analysis.

through March 2020.[15] Each survey participant's reported total fruit intake was divided by recommendations in the *Dietary Guidelines for Americans, 2020–25*, for a moderately active person of the same age and sex as well as reference height and weight. Separate distributions were generated for children and adults (tables 1 and 2, figures 3 and 4).

Table 1
Adherence with total fruit recommendations among U.S. children, 2005–March 2020

Share of U.S. children who:	2005–08	2009–12	2013–16	2017–20
Consumed below 25 percent of recommendations	0.240	0.226	0.258	0.288
	(0.010)	(0.011)	(0.041)	(0.019)
Consumed below 50 percent of recommendations	0.476	0.448	0.500	0.508
	(0.010)	(0.013)	(0.066)	(0.020)
Consumed below 75 percent of recommendations	0.655	0.623	0.673	0.663
	(0.009)	(0.012)	(0.064)	(0.017)
Consumed below 100 percent of recommendations	0.778	0.748	0.790	0.768
	(0.009)	(0.011)	(0.054)	(0.013)
Fully satisfied recommendations	0.222	0.252	0.210	0.232
	(0.009)	(0.011)	(0.054)	(0.013)

Children = individuals aged 2 through 19.

Note: The share of U.S. children who regularly consumed below 25 percent, and 50, 75, and 100 percent of total fruit recommendations in the *Dietary Guidelines for Americans*, is estimated. The analysis was limited to children whose families provided a complete dietary recall for at least Day 1. For each of these individuals, calculations were based on the amount of fruit they reported consuming over all days for which they provided reliable intake data (i.e., either Day 1 alone or both Day 1 and Day 2). Those consumption amounts were then divided by the recommendation for a moderately active individual of the same age and sex as well as reference height and weight. Finally, using the National Cancer Institute's recommended methodology, including software programs, the distribution of fruit intake relative to recommendations was simulated. Standard errors are in parentheses. Data for 2020 are only available through March.

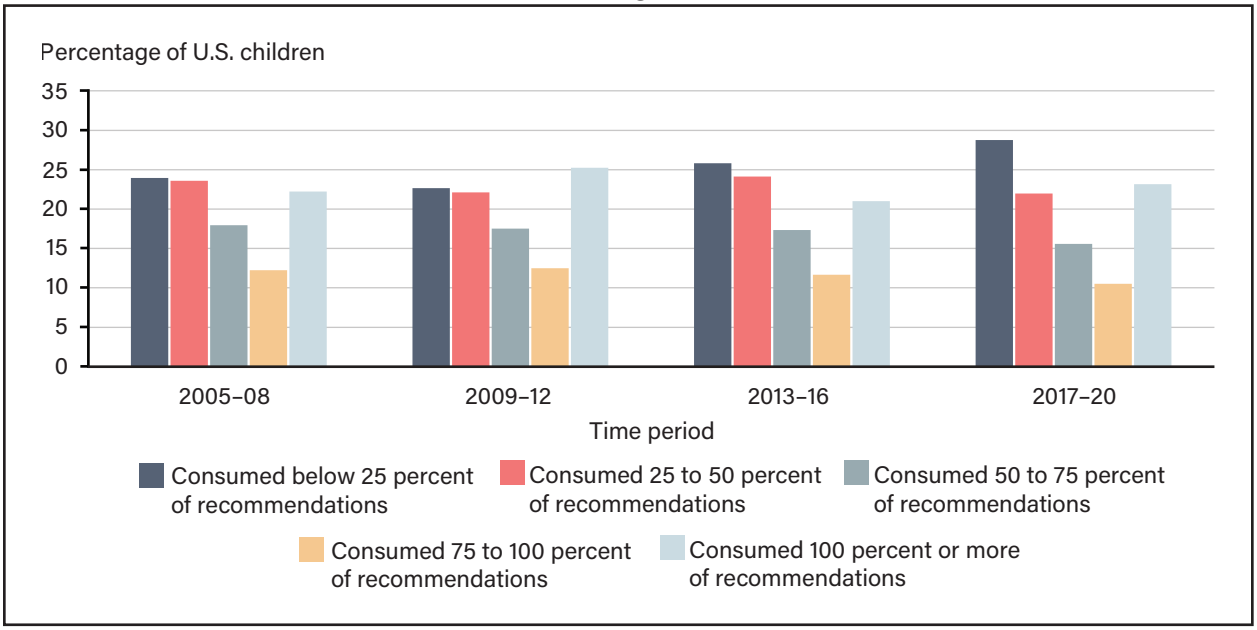
Sample sizes are 7,138 (2005–08), 6,412 (2009–12), 5,919 (2013–16), and 4,090 (2017–20).

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey, What We Eat In America data, 2005–March 2020.

[15] SAS software was used and included code written by NCI to create the BRR weights, a macro developed by NCI to estimate its model for episodically consumed foods that allows for correlation between the two equations (MIXTRAN), and a macro developed by NCI to perform the MCMC simulation (DISTRIB).

Figure 3

Adherence with total fruit recommendations among U.S. children, 2005–March 2020



Children = individuals aged 2 to 19.

Note: The share of U.S. children who regularly consumed below 25 percent, and 50, 75, and 100 percent of total fruit recommendations in the *Dietary Guidelines for Americans*, (table 1) is estimated. The analysis was limited to children whose households provided a complete dietary recall for at least Day 1. For each of these individuals, calculations are based on the amount of fruit they reported consuming over all days for which they provided reliable intake data (i.e., either Day 1 alone or both Day 1 and Day 2). Those consumption amounts were then divided by the recommendation for a moderately active individual of the same age and sex as well as reference height and weight. Finally, using the National Cancer Institute's recommended methodology, including software programs, the distribution of fruit intake relative to recommendations was simulated. Data for 2020 are only available through March. Sample sizes are 7,138 (2005–08), 6,412 (2009–12), 5,919 (2013–16), and 4,090 (2017–20).

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey, What We Eat In America data, 2005–March 2020.

Table 2

Adherence with total fruit recommendations among U.S. adults, 2005–March 2020

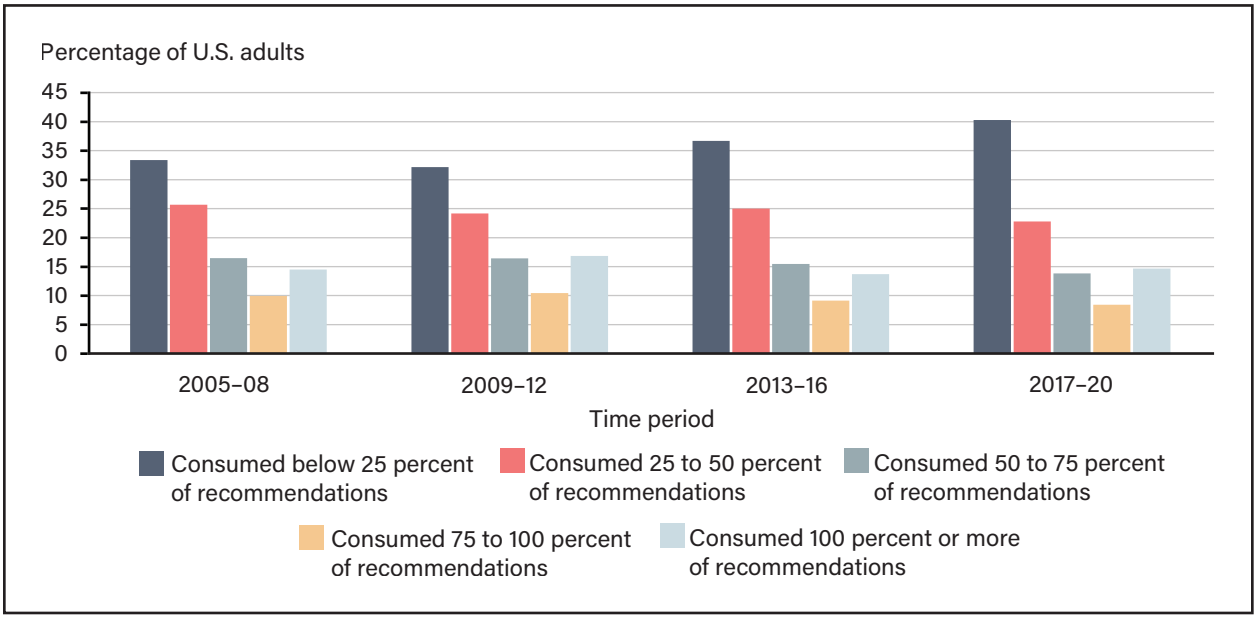
Share of U.S. adults who:	2005–08	2009–12	2013–16	2017–20
Consumed below 25 percent of recommendations	0.334	0.322	0.367	0.403
	(0.013)	(0.008)	(0.062)	(0.016)
Consumed below 50 percent of recommendations	0.591	0.563	0.617	0.631
	(0.013)	(0.008)	(0.073)	(0.013)
Consumed below 75 percent of recommendations	0.755	0.727	0.772	0.769
	(0.011)	(0.007)	(0.060)	(0.010)
Consumed below 100 percent of recommendations	0.855	0.832	0.863	0.853
	(0.009)	(0.006)	(0.042)	(0.007)
Fully satisfied recommendations	0.145	0.168	0.137	0.147
	(0.009)	(0.006)	(0.042)	(0.007)

Adults = individuals aged 20 years and older.

Note: The share of U.S. adults who regularly consumed below 25 percent, and 50, 75, and 100 percent of total fruit recommendations in the *Dietary Guidelines for Americans*, is estimated. The analysis was limited to adults who provided a complete dietary recall for at least Day 1. For each of these individuals, calculations were based on the amount of fruit they reported consuming over all days for which they provided reliable intake data (i.e., either Day 1 alone or both Day 1 and Day 2). Those consumption amounts were then divided by the recommendation for a moderately active individual of the same age and sex as well as reference height and weight. Finally, using the National Cancer Institute's recommended methodology, including software programs, the distribution of fruit intake relative to recommendations was simulated. Standard errors are reported in parentheses. Data for 2020 are only available through March. Sample sizes are 9,939 (2005–08), 10,563 (2009–12), 10,064 (2013–16), and 7,706 (2017–20).

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey, What We Eat In America data, 2005–March 2020.

Figure 4
Adherence with total fruit recommendations among U.S. adults, 2005–March 2020



Adults = individuals aged 20 years and older.

Note: The share of U.S. adults who regularly consumed below 25 percent, and 50, 75, and 100 percent of total fruit recommendations in the *Dietary Guidelines for Americans* (table 2), is estimated. The analysis was limited to adults who provided a complete dietary recall for at least Day 1. For each of these individuals, calculations were based on the amount of fruit they reported consuming over all days for which they provided reliable intake data (i.e., either Day 1 alone or both Day 1 and Day 2). Those consumption amounts were then divided by the recommendation for a moderately active individual of the same age and sex as well as reference height and weight. Finally, using the National Cancer Institute's recommended methodology, including software programs, the distribution of fruit intake relative to recommendations was simulated. Data for 2020 are only available through March. Sample sizes are 9,939 (2005–08), 10,563 (2009–12), 10,064 (2013–16), and 7,706 (2017–20).

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey, What We Eat In America data, 2005–March 2020.

Distributions generated using NCI's method reveal significant variation in total fruit consumption (tables 1 and 2, figures 3 and 4). During 2017–20, about 23.2 percent of U.S. children and 14.7 percent of adults fully satisfied total fruit recommendations in the *Dietary Guidelines for Americans, 2020–25*.[16] The percentages that satisfied less than 75 percent of recommendations were 66.3 percent of children and 76.9 percent of adults. Satisfying less than 50 percent of recommendations were 50.8 percent of children and 63.1 percent of adults. And finally, 28.8 percent of children and 40.3 percent of adults satisfied less than 25 percent of recommendations.

The distribution of total fruit consumption is also changing in shape over time (tables 1 and 2, figures 3 and 4). On one end of the spectrum, a relatively stable share of the population continues to meet total fruit recommendations in the *Dietary Guidelines for Americans*. About 23 percent of all U.S. children and 15 percent of adults satisfied the recommendations from 2005–08 through 2017–20, with small fluctuations from year to year.[17] On the other end of the spectrum, a larger and growing group of individuals is

[16] The authors' results on the population shares that eat enough fruit are consistent with previously published estimates. According to the 2020 Dietary Guidelines Advisory Committee and Data Analysis Team (2020), for example, about 12 percent of adult men and 18 percent of adult women fully satisfy the recommendations in the guidelines. However, the authors are unaware of previously published estimates of the population shares that consume below 75 percent, below 50 percent, and below 25 percent of the same recommendations.

[17] The population shares shown in tables 1 and 2 to fully satisfy total fruit recommendations are not statistically significantly different from 2005–08 and 2017–20 for either children or adults.

consuming below a quarter of the recommendations on a regular basis. The share of U.S. children and adults who are in this group increased by 4.8 and 6.9 percentage points, respectively, over the period the data covered.[18]

Daily Average Intakes of Those Who Consume the Most and Least Amounts of Fruit

For the second part of the descriptive analysis, the authors reviewed the reported 2-day average fruit intakes of NHANES participants for a better understanding of the types and amounts of fruit consumed by individuals with relatively low and high intakes. The analytical sample was restricted to children and adults with reliable dietary records for both Day 1 and Day 2.[19] Tables 3 and 4 show measures of the daily average consumption among individuals who reported consuming below 25 percent of the total fruit recommendations, between 25 and 50 percent, between 50 and 75 percent, between 75 and 100 percent, and 100 percent or more of the recommendations for a moderately active person of the same age and sex as well as reference height and weight.

Table 3a
Total fruit consumption by U.S. children categorized by level of adherence with total fruit recommendations; daily average quantities measured in cup equivalents, 2005–March 2020

U.S. children who:	2005–08	2009–12	2013–16	2017–20
Consumed below 25 percent of recommendations	0.138	0.138	0.137	0.114
	(0.007)	(0.009)	(0.006)	(0.008)
Consumed 25 to 50 percent of recommendations	0.644	0.655	0.652	0.659
	(0.011)	(0.009)	(0.008)	(0.011)
Consumed 50 to 75 percent of recommendations	1.050	1.048	1.036	1.038
	(0.009)	(0.011)	(0.012)	(0.012)
Consumed 75 to 100 percent of recommendations	1.440	1.478	1.430	1.427
	(0.017)	(0.018)	(0.021)	(0.031)
Fully satisfied recommendations	2.445	2.499	2.428	2.541
	(0.031)	(0.050)	(0.037)	(0.066)

Children = individuals aged 2 through 19.

Note: All individuals were categorized by how much total fruit they consumed over 48 hours relative to recommendations in the *Dietary Guidelines for Americans* for a moderately active person of the same age and sex as well as reference height and weight. Daily average of total fruit consumption was measured in cup equivalents. All estimates have been weighted and the standard errors of those estimates corrected for clustering. The analysis was limited to children whose families provided complete dietary recalls for both Day 1 and Day 2. Standard errors are in parentheses. Data for 2020 are only available through March. Sample sizes are 6,200 (2005–08), 5,553 (2009–12), 4,906 (2013–16), and 3,460 (2017–20).

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey, What We Eat In America data, 2005–March 2020.

[18] The population shares shown in tables 1 and 2 to consume less than 25 percent of total fruit recommendations are statistically significantly different between 2005–08 and 2017–20 for both children and adults. Statistical significance was confirmed by a T-test performed at the 5-percent confidence level.

[19] The authors could have conducted this part of the analysis using only Day 1 fruit consumption records. This approach would have allowed the authors to retain survey participants who completed only Day 1 in the analytical sample. However, it would have also prevented the authors from utilizing information provided by other participants about their food choices on Day 2. Because individuals vary widely in their daily food choices, the authors believed that their 2-day average intakes were more informative than the behavior of survey participants on any given day.

Table 3b

Whole and cut fruit consumption by U.S. children categorized by level of adherence with total fruit recommendations; daily average quantities measured in cup equivalents, 2005–March 2020

U.S. children who:	2005–08	2009–12	2013–16	2017–20
Consumed below 25 percent of recommendations	0.075	0.076	0.084	0.073
	(0.004)	(0.008)	(0.004)	(0.007)
Consumed 25 to 50 percent of recommendations	0.382	0.382	0.414	0.432
	(0.013)	(0.018)	(0.015)	(0.019)
Consumed 50 to 75 percent of recommendations	0.616	0.636	0.676	0.735
	(0.023)	(0.021)	(0.027)	(0.022)
Consumed 75 to 100 percent of recommendations	0.806	0.919	0.907	0.920
	(0.029)	(0.036)	(0.033)	(0.039)
Fully satisfied recommendations	1.388	1.582	1.546	1.837
	(0.044)	(0.061)	(0.051)	(0.071)

Children = individuals aged 2 through 19.

Note: All individuals were categorized by how much total fruit they consumed over 48 hours relative to recommendations in the *Dietary Guidelines for Americans* for a moderately active person of the same age and sex as well as reference height and weight. Daily average of total fruit consumption was measured in cup equivalents. All estimates have been weighted and the standard errors of those estimates corrected for clustering. The analysis was limited to children whose families provided complete dietary recalls for both Day 1 and Day 2. Standard errors are in parentheses. Data for 2020 are only available through March. Sample sizes are 6,200 (2005–08), 5,553 (2009–12), 4,906 (2013–16), and 3,460 (2017–20).

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey, What We Eat In America data, 2005–March 2020.

Table 3c

Fruit juice drinking by U.S. children categorized by level of adherence with total fruit recommendations, daily average quantities measured in cup equivalents, 2005–March 2020

U.S. children who:	2005–08	2009–12	2013–16	2017–20
Consumed below 25 percent of recommendations	0.063	0.062	0.053	0.042
	(0.005)	(0.004)	(0.005)	(0.004)
Consumed 25 to 50 percent of recommendations	0.262	0.273	0.237	0.226
	(0.009)	(0.017)	(0.018)	(0.017)
Consumed 50 to 75 percent of recommendations	0.434	0.412	0.360	0.303
	(0.023)	(0.020)	(0.023)	(0.025)
Consumed 75 to 100 percent of recommendations	0.634	0.559	0.523	0.507
	(0.033)	(0.029)	(0.026)	(0.058)
Fully satisfied recommendations	1.057	0.917	0.882	0.704
	(0.059)	(0.042)	(0.052)	(0.045)

Children = individuals aged 2 through 19.

Note: All individuals were categorized by how much total fruit they consumed over 48 hours relative to recommendations in the *Dietary Guidelines for Americans* for a moderately active person of the same age and sex as well as reference height and weight. Daily average of total fruit consumption was measured in cup equivalents. All estimates have been weighted and the standard errors of those estimates corrected for clustering. The analysis was limited to children whose families provided complete dietary recalls for both Day 1 and Day 2. Standard errors are in parentheses. Data for 2020 are only available through March. Sample sizes are 6,200 (2005–08), 5,553 (2009–12), 4,906 (2013–16), and 3,460 (2017–20).

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey, What We Eat In America data, 2005–March 2020.

Table 4a

Total fruit consumption by U.S. adults categorized by level of adherence with total fruit recommendations; daily average quantities measured in cup equivalents, 2005–March 2020

Share of U.S. adults who:	2005–08	2009–12	2013–16	2017–20
Consumed below 25 percent of recommendations	0.130	0.136	0.120	0.113
	(0.004)	(0.003)	(0.005)	(0.005)
Consumed 25 to 50 percent of recommendations	0.708	0.710	0.691	0.689
	(0.006)	(0.007)	(0.004)	(0.007)
Consumed 50 to 75 percent of recommendations	1.159	1.157	1.137	1.133
	(0.010)	(0.008)	(0.011)	(0.010)
Consumed 75 to 100 percent of recommendations	1.612	1.610	1.606	1.595
	(0.011)	(0.014)	(0.011)	(0.014)
Fully satisfied recommendations	2.784	2.899	2.908	2.885
	(0.046)	(0.045)	(0.039)	(0.047)

Adults = individuals aged 20 years and older.

Note: All individuals were categorized by how much total fruit they consumed over 48 hours relative to recommendations in the *Dietary Guidelines for Americans* for a moderately active person of the same age and sex as well as reference height and weight. Daily average of total fruit consumption was measured in cup equivalents. All estimates have been weighted and the standard errors of those estimates corrected for clustering. The analysis was limited to adults who provided complete dietary recalls for both Day 1 and Day 2. Standard errors are in parentheses. Data for 2020 are only available through March. Sample sizes are 8,745 (2005–08), 9,346 (2009–12), 8,682 (2013–16), and 6,639 (2017–20).

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey, What We Eat In America data, 2005–March 2020.

Table 4b

Whole and cut fruit eating by U.S. adults categorized by level of adherence with total fruit recommendations; daily average quantities measured in cup equivalents, 2005–March 2020

U.S. adults who:	2005–08	2009–12	2013–16	2017–20
Consumed below 25 percent of recommendations	0.093	0.095	0.093	0.086
	(0.003)	(0.003)	(0.004)	(0.006)
Consumed 25 to 50 percent of recommendations	0.482	0.463	0.506	0.508
	(0.012)	(0.015)	(0.009)	(0.016)
Consumed 50 to 75 percent of recommendations	0.752	0.834	0.819	0.884
	(0.018)	(0.022)	(0.015)	(0.019)
Consumed 75 to 100 percent of recommendations	1.067	1.144	1.181	1.214
	(0.031)	(0.026)	(0.033)	(0.033)
Fully satisfied recommendations	1.867	2.095	2.242	2.253
	(0.045)	(0.049)	(0.048)	(0.055)

Adults = individuals aged 20 years and older.

Note: All individuals were categorized by how much total fruit they consumed over 48 hours relative to recommendations in the *Dietary Guidelines for Americans* for a moderately active person of the same age and sex as well as reference height and weight. Daily average of total fruit consumption was measured in cup equivalents. All estimates have been weighted and the standard errors of those estimates corrected for clustering. The analysis was limited to adults who provided complete dietary recalls for both Day 1 and Day 2. Standard errors are in parentheses. Data for 2020 are only available through March. Sample sizes are 8,745 (2005–08), 9,346 (2009–12), 8,682 (2013–16), and 6,639 (2017–20).

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey, What We Eat In America data, 2005–March 2020.

Table 4c

Fruit juice drinking by U.S. adults categorized by level of adherence with total fruit recommendations; daily average quantities measured in cup equivalents, 2005–March 2020

Share of U.S. adults who:	2005–08	2009–12	2013–16	2017–20
Consumed below 25 percent of recommendations	0.036	0.041	0.027	0.028
	(0.003)	(0.002)	(0.002)	(0.002)
Consumed 25 to 50 percent of recommendations	0.227	0.247	0.185	0.182
	(0.010)	(0.014)	(0.009)	(0.016)
Consumed 50 to 75 percent of recommendations	0.407	0.323	0.318	0.249
	(0.020)	(0.021)	(0.017)	(0.018)
Consumed 75 to 100 percent of recommendations	0.545	0.466	0.425	0.382
	(0.029)	(0.027)	(0.031)	(0.032)
Fully satisfied recommendations	0.917	0.803	0.666	0.632
	(0.033)	(0.038)	(0.037)	(0.037)

Adults = individuals aged 20 years and older.

Note: All individuals were categorized by how much total fruit they consumed over 48 hours relative to recommendations in the *Dietary Guidelines for Americans* for a moderately active person of the same age and sex as well as reference height and weight. Daily average of total fruit consumption was measured in cup equivalents. All estimates have been weighted and the standard errors of those estimates corrected for clustering. The analysis was limited to adults who provided complete dietary recalls for both Day 1 and Day 2. Standard errors are in parentheses. Data for 2020 are only available through March. Sample sizes are 8,745 (2005–08), 9,346 (2009–12), 8,682 (2013–16), and 6,639 (2017–20).

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey, What We Eat In America data, 2005–March 2020.

Many individuals who participated in the NHANES reported little or no fruit consumption over both Day 1 and Day 2. In 2017–20, total fruit consumption averaged 0.114 cup equivalents per day among children whose households reported them consuming below 25 percent of total fruit recommendations (table 3a). Similarly, total fruit consumption averaged 0.113 cup equivalents per day among adults who ate and drank below 25 percent of the recommendations (table 4a). These reported quantities are consistent with consuming a small amount of fruit, possibly as an ingredient in another type of food, such as a blueberry muffin[20] or cinnamon raisin bagel.[21]

Habitually consuming less than a quarter of total fruit recommendations in the *Dietary Guidelines for Americans, 2020–25* (tables 1 and 2, figures 3 and 4) is consistent with consuming little or no fruit over 2 randomly selected days (tables 3 and 4). If an individual meets the recommendations by consuming 2 cup equivalents of fruit per day but regularly consumes less than 25 percent of this amount, then the person's habitual level of consumption is below 0.5 cup equivalent. This would equate to eating a small apple or similar portion of another type of fruit less often than once every other day (USDA, Food and Nutrition Service (FNS), 2024b), even if the person consumes no other foods that contain fruit as a recipe ingredient.

It is not a new development that many people eat little or no fruit on a majority or more of days. Analysis of NHANES data from the mid-2000s revealed somewhat similar consumption patterns, although average consumption among individuals who satisfied below 25 percent of recommendations was lower in 2017–20 than it was in 2005–08 (tables 3a and 4a). This was driven by reductions in fruit juice drinking (tables 3a–3c and 4a–4c).[22]

[20] One blueberry muffin prepared with 2 percent milk from a recipe contains about 0.04 cup equivalents of fruit (USDA, ARS, 2024a,b).

[21] One medium cinnamon raisin bagel contains about 0.14 cup equivalents of fruit (USDA, ARS, 2024a,b).

[22] Statistical significance of these differences was confirmed by a T-test performed at the 5-percent level.

Among NHANES participants who reported consuming enough fruit over 2 days to satisfy the recommendation, consumption patterns are notably different. Looking at these individuals' 2-day average intakes in 2017–20, the authors found that children in this group averaged 2.541 cup equivalents per day while adults in this group averaged 2.885 cup equivalents per day. These reported quantities are consistent with consuming 1 cup equivalent of fruit, such as a small apple, a large orange, or 8 fluid ounces of 100 percent juice, on two or more occasions per day (USDA, Food and Nutrition Service (FNS), 2024b).

The reported average total fruit consumption among individuals who fully satisfied the recommendations was also similar in 2017–20 and 2005–08 for children and adults (tables 3a and 4a).[23] Individuals in the high consumption group offset decreases in juice drinking by eating more whole and cut fruit (tables 3a–3c, and 4a–4c).[24]

Factors Potentially Driving U.S. Fruit Consumption Patterns

Economic theory and published research provide a framework for analyzing consumer behavior including the identification of factors potentially responsible for individuals' fruit choices. Household production theory, in particular, extends traditional models of consumer behavior to incorporate an individual's health status (Huffman, 2011; Huston & Finke, 2003; Variyam & Golan, 2002). In Huffman's (2011) model, for example, food demand is driven by income, prices, health knowledge, concern for health, and the amount of pleasure or well-being someone receives by consuming foods and beverages. Any of these factors could motivate some people to eat enough fruit to meet recommendations and other people to eat little or no fruit.

Health Knowledge, Concern for Health, and Tastes

Consumers desire products that make them happy. Eating and drinking, much like exercising and smoking, can provide immediate gratification. Such activities can also affect future well-being through their impact on health. An individual's demand for foods and beverages depends on one's taste for a product (impact on current well-being) and one's perceptions about how consuming the product will affect their health (impact on future well-being). For a food group such as fruit, whose nutritional benefits are highlighted in the *Dietary Guidelines for Americans,* demand is expected to be greater among individuals who are more concerned about health and better understand which foods constitute a healthy diet. Such consumers may make a greater effort than others to incorporate fruit into their diets. However, consumers may still deviate from the recommendations. Fruit consumption may be greatest among individuals who also enjoy the flavor of fruits. Consumers have reported that taste is the primary determinant of their food choices (Mancino & Guthrie, 2014). Researchers have also identified an association between fruit consumption and one's underlying taste for sweet and sour foods (Sijtsema et al., 2012).

Differences in fruit consumption between individuals were expected by the authors to be associated with proxies for the level of nutrition knowledge and health-related behaviors. These include formal education, exercising, smoking, taking nutrient supplements, and awareness of USDA food guidance systems, including the Food Guide Pyramid, MyPyramid, and MyPlate. Jahns et al. (2018) identified a positive association between diet quality and awareness of USDA food guidance systems. Formal education is also believed to play a key role in food choices. Better educated individuals may better understand what constitutes a healthy diet and have a deeper knowledge of how nutrition affects health (Variyam & Golan, 2002). Obtaining

[23] The observed differences in total fruit consumption were found to be statistically insignificant for both age groups at the 5-percent level based on a T-test.

[24] Statistical significance of the observed differences in juice consumption was confirmed by a T-test performed at the 5-percent level.

a higher level of formal education may also signal a willingness to invest in future well-being and possibly sacrifice immediate gratification (Huston & Finke, 2003). Empirical studies that found a positive association between fruit intake and formal education include Desbouys et al. (2019) and Drewnowski and Rheem (2015). Individuals with more years of education, along with other members of their families, consume more fruit.

Empirical research also suggests that age, sex, ethnicity, and race are associated with an individual's fruit consumption choices. Hoy et al. (2017) found no difference between men and women in average total fruit consumption. However, after adjusting individuals' total fruit intake for daily calorie intake, because men consume more food overall and on average have higher calorie needs, the researchers found that women eat more fruit-rich diets. Other research found a relationship between fruit consumption and age (USDA, ERS, 2024b; Hoy et al., 2017; Drewnowski & Rheem, 2015) as well as fruit consumption related to race and ethnicity (Hoy et al., 2017; Drewnowski & Rheem, 2015; Tichenor & Conrad, 2015). These demographic characteristics of individuals may be associated with a combination of one's taste for fruit as well as one's attitudes toward health and nutrition.

Lower Income Households and Fruit Affordability

Nutrition assistance programs help households obtain nutritious diets, including USDA's Supplemental Nutrition Assistance Program (SNAP) and USDA's Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). As the largest U.S. nutrition assistance program, SNAP increases the food purchasing power of lower income households (USDA, Food and Nutrition Service (FNS), 2024c). WIC provides lower income individuals at nutritional risk with supplemental foods, along with nutrition counseling and other benefits. WIC serves pregnant, breastfeeding, and postpartum women as well as infants and children up to age 5 (USDA, Food and Nutrition Service (FNS), 2024d). In 2007, WIC introduced a cash-value benefit (CVB) that women and children can use to purchase fruits and vegetables. Studies show that receipt of this benefit is associated with improved fruit and vegetable consumption (Anderson et al., 2023; Zhang et al., 2020). WIC participants may also receive additional benefits to redeem at farmers' markets through the WIC Farmers' Market Nutrition Program (FMNP) (USDA, Food and Nutrition Service (FNS), 2024a). Nonprofit organizations, such as the Fair Food Network (FFN), also help SNAP households. For example, FFN's Double Up Food Bucks (DUFB) program helps households make the most of their SNAP benefits. SNAP shoppers receive a dollar-for-dollar match at participating retailers on their purchases of fresh fruits and vegetables up to a specified cap (FFN, 2024). As of 2023, more than 1,700 Double Up locations operated across 30 States. Studies show that SNAP households receiving these additional benefits consume more fruits and vegetables (Atoloye et al., 2021; Durward et al., 2019).

Lower income households may forgo purchasing fruits despite the wealth of programs that seek to help them acquire a healthy and nutritious diet. Consumers generally purchase meats first whenever money is tight (Askelson et al., 2018; Wiig & Smith, 2009). Grains, such as pasta and rice, may also be prioritized because households believe these foods "stretch out" other foods (e.g., preparing meat with rice or pasta ensures that the meat can produce more servings) (Askelson et al., 2018). Fruits are not generally a priority, and little money may be left over to buy them (Askelson et al., 2018). In a study of lower income households with children, a parent explained, "If we don't have the money…then a lot of the fresh fruit is cut out…." (Askelson et al., 2018).

Lower income households in parts of the United States where retail food prices exceed national average prices may struggle even more than other households (Young & Stewart, 2022; Christensen & Bronchetti, 2020). SNAP benefit amounts are not adjusted within the continental United States for variations in food prices where different households live and shop.[25]

[25] Alaska and Hawaii are exceptions.

Overall, despite receiving benefits, about 43 percent of SNAP households have reported that fresh fruits remain difficult to afford (Gearing et al., 2021).[26] These and other lower income households also consume less fruit than higher income households (USDA, ERS, 2024b; Drewnowski & Rheem, 2015; Grimm et al., 2012; Dong & Lin, 2009). In 2017–18, individuals in households with incomes below 185 percent of the poverty line consumed about 10 percent less fruit than those in households with incomes above 300 percent of poverty (USDA, ERS, 2024b).

Based on economic theory and existing empirical research, the authors expected fruit consumption to vary with an individual's household income relative to the poverty threshold. Changes in U.S. income levels during the 2000s and 2010s may have also contributed to variation in fruit consumption over those years. The Great Recession, which officially lasted from December 2007 to June 2009, was the most severe U.S. economic recession since the 1930s. Labor markets did not fully recover for 9 years (Shambaugh & Strain, 2021).

Fruit Product Prices

Consumers adjust their food purchases with changes in retail product prices. Fruit purchases are no exception, although research shows that U.S. consumer demand for fruit is inelastic, meaning that consumers adjust their purchases when prices change, but the size of the response is less than proportional (Powell et al., 2013; Andreyeva et al., 2010; Dong & Lin, 2009). Powell et al. (2013) estimated that holding constant other food prices, a 10-percent increase in retail fruit prices would decrease U.S. fruit consumption by about 4.9 percent. Any decrease in retail fruit prices would have the opposite effect. A 10-percent decrease in retail fruit prices would raise fruit consumption about 4.9 percent. For example, if an individual should consume 2 cup equivalents of fruit per day but consumes only 1 cup, then this person is satisfying 50 percent of the recommendations. A 10-percent decrease in retail fruit prices would bring the consumer closer to guidelines. The individual's total intake would increase to 1.049 cup equivalents, which is 52.5 percent of the recommendations.

Price elasticities of demand (measures of the sensitivity of demand to price changes) tend to be low for fruit for all U.S. households, but lower income households are particularly insensitive to fruit prices (Durward et al., 2019; Dong & Lin, 2009).[27] For example, when Utah's Double Up Food Bucks (DUFB) program matched each dollar that a SNAP household spent on fruits and vegetables at farmers' markets with a $1 token good for the purchase of more fruits and vegetables (effectively halving a household's costs to buy fruits and vegetables at those markets) median fruit and vegetable consumption increased from 2.82 times per day to 3.29 times per day. This increase represented a change in consumption that may be nutritionally significant but is proportionally much smaller than the price decrease (Durward et al., 2019).

Low fruit price inflation during the 2000s and 2010s may have lifted U.S. fruit consumption somewhat above what it would have been otherwise. The Bureau of Labor Statistics (BLS) publishes the Consumer Price Index (CPI) to track U.S. consumer prices. Between January 2005 and December 2020, the CPI for all items (a broad measure of retail price inflation for all consumer goods and services) increased by 37 percent. By comparison, the CPI for fresh fruit increased 21 percent, the CPI for frozen fruit and vegetables rose 25 percent, the CPI for juices and nonalcoholic drinks rose 30 percent, and the CPI for canned fruit rose 42 percent. Retail prices for many fruit products, especially prices for fresh fruits, stayed the same or fell on an inflation-adjusted basis.

[26] The data for this survey were collected before USDA raised SNAP benefit levels in 2021 by 21 percent (USDA, Food and Nutrition Service, 2021).

[27] A reduction in retail fruit prices alone may not solve all obstacles these households can face in purchasing a healthy diet rich in foods such as fruit.

Research Hypotheses and the Statistical Model

Several factors may explain why some U.S. children and adults continue to satisfy total fruit recommendations in the *Dietary Guidelines for Americans* while others consume little or no fruit. Based on a descriptive analysis of NHANES data, a review of household production theory, and a review of existing research, the authors hypothesize that:

(1) Individuals who care more about health and better understand what foods constitute a healthy diet may consume fruit more regularly. They may be less likely than others to report consuming little or no fruit on 2 randomly selected days. However, such people may not fully satisfy total fruit recommendations. Tastes also decide an individual's fruit consumption.

(2) Income variation and low fruit price inflation during the 2000s and 2010s may have also affected how far consumers deviated from recommendations over these years.

Using NHANES data on adults with reliable information for Day 1 and Day 2 between January 2005 and March 2020,[28] the above two hypotheses were tested by estimating a statistical model. The probability that an adult satisfied total fruit recommendations in the *Dietary Guidelines for Americans* over 2 randomly selected days was modeled along with the probability that the person consumed less than 25 percent of the recommendations. Household production theory and existing empirical research guided the selection of explanatory variables. In addition to income, prices, age, sex, race, and ethnicity, the authors included explanatory variables to proxy for each person's concern for health and knowledge of health and nutrition. The analysis focused on adults because the NHANES does not collect enough information on participants and their families to define the necessary explanatory variables for children.[29]

The Statistical Model

A probit model was estimated in this study.[30] Researchers may use this type of statistical model when a phenomenon of interest has two possible outcomes (e.g., someone did or did not consume a specific amount of fruit over 2 days). Formally,

$$\text{Probability}\ (Y_i=1 \mid X_i) = \Phi(\beta X_i)$$

where $\Phi(\cdot)$ denotes the standard normal cumulative distribution function, i denotes a particular individual in the dataset, Y_i is the dependent variable, X_i is a set of explanatory variables, and β is a corresponding vector of parameters. The dependent variable is binary. Y_i equals 1 if a statement is true for individual i and zero if the statement is false. The unconditional, population-average value of Y is the probability of truth for a randomly selected person or, equivalently, the share of all individuals for whom the statement is true. Modeling Y as a function of explanatory variables, X, reveals whether those shares vary across different segments of the population (e.g., Is consumption greater among individuals who exercise or who are aware of MyPlate than it is among individuals who do not exhibit these characteristics?). The strength of any association between Y and a

[28] This part of the authors' analysis included only participants who provided reliable dietary intake for Day 1 and Day 2. The authors also excluded (from model estimation) NHANES participants who did not answer all survey questions used to define each model's explanatory variables.

[29] The authors could develop a set of explanatory variables to proxy for an adult's concern for health and nutrition knowledge. However, for children, research suggests that parental concern for health and nutrition knowledge may be the relevant demand determinant (e.g., Desbouys et al., 2019). The NHANES does not identify and may not have surveyed the parents of children.

[30] Alternatives to the probit model include the linear probability and logit models. The authors confirmed that a linear probability model yields similar results.

particular explanatory variable, say X_1, is measured by that explanatory variable's marginal effect.[31] Marginal effects predict how a unit change in an explanatory variable would change the modeled probability, and can be calculated given estimates of the model's parameters (e.g., Wooldridge, 2010, pages 566–567).

Consumer adherence to dietary recommendations for total fruit consumption, as stated in the *Dietary Guidelines for Americans*, is the focus of this report. The dependent variable in the model, Y_i equals 1 or zero, according to how much fruit individual i ate and drank relative to the recommendations. The recommendation for a 45-year-old, moderately active female of reference height and weight is 2 cup equivalents per day. Thus, if a 45-year-old female respondent ate that much fruit (4 cup equivalents in total over Day 1 and Day 2), then the dependent variable would equal zero for her when modeling whether individuals consumed below 25 percent of the recommended amount. That statement is false. She ate and drank more than that amount of fruit. The dependent variable would equal 1 for this person when modeling whether individuals fully satisfied the recommendations. The statement is true for her.

In addition to completing a 2-day food diary, NHANES participants also reported their income, demographic characteristics, and health-related behaviors during a series of interviews. These data defined many of the explanatory variables, X_i, including INCOME, FEMALE, BLACK, WHITE, AGE, COLLEGE, SUPPLEMENTS, EXERCISES, GUIDANCE, and NOSMOKING. [32] For example, the model included an individual's family income relative to the poverty threshold for a household of the same size at the time this person participated in the NHANES. Dividing family income by the appropriate poverty threshold adjusts for both inflation and for the fact that larger households need more income to attain the same standard of living as smaller households. Definitions and means for INCOME and the other explanatory variables are provided in table 5.

To account for fruit product prices, the authors used the CPI. Economists commonly use the CPI or other price index in lieu of actual product prices when estimating food demand models with data that span many years (e.g., Okrent & Alston, 2012; Okrent & Alston, 2011). In this study, FRUITPRICE equaled the CPI for fresh fruit adjusted for inflation based on the CPI for all items (table 5).[33] [34] The authors merged this variable with the NHANES data using information on when individuals participated in the survey.[35] The value of FRUITPRICE varied over time. It took on a different value during each of the 183 months under

[31] Marginal effects reported in this study are not causal effects. The authors did not purport to test, for example, whether encouraging individuals to attend college or encouraging smokers to stop would improve fruit consumption. Most explanatory variables in the models instead proxy for some underlying traits of a person, such as one's concern for health, knowledge of health and nutrition, and taste for fruit. The estimated effects are best interpreted as measures of the strength of the association between fruit consumption and those traits.

[32] The NHANES includes a variable to identify each survey participant's race and ethnicity (named RIDRETH3). Distinct and mutually exclusive values of the variable indicate whether a person is "Mexican American," "Other Hispanic," "Non-Hispanic White," "Non-Hispanic Black," or "Other Race—Including Multi-Racial." Beginning with the 2011–2012 NHANES, NCHS has expanded the set of variable values to further distinguish "Non-Hispanic Asian" survey participants. In prior surveys, such individuals were included among "Other Race—Including Multi-Racial" persons. Given the need to define the study's explanatory variables in a consistent manner across all years under study, the authors included in the study's statistical model two separate explanatory variables for race and ethnicity: BLACK indicates whether an individual identifies as non-Hispanic Black and WHITE indicates whether an individual identifies as non-Hispanic White. These two variables serve to contrast the behavior of individuals in their respective groups with that of individuals who identify as "Mexican American," "Other Hispanic," "Non-Hispanic Asian," or "Other Race—Including Multi-Racial."

[33] The BLS does not publish a CPI for all fruit. The authors focused on the CPI for fresh fruit because fresh products represent almost two-thirds of total U.S. fruit consumption (see footnote 4). Also, the CPI for fresh fruit increased less between 2005 and 2020 than did the CPI for canned fruit, the CPI for frozen fruit and vegetables, the CPI for juices and nonalcoholic drinks, and the CPI for all items. The authors, therefore, believed that movements in the CPI for fresh fruit were most likely among movements in all CPI that contain fruit products to be associated with changes in total fruit consumption over those years.

[34] The authors normalized both CPI series to have the same base period (January 2005). They then divided the normalized fresh fruit series by the normalized all items series. Finally, they multiplied the ratio of the two series by 100.

[35] Public-use NHANES data do not report the month and year when individuals completed the survey. This information is confidential. It can only be accessed through a secure NCHS Research Data Center or a Federal Statistical Research Data Center managed by the U.S. Department of Commerce, Bureau of the Census. Researchers seeking access to restricted-use NHANES data must apply to NCHS.

study from January 2005 through March 2020. The value of FRUITPRICE assumed the same value among consumers who participated in the NHANES during the same month of the same year.

Finally, a time trend variable was included in the model to account for changes over time in the dependent variable not captured by the other explanatory variables.[36] TREND equals 1 for individuals who participated in the NHANES during 2005–06, 2 for individuals who participated in 2007–08, 3 for individuals who participated in 2009–10, and so on. The maximum value of TREND was 8 for individuals who participated in 2019–20.

Table 5
Definitions, units, and means of the statistical model's explanatory variables

Variable	Definition	Unit	Children	Adults
INCOME	Ratio of family income to poverty	No.	2.48	3.02
AGE	Age	No.	10.59	47.49
FEMALE	Female	0/1	0.50	0.52
BLACK	Non-Hispanic Black	0/1	0.14	0.11
WHITE	Non-Hispanic White	0/1	0.55	0.67
COLLEGE	Graduated college	0/1	NA	0.30
SUPPLEMENTS	Taking nutrient supplements	0/1	NA	0.60
GUIDANCE	Aware of USDA food guidance	0/1	NA	0.43
NOSMOKING	Does not smoke	0/1	NA	0.81
EXERCISES	Does vigorous aerobic exercise	0/1	NA	0.28
FRUITPRICE	Inflation-adjusted CPI for fresh fruit	No.	114.1	114.1

Children = individuals aged 2 through 19; adults = individuals aged 20 years and older; No. = continuous number; 0/1 = binary variable that indicates whether an individual exhibits the characteristic in question; NA = not available.

Note: Data for most variables are from the National Health and Nutrition Examination Survey (NHANES), 2005–06, 2007–08, 2009–10, 2011–2012, 2013–14, 2015–16, and 2017–March 2020 survey cycles. The reported means are average values calculated across all survey participants within each age group. Values for children cannot be calculated for some variables. NHANES participants report their income, demographic characteristics, and health-related behaviors during a series of interviews. However, the NHANES collects less information on participants aged 2 through 19 years than it collects on adults. The sample includes 20,119 children and 30,579 adults who provided complete dietary information for Day 1 and Day 2 as well as complete income and demographic information. FRUITPRICE is calculated differently and is defined using the Consumer Price Index (CPI). The CPI for fresh fruit and the CPI for all items were both normalized to have same base period (January 2005). The normalized fresh fruit series was then divided by the normalized all items series. Finally, the ratio of the 2 series was multiplied by 100. The reported value is the average value calculated across months. Equal weight was given to each monthly value.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey, What We Eat In America data, 2005–March 2020.

Findings From Model Estimation

All models were estimated using Stata software with a correction for survey design. NHANES data are collected using a complex, multistage, probability cluster design that oversamples minority and lower income households. Following recommendations for working with such data (e.g., Solon et al., 2015), the authors estimated the statistical model without using sample weights. However, unweighted regression estimates were later compared with those from weighted regressions as a robustness test. In both cases, corrections were made to the standard errors of the reported parameters and marginal effects for clustering.

Marginal effects based on unweighted probit models are reported in table 6a and 6b. According to the data, about 17.6 percent of adults reported fully satisfying total fruit recommendations over Day 1 and Day 2 (last

[36] Time-varying factors not captured by the model's explanatory variables include, for example, the evolving mix of products available at retail stores that could potentially compete with 100 percent fruit juice and other fruit products.

row of table 6a). Another 41.4 percent satisfied less than 25 percent of the recommendations (last row of table 6b). These are the unconditional, population-average values of Y and can be interpreted as the probability that a randomly selected adult was in the high and low consumption groups, respectively. Each explanatory variable's marginal effect predicts how a unit change in the variable would affect the two probabilities. Other model estimation results including parameter estimates and tests of model significance are provided in appendix A.

Estimation of the statistical model confirms the authors' expectations based on household production theory and empirical research: Among adults, conformance with total fruit recommendations in the *Dietary Guidelines for Americans* is positively associated with concern for health and nutrition knowledge. A college graduate who does not smoke, exercises, takes nutrient supplements, and is aware of USDA food guidance systems, such as MyPlate, is about 42 percentage points less likely to consume below 25 percent of recommendations and 24 percentage points more likely to fully satisfy recommendations over any randomly selected 2 days as compared with an otherwise similar individual who exhibits none of these characteristics.[37]

Results also confirm that age, sex, ethnicity, and race are important consumption determinants. These characteristics of individuals may be associated with one's taste for fruit as well as one's attitudes toward health and nutrition. An adult female is 6.1 percentage points less likely to fall into the low consumption group that satisfies less than 25 percent of total fruit recommendations than an otherwise similar adult male. Non-Hispanic White and non-Hispanic Black adults are 11.3 and 7.4 percentage points, respectively, more likely to be in the low consumption group than are otherwise similar individuals who do not identify with either of these two groups.[38]

Fruit consumption also depends on household income. Doubling a household's earnings from 100 to 200 percent of poverty (from the poverty threshold to twice the poverty threshold) increases the likelihood that adult members satisfy at least 25 percent of recommendations by 0.6 percentage points.[39] While this result underscores the role financial constraints can play in purchasing fruit, it is also smaller than the other characteristics of individuals.

Research results are inconclusive regarding fruit prices. Not enough evidence is available to conclude that low fruit price inflation over the 2000s and 2010s, as measured by the CPI, significantly helped consumption levels. The estimated marginal effect of FRUITPRICE is negative in table 6a and positive in table 6b, as expected,[40] but not statistically significant in either model. This is not necessarily inconsistent with previous studies that showed a modest change in fruit prices led to even more modest changes in consumption (Powell et al., 2013; Dong & Lin, 2009). Other food prices may have changed in ways that offset the effects of low fruit price inflation.[41] It is also possible that monthly prices are too imprecise due to the small size of the potential change in consumption.[42]

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[37] The joint effects of COLLEGE, NOSMOKING, EXERCISES, SUPPLEMENTS, and GUIDANCE are calculated as the sum of each variable's individual effect.

[38] Individuals who do not identify as non-Hispanic Black or non-Hispanic White include Mexican American consumers, other Hispanic consumers, non-Hispanic Asian consumers, and consumers of other races including multi-racial persons. See table 5 and footnote 32 for definitions of the variables BLACK and WHITE.

[39] INCOME is defined as the ratio of an individual's family income to the poverty threshold for a household of the same size at the time when the person participated in the NHANES. Increasing the value of INCOME from 1 to 2 is, therefore, equivalent to doubling the survey participant's household income from the poverty threshold to twice the poverty threshold. Table 6b shows that a unit increase in INCOME is associated with a 0.6 percentage point decrease in the likelihood an individual in the household consumes below 25 percent of total fruit recommendations over 2 randomly selected days.

[40] If low fruit price inflation helped to lift fruit consumption during the 2000s and 2010s, then lower prices should be associated with more people satisfying both 25 percent and 100 percent of recommendations, while higher prices should be associated with fewer people consuming each of these amounts of fruit.

[41] The authors attempted to estimate the model with additional explanatory variables based on the CPI for canned fruit and the CPI for all types of food at home, but the results on these variables were also insignificant. Adding them to the model had no statistically significant influence on the estimated marginal effect of FRUITPRICE.

[42] The BLS reports CPI data on a monthly basis. However, retail prices change every day, so monthly indices may not adequately capture what consumers paid for foods on any given shopping occasion.

Table 6a

Estimation results for the statistical model predicting whether an individual consumes enough total fruit to fully satisfy recommendations on 2 randomly selected days, 2005–March 2020

Variable	Marginal effect
INCOME	0.0036**
	(0.0016)
AGE	0.0027**
	(0.0001)
FEMALE	0.0259**
	(0.0048)
BLACK	-0.0439**
	(0.0074)
WHITE	-0.0702**
	(0.0057)
COLLEGE	0.0446**
	(0.0052)
SUPPLEMENTS	0.0401**
	(0.0048)
GUIDANCE	0.0209**
	(0.0045)
EXERCISES	0.0470**
	(0.0058)
NOSMOKING	0.0863**
	(0.0064)
FRUITPRICE	-0.0005
	(0.0013)
TREND	-0.0079**
	(0.0022)
Average value of Y (dependent variable)	0.176

Note: The analytical dataset includes 30,579 individuals aged 20 years and older who participated in the National Health and Nutrition Examination Survey (NHANES) between January 2005 and March 2020. Probit models were estimated for whether someone consumed enough fruit to fully satisfy recommendations in the *Dietary Guidelines for Americans*, for a moderately active person of the same age and sex as well as reference height and weight. Explanatory variables were included in the model based on household production theory and account for prices, income, demographic, and some health-related characteristics of the consumer. Reported in the last row of the table is the simple, weighted average value of Y, the dependent variable, calculated across all survey participants. The average represents the probability that a randomly selected individual fully satisfied the recommendation or, equivalently, the share of all individuals who did so. The reported marginal effects measure how a unit change in an explanatory variable would affect that share. All standard errors have been corrected for clustering and are reported in parentheses beneath the estimate. Double asterisks (**) indicate significance at the 5-percent level.

Source: USDA, Economic Research Service analysis of NHANES data, January 2005–March 2020.

Table 6b

Estimation results for the statistical model predicting whether an individual consumed less than 25 percent of total fruit recommendations on 2 randomly selected days, 2005–March 2020

Variable	Marginal effect
INCOME	-0.0060**
	(0.0020)
AGE	-0.0046**
	(0.0002)
FEMALE	-0.0607**
	(0.0056)
BLACK	0.0735**
	(0.0096)
WHITE	0.1126**
	(0.0085)
COLLEGE	-0.0917**
	(0.0065)
SUPPLEMENTS	-0.0607**
	(0.0056)
GUIDANCE	-0.0292**
	(0.0064)
EXERCISES	-0.0885**
	(0.0064)
NOSMOKING	-0.1472**
	(0.0068)
FRUITPRICE	0.0010
	(0.0016)
TREND	0.0159**
	(0.0026)
Average value of Y (dependent variable)	0.414

Note: The analytical dataset includes 30,579 individuals aged 20 years and older who participated in the National Health and Nutrition Examination Survey (NHANES) between January 2005 and March 2020. Probit models were estimated for whether someone consumed less than 25 percent of total fruit recommendations in the *Dietary Guidelines for Americans*, for a moderately active person of the same age and sex. Explanatory variables were included in the model based on household production theory and account for prices, income, demographic, and some health-related characteristics of the consumer. Reported in the last row of the table is the simple, weighted average value of Y, the dependent variable, calculated across all survey participants. The average represents the probability that a randomly selected individual consumed less than 25 percent of the recommendation or, equivalently, the share of all individuals who did so. The reported marginal effects measure how a unit change in an explanatory variable would affect that share. All standard errors have been corrected for clustering and are reported in parentheses beneath the estimate. Double asterisks (**) indicate significance at the 5-percent level.

Source: USDA, Economic Research Service analysis of NHANES data, January 2005–March 2020.

Robustness Tests

Trends in U.S. fruit consumption were examined using NHANES data collected between January 2005 and March 2020. Changes taking place over time in the distribution of fruit intake across the population were identified. A review of economic theory and the published literature was then conducted to identify factors that could motivate some consumers to meet recommendations and others to eat little or no fruit. Finally, a statistical model was proposed and estimated to test some research hypotheses. However, the NHANES data used in this study had a few notable limitations. Tests were conducted to confirm the robustness of the key results.

Participants in the NHANES–WWEIA dietary intake module reported their Day 1 and Day 2 food and beverage intake. The NCI developed a method for working with these data that focuses on "usual" or habitual" intake patterns. NCI's method was used to simulate the distribution of total fruit consumption relative to recommendations in the *Dietary Guidelines for Americans* for U.S. children and adults. Results reported in tables 1 and 2 show that while a stable share of individuals in both age groups continues to consume at least the recommended amount of fruit, a larger and growing share is consuming almost no fruit. In other parts of the study, including the regression analysis, the focus was on individuals' 2-day average intakes. For the first robustness test, the authors analyzed whether changes in the distribution of U.S. fruit consumption were similar regardless of whether the data were examined using NCI's method or the data were examined using individuals' 2-day average intakes. Results confirmed that both approaches led to similar and qualitatively consistent results (appendix B).

For the second robustness test, given that the NHANES oversamples lower income and minority individuals, there was an allowance for the possibility that the unweighted regression results were biased. It is possible, for example, that race, ethnicity, and income influence how much a person adjusts their fruit consumption with a change in income or after acquiring new information about the effect of diet on health. The estimated coefficients and marginal effects in tables 6a and 6b would disproportionately reflect the behavior of oversampled population segments in this case. Researchers may apply sample weights in an effort to obtain population-average marginal effects (e.g., Deaton, 1997). However, Solon et al. (2015) advised against this approach. The results of a weighted regression are generally biased as well. Weighted regressions may, for example, place too much importance on under sampled population segments. Following Solon et al. (2015) and DuMochel and Duncan (1983), among others, results were compared based on the two approaches. Weighted regression results continued to show that concern for health and nutrition knowledge were key determinants of whether an individual was in the high or low end of the fruit consumption distribution. Household income and prices also may have influenced fruit choices but played comparatively smaller roles (appendix C).

Conclusions

A stable share of the U.S. population continues to meet recommendations in the *Dietary Guidelines for Americans*. However, a larger and growing share of individuals is consuming less than a quarter of the recommendations on a regular basis. This low consumption group included almost 29 percent of children and 40 percent of adults by the dawn of the 2020s. Statistical models estimated using data on adults suggested that being in this low-consumption group is closely associated with having less concern for health and less understanding of what constitutes a healthy diet, as evidenced by behaviors such as smoking and being unaware of MyPlate (USDA's official symbol of the five food groups). Household income and prices may also influence food choices but play comparatively smaller roles. Insights provided in this study may benefit programs that seek to improve consumer diet quality as well as fruit growers seeking to maintain and expand marketing opportunities.

Amidst a growing share of U.S. consumers eating and drinking almost no fruit, growers and policymakers have worked to increase consumption. For example, expanded domestic production and imports of fresh strawberries have made it possible for people to eat this type of fruit year-round (Yeh et al., 2023). The Florida Department of Citrus (FDOC), funded by an assessment paid by growers of Florida citrus, launched an advertising campaign (The Original Wellness Drink) to highlight the nutritional benefits of consuming 100 percent orange juice, including hydration, immune system support, and heart health (FDOC, 2021).[43] [44]

Insights provided in this study may also benefit programs that seek to improve consumer diet quality, such as SNAP and WIC. Federal dietary guidance has long emphasized fruit consumption. In 2023, HHS and USDA appointed a team of nutrition and public health experts to serve on the 2025 Dietary Guidelines Advisory Committee, which will provide independent, science-based advice for the two departments to consider as they develop the future *Dietary Guidelines for Americans, 2025–30*.[45]

[43] Domestic oranges and grapefruit for juicing are primarily grown in Florida, while those for eating in fresh form are grown primarily in California (USDA, ERS, 2024c).

[44] Changing beliefs about the healthfulness of fruit juice products is contributing to decreases in the consumption of 100 percent orange and 100 percent grapefruit juice over time (Stewart et al., 2024).

[45] The 2025 Dietary Guidelines Advisory Committee reviews the current body of nutrition science on specific topics and questions and develops a scientific report that includes independent, science-based advice. The committee's review, along with public comments on the scientific report and agency input, helps inform HHS and USDA (USDA & HHS, 2023).

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Appendix A: Additional Estimation Results for Statistical Model

Probit models were estimated in this study and the results used to estimate marginal effects for all explanatory variables in the statistical model. The authors report the estimated marginal effects in tables 6a and 6b. Additional model estimation results including the parameter estimates and test of overall model significance are provided below in appendix tables A.1 and A.2.

Table A.1
Additional estimation results for the statistical model predicting whether an individual consumes enough total fruit to fully satisfy recommendations on 2 randomly selected days, 2005–March 2020

Variable	Parameter estimate
Constant	-1.5630**
	(0.5080)
INCOME	0.0143**
	(0.0062)
AGE	0.0105**
	(0.0006)
FEMALE	0.0888**
	(0.0189)
BLACK	-0.1725**
	(0.0292)
WHITE	-0.2761**
	(0.0225)
COLLEGE	0.1754**
	(0.0204)
SUPPLEMENTS	0.1578**
	(0.0189)
GUIDANCE	0.0823**
	(0.0179)
EXERCISES	0.1847**
	(0.0224)
NOSMOKING	0.3395**
	(0.0256)
FRUITPRICE	-0.0018
	(0.0049)
TREND	-0.0309**
	(0.0086)
Test of overall model significance	
F(12,108)	102.36
Prob > F	0.0000

Note: The analytical dataset includes 30,579 individuals aged 20 years and older who participated in the National Health and Nutrition Examination Survey (NHANES) between January 2005 and March 2020. Probit models were estimated for whether someone consumed enough fruit to fully satisfy recommendations in the *Dietary Guidelines for Americans*, for a moderately active person of the same age and sex as well as reference height and weight. Explanatory variables were included in the model based on household production theory and account for prices, income, demographic, and some health-related characteristics of the consumer. A test of the model's overall significance was performed. Shown in the bottom rows of the table are the test statistic and p-value (probability

all model coefficients beside the constant term are zero). Results for individual variables are shown in the top rows. All standard errors have been corrected for clustering and appear in parentheses beneath the parameter estimates. Double asterisks (**) indicate significance at the 5-percent level.

Source: USDA, Economic Research Service analysis of NHANES data, January 2005–March 2020.

Table A.2

Additional estimation results for the statistical model predicting whether an individual consumed less than 25 percent of total fruit recommendations on 2 randomly selected days, 2005–March 2020

Variable	Parameter estimate
Constant	0.4361**
	(0.4435)
INCOME	-0.0167**
	(0.0057)
AGE	-0.0128**
	(0.0006)
FEMALE	-0.1692**
	(0.0158)
BLACK	0.2051**
	(0.0271)
WHITE	0.3142**
	(0.0243)
COLLEGE	-0.2557**
	(0.0181)
SUPPLEMENTS	-0.1693**
	(0.0158)
GUIDANCE	-0.0815**
	(0.0058)
EXERCISES	-0.2469**
	(0.0217)
NOSMOKING	-0.4106**
	(0.0197)
FRUITPRICE	0.0028
	(0.0044)
TREND	0.0445**
	(0.0074)
Test of overall model significance	
F(12,108)	168.59
Prob > F	0.0000

Note: The analytical dataset includes 30,579 individuals aged 20 years and older who participated in the National Health and Nutrition Examination Survey (NHANES) between January 2005 and March 2020. Probit models were estimated for whether someone consumed less than 25 percent of total fruit recommendations in the *Dietary Guidelines for Americans*, for a moderately active person of the same age and sex. Explanatory variables were included in the model based on household production theory and account for prices, income, demographic, and some health-related characteristics of the consumer. A test of the model's overall significance was performed. Shown in the bottom rows of the table are the test statistic and p-value (probability all model coefficients beside the constant term are zero). Results for individual variables are shown in the top rows. All standard errors have been corrected for clustering and appear in parentheses beneath the parameter estimates. Double asterisks (**) indicate significance at the 5-percent level.

Source: USDA, Economic Research Service analysis of NHANES data, January 2005–March 2020.

Appendix B: Comparing Results Based on 2-Day Average Intakes and the National Cancer Institute's (NCI) Method

For the first robustness test of this report, the authors reviewed whether analysis of trends in U.S. total fruit consumption led to similar conclusions regardless of whether National Health and Nutrition Examination Survey (NHANES) data were examined using individuals' 2-day average intakes or the NCI's method. To check, employing the same data used to obtain the results shown in tables 6a and 6b, the authors estimated the statistical model for both children and adults with only a constant term and TREND as explanatory variables. Marginal effects based on the estimated probit regressions models are shown in appendix tables B.1 and B.2 and reveal how the population shares that fall into the high and low consumption groups over Day 1 and Day 2 are changing over time. Given the findings using NCI's method, the authors expected that a growing segment of NHANES participants reported consuming less than 25 percent of the recommendations over these 2 days. A comparatively stable share should have reported eating and drinking enough fruit to fully satisfy the recommendations.

Before the regression results were examined, it is important to note that a similar share of individuals fell into the high and low consumption groups regardless of how the data were analyzed. For example, it was found that about 24.4 percent of children and 17.6 percent of adults consumed enough fruit to fully satisfy total recommendations over Day 1 and Day 2 (last row of appendix table B.1). These shares are consistent with estimates based on NCI's method. As shown in tables 1 and 2, about 23 percent of all children and 15 percent of all adults habitually satisfied total fruit recommendations. These numbers are smaller than this report's estimates based on 2-day average intakes, but the difference is not large. Most, but not all, NHANES participants with high 2-day reported intakes habitually consumed enough fruit to fully satisfy total recommendations.

Estimation of the statistical model using individuals' 2-day average fruit consumption also confirmed that a growing share of NHANES participants reported little or no fruit consumption over Day 1 and Day 2. Among children, the share whose households reported consuming less than a quarter of the recommendation over these 2 days grew at the rate of 0.93 percentage points every 2 years between January 2005 and March 2020 (marginal effect of TREND in the first column of appendix table B.2). Among adults, the rate of increase was 1.13 percentage points every 2 years (second column of appendix table B.2).

A comparatively stable share of NHANES participants reported fully satisfying recommendations, which is again consistent with the results using NCI's method (tables 1 and 2). The percent of all children who fully satisfied fruit consumption recommendations has remained unchanged over time (the marginal effect of TREND in the first column of appendix table B.1 is not statistically significant), while the percent of adults doing so fell at a relatively modest rate of 0.55 percentage points every 2 years (second column of appendix table B.1).

Table B.1

Estimation results for statistical model predicting whether an individual consumes at least enough total fruit to fully satisfy recommendations on 2 randomly selected days, 2005–March 2020

Variable	Children	Adults
Variable	**Marginal effect**	**Marginal effect**
TREND	-0.0038	-0.0055**
	(0.0022)	(0.0015)
Average value of Y (dependent variable)	0.244	0.176

Children = individuals aged 2 through 19; adults = individuals aged 20 years and older.

Note: The analytical dataset includes information on 33,412 adults and 20,119 children who participated in the National Health and Nutrition Examination Survey (NHANES) between January 2005 and March 2020. Probit models were estimated for whether an individual consumed enough fruit to fully satisfy recommendations in the *Dietary Guidelines for Americans*, for a moderately active person of the same age and sex as well as reference height and weight. The model includes only an intercept and time trend variable. Reported in the last row of the table is the simple, weighted average value of Y, the dependent variable, calculated across all survey participants. The average represents the probability that a randomly selected individual of the specified age fully satisfied the recommendation or, equivalently, the share of all individuals within the age group who did so. The marginal effects reported for TREND provide for a measure of how quickly those shares changed over time. The standard errors of these effects have been corrected for clustering. These are reported in parentheses beneath the estimate. Double asterisks (**) indicate significance at the 5-percent level.

Source: USDA, Economic Research Service analysis of NHANES data, January 2005–March 2020.

Table B.2

Estimation results for statistical model predicting whether an individual consumed below 25 percent of total fruit recommendations on 2 randomly selected days, 2005–March 2020

Variable	Children	Adults
Variable	**Marginal effect**	**Marginal effect**
TREND	0.0093**	0.0113**
	(0.0026)	(0.0021)
Average value of Y (dependent variable)	0.320	0.414

Children = individuals aged 2 through 19; adults = individuals aged 20 years and older.

Note: The analytical dataset includes information on 33,412 adults and 20,119 children who participated in the National Health and Nutrition Examination Survey (NHANES) between January 2005 and March 2020. Probit models were estimated for whether an individual consumed below 25 percent of total fruit recommendations in the *Dietary Guidelines for Americans*, for a moderately active person of the same age and sex as well as reference height and weight. The model includes only an intercept and time trend variable. Reported in the last row of the table is the simple, weighted average value of Y, the dependent variable, calculated across all survey participants. The average represents the probability that a randomly selected individual of the specified age consumed less than 25 percent of the recommendation or, equivalently, the share of all individuals within the age group who did so. The marginal effects reported for TREND provide for a measure of how quickly those shares changed over time. The standard errors of these effects have been corrected for clustering. These are reported in parentheses beneath the estimate. Double asterisks (**) indicate significance at the 5-percent level.

Source: USDA, Economic Research Service analysis of NHANES data, January 2005–March 2020.

Appendix C: Comparing Unweighted and Weighted Regression Results

The National Health and Nutrition Examination Survey (NHANES) oversamples minority and lower income households (U.S. Department of Health and Human Services, National Center for Health Statistics, 2024b). The results of the unweighted regressions reported in tables 6a and 6b are biased if consumers belonging to different sociodemographic and economic groups do not similarly adjust their fruit consumption with a change in income or after acquiring new information about the effect of diet on health (e.g., Solon et al., 2015; Deaton, 1997; DuMochel & Duncan, 1983). The estimated marginal effects disproportionately reflect the behavior of oversampled population segments in this case. Marginal effects based on weighted regressions are shown in appendix tables C.1 and C.2 for comparison. This report's key results are unchanged by weighting. The authors continued to find that the largest factors associated with consuming enough fruit are health behaviors including not smoking and engaging in physical activity as well as health knowledge captured by awareness of USDA's MyPlate, a tool used to visualize recommendations for a healthy diet. The inverse was the case for those in the low consumption category—those with these healthy behaviors and knowledge were less likely to be low fruit consumers. Weighting does affect results on INCOME. This variable is positive in table 6a and negative in table 6b whereas it is not statistically significantly different than zero in either appendix table C.1 or C.2. After weighting the regressions, household income is found to be even less important than the unweighted regression suggests. Income may be a more significant determinant of fruit consumption among certain racial, ethnic, and economic groups than it is among the population as a whole. Future research is needed to confirm and better understand this possibility.

Table C.1

Estimation results for statistical model predicting whether an individual consumes at least enough fruit to fully satisfy recommendations on 2 randomly selected days, 2005–March 2020, sample weighted regression

Variable	Marginal effect
INCOME	0.0003
	(0.0021)
AGE	0.0028**
	(0.0002)
FEMALE	0.0045**
	(0.0067)
BLACK	-0.0345**
	(0.0094)
WHITE	-0.0659**
	(0.0072)
COLLEGE	0.0415**
	(0.0082)
SUPPLEMENTS	0.0436**
	(0.0073)
GUIDANCE	0.0356**
	(0.0068)
EXERCISES	0.0461**
	(0.0086)
NOSMOKING	0.0823**
	(0.0095)

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Variable	Marginal effect
FRUITPRICE	0.0005
	(0.0017)
TREND	-0.0043**
	(0.0027)
Average value of Y (dependent variable)	0.176

Note: The analytical dataset includes information on 30,579 adults (individuals aged 20 years and older) who participated in the National Health and Nutrition Examination Survey (NHANES) between January 2005 and March 2020. Probit models were estimated for whether someone fully satisfied total fruit recommendations in the *Dietary Guidelines for Americans*, for a moderately active person of the same age and sex as well as reference height and weight. Explanatory variables account for prices, income, demographic, and some health-related characteristics of the consumer. Reported in the last row of the table is the simple, weighted average value of Y, the dependent variable, calculated across all survey participants. The average represents the probability that a randomly selected individual fully satisfied the recommendation or, equivalently, the share of all individuals who did so. The reported marginal effects measure how a unit change in an explanatory variable would affect the reported share. Sample weights are used in model estimation. The standard errors of the estimates have also been corrected for clustering and are reported in parentheses beneath each estimate. Double asterisks (**) indicate significance at the 5-percent level.

Source: USDA, Economic Research Service analysis of NHANES data, January 2005–March 2020.

Table C.2

Estimation results for statistical model predicting whether an individual consumed less than 25 percent of total fruit recommendations on 2 randomly selected days, 2005–March 2020, sample weighted regression

Variable	Marginal effect
INCOME	0.0020
	(0.0030)
AGE	-0.0050**
	(0.0003)
FEMALE	-0.0608 **
	(0.0082)
BLACK	0.0586**
	(0.0123)
WHITE	0.0987**
	(0.0116)
COLLEGE	-0.0915**
	(0.0112)
SUPPLEMENTS	-0.0566**
	(0.0078)
GUIDANCE	-0.0313**
	(0.0095)
EXERCISES	-0.0905 **
	(0.0102)
NOSMOKING	-0.1567**
	(0.0111)
FRUITPRICE	0.0022
	(0.0022)

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Variable	Marginal effect
TREND	0.0158**
	(0.0038)
Average value of Y (dependent variable)	0.414

Note: The analytical dataset includes information on 30,579 adults (individuals aged 20 years and older) who participated in the National Health and Nutrition Examination Survey (NHANES) between January 2005 and March 2020. Probit models were estimated for whether someone consumed less than 25 percent of total fruit recommendations in the *Dietary Guidelines for Americans*, for a moderately active person of the same age and sex. Explanatory variables account for prices, income, demographic, and some health-related characteristics of the consumer. Reported in the last row of the table is the simple, weighted average value of Y, the dependent variable, calculated across all survey participants. The average represents the probability that a randomly selected individual consumed less than 25 percent of the recommendation or, equivalently, the share of all individuals who did so. The reported marginal effects measure how a unit change in an explanatory variable would affect the reported share. Sample weights are used in model estimation. The standard errors of the estimates have also been corrected for clustering and are reported in parentheses beneath each estimate. Double asterisks (**) indicate significance at the 5-percent level.

Source: USDA, Economic Research Service analysis of NHANES data, January 2005–March 2020.