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# Assessing the consumption of berries and associated factors in the United States using the National Health and Nutrition Examination Survey (NHANES), 2007–2012

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Intake of berries was assessed relative to other fruit and fruit juices and total fruit intake in the U.S. population age 2 years and older using the National Health and Nutrition Examination Survey, 2007–2012. Average daily intake of total fruit was about 1 cup, and berries comprised approximately 10% of total fruit consumption. Only 18% of the population met the recommendation of at least 2 cups of fruit per day. Children ages 2 to 5 years consumed the most total fruit of which about half was juice and 4% of which was berries. Among adults, the highest berry consumption was by those who were 65 years and older, non-Hispanic White, and had the highest education and income levels. Use of the Nutrition Facts panel and ingredient labeling was associated with greater total fruit and berry intake. Those who were aware of an amount of fruit that is associated with good health and of dietary guidance in general and those who had fruit available in the home consumed about twice as much berries as others. Fruit intake remains below recommendations in the U.S.; berry intake is particularly low. Behavioral indicators provided insight on how fruit and berry consumption might be increased.

## Introduction

The Dietary Guidelines for Americans (DGA) as well as other guidelines world-wide recommend increasing fruit and vegetable intake for better health.[1,2] In the United States (U.S.), the DGA emphasizes eating a variety of fruits and vegetables rather than only a few types. The USDA Food Patterns, which are part of the DGA, specify several sub-categories of vegetables (dark-green, beans and peas, red and orange, starchy, and other). For fruit, however, the only distinctions are that at least half the fruit consumed be whole and no more than half should be juice.[3] The limited guidance for fruit compared to recommendations for vegetables is concerning in light of the differing nutrient and phytochemical content of different types of fruits and their corresponding potential health benefits.

Berries, including strawberries, blueberries, blackberries, raspberries and cranberries, are low in calories (~0.3–0.6 kcal $g^{-1}$) and provide a number of essential nutrients such as vitamin C, potassium, and manganese as well as other vitamins and minerals.[4] In addition, berries are an excellent source of dietary fiber contributing 4.3–12.5 g of fiber per 100 kcal, while other commonly consumed fruits contribute 1.3–4.6 g of fiber per 100 kcal. Berries also contain an array of polyphenol phytochemical compounds including flavonoids, hydrolysable and condensed tannins.[5,6] Notably, berries contain anthocyanin-type polyphenols that give them their distinctive blue, red, and purple color, ranging as high as 300 mg per cup, while most other fruit have limited amounts of these bioactive polyphenols.[5] Berries also contain significant amounts of flavan 3-ols in the range of 31 to 461 mg per cup across the category.[6] The consumption of berries and of dietary anthocyanins have been associated with a number of health benefits, including, reduced risk of CVD risk factors,[7,8] reduced diabetes risk,[9] improved insulin sensitivity,[10] and enhanced cognitive performance in elderly[11,12] and children.[13] Thus, berries not only supply important essential nutrients, but also provide a unique and dense profile of phytochemicals found in only limited amounts in other fruits. Moreover, epidemiology and clinical trial data suggest berries have a role in disease-risk reduction and maintenance of health.

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The growing evidence on the health benefits of berries suggests a need to understand the amounts of berries currently consumed. Limited information is available regarding berry intake in the U.S. population, especially who consumes berries (*i.e.*, how intake varies by age, sex, race/ethnicity, socio-economic status) and what motivates berry consumption. Several previous reports have identified total fruit intake below recommendations with no clear description of berry intake. Additionally, motivators of fruit intake in general and berry intake specifically are not well known. Increasing fruit and berry consumption requires understanding who consumes fruit and how much they consume as well as knowledge of attitudes and behaviors related to fruit and berry intake. Therefore, the purpose of the current research is to characterize berry intake compared to overall fruit intake in the U.S., including a comparison of who is consuming berries and how much are being consumed. A second objective was to assess attitudinal and behavioral measures associated with berry consumption and overall fruit intake.

# Methods

### Dietary data

Data for the analysis came from the National Health and Nutrition Examination Surveys (NHANES) conducted in 2007–2008,[14] 2009–2010,[15] and 2011–2012.[16] NHANES includes the collection of 24-hour recalls of dietary intakes by individuals, known as "What We Eat in America". Trained interviewers use a standardized, computer-assisted protocol in a mobile examination center. In addition, a consumer behavior module, known as the "Flexible Consumer Behavior Survey" (FCBS), collects information on knowledge, attitudes, and behaviors related to diet and health.

In the combined NHANES sample of individuals who were age 2 years old and older, 25 514 individuals reported dietary intakes. The survey results are representative of the US population with appropriate use of weighting to account for the complex survey design, to adjust for a non-response, and to combine survey years. Data on two days of dietary intakes were collected in the NHANES, the first day (Day 1) through the in-person interview and the second day through telephone interview administered 3 to 10 days after the in-person interview.

Berry and other fruit consumption in the NHANES was estimated using the associated Food Patterns Equivalent Databases (FPED) 2007–2008,[17] 2009–2010,[18] and 2011–2012.[19] The FPED converts amounts of foods and beverage items reported into amounts of the 37 USDA Food Patterns components. The FPED includes four fruit components "Total Fruit", "Citrus, Melons, and Berries", "Other Fruit", and "Fruit Juice". The sum of the latter three fruit components is "Total Fruit". The "Fruit Juice" component includes only 100% juice. In the FPED, all fruit drinks are assumed to contain 15% fruit juice, so 15% of any fruit drink is counted as "Fruit Juice". The amounts of fruit are expressed in terms of "cup equivalents". Both 1 cup of whole fruit and 1 cup of fruit juice are equal to 1 cup equivalent of fruit; however, 1/2 cup of dried fruit equals 1 cup equivalent of fruit.[1] (The metric equivalent of 1 cup is 237 mL.)

The authors separated the berries from the citrus and melon in the "Citrus, Melon, and Berries" component and then combined the citrus and melon with the "Other fruit" component of the FPED. Therefore, in our analyses "Other fruit" includes all whole fruits except berries. Berries were identified by searching for the terms "berry" and "berries" in the food item description (*e.g.*, the fruit in "blueberry crisp") and also by reviewing the food descriptions for all foods that contained a citrus, melon, and berries component and deciding if that component was likely to be berry or not. Baby foods were excluded from the analysis.

### Socio-economic data

Demographic and economics characteristics are available on individuals and include age; sex; race/ethnicity; family income; and, for adults, education. Classifications on these characteristics were developed based on dietary requirements and population groups of interest. For children, age groups were 2–5, 6–11 and 12–17 years old; for men and women, age groups were 18–40, 41–64 and 65 years and older. Race/ethnicity groups were White, non-Hispanic; Black, non-Hispanic; Other Race, non-Hispanic; and Hispanic. Income is expressed as % of poverty level and grouped as less than or equal to 130%, 131–185%, 186–299%, 300–499%, and ≥500%. Education level was defined as less than high school degree or equivalent, high school degree, some college, and college degree or higher.

### Behavioral characteristics

Information on food-related attitudes and behaviors came from the FCBS (2007–2008, 2009–2010). The dataset included responses from 17 575 individuals, and of these, 11 741 adults reported dietary intake. The set of questions asked in 2011–2012 differed from the previous years; therefore, the analysis of the FCBS focused on the common set of questions asked in the previous surveys (2007–2008, 2009–2010). Responses to the survey questions were generally on a 5-point Likert scale ranging from excellent to poor for some questions and always to never for other questions. For ease of interpretation, results presented here were aggregated into bivariate responses, for example, "Excellent/very good" *vs.* "Other", which included good, fair, poor. The individuals reporting on the FCBS were matched to their reported dietary intake data to assess amounts consumed of total fruit and berries.

### Statistical analysis

The distribution of usual intakes (where "usual" intake is an individual's long-term daily intake) of total fruit and fruit subgroups and the proportion of the population with intakes below recommended levels were estimated using the Statistical Program for Age-adjusted Dietary Assessment (SPADE) from 2 days of reported dietary intake.[20] The remaining data analyses and statistical computations were conducted using the statisti-

 

cal software package SAS® release 9[21] (2013) and 1 day of dietary intake data. The mean values for all days, the percentile distributions of intakes on consumption days, and standard errors were computed with "proc surveymeans". Statistical analysis of *t*-tests of means was applied to the FCBS question responses using "proc *t*-test". The sampling weights provided in the dataset were used; therefore, the results may be generalized to the U.S. population.

# Results

### Usual fruit intakes

The estimated distributions of usual intakes indicate that only 18.2% (= 100.0%–81.8%) of the population have long-term daily average intakes that meet the commonly recommended 2-cup equivalent amount of total fruit (Table 1). Only half of the population consumes at least 3/4 cup equivalent of total fruit per day on average. Only 22% meet the recommendation of at least 1 cup equivalent of whole fruit per day; and less than 1% of the population consumes 1 cup equivalent of berries per day.

### Percent of population consuming fruit

On a given day, almost 75% of the U.S. population consumes some type of whole fruit or fruit juice, and the median amount consumed on consumption days (the day when an individual consumes any fruit) is approximately 1 cup equivalent (Table 2). Less than one-fifth of the population consumes berries on a given day, and the median consumption on the consumption day is about 1/8 cup. On a given day, about two-fifths of the population drink fruit juice; and the median amount is 1/2 cup.

### Average fruit intakes by subpopulations

Average daily intakes of all types of fruit, berries, and fruit juice vary considerably among various subpopulations in the U.S. (Table 3 and Fig. 1); however, none of the subpopulations had mean intakes close to 2 cup equivalents, the commonly recommended amount. Among the characteristics analyzed, age presented the greatest differences in mean daily fruit intakes, ranging from ~0.9 cups by teenagers and younger and middle-age women to ~1.5 cups by pre-school aged children. A similar pattern in berry intake was noted but at lower levels of intake. Fruit and berry intake varied less by race/ethnicity than by income and education level.

### Attitudes and behaviors related to fruit intake

Several food-related attitudes and behaviors were associated with the amounts of total fruit and berries consumed (Table 4). Adults who rate the healthfulness of their diet as excellent or very good ate more total fruit and more berries than those who rated their diets as good, fair, or poor ($p < 0.001$). Those who had some familiarity with the USDA food guidance system, MyPyramid (now known as MyPlate) or the

**Table 1** Estimated distributions of usual intakes of total fruit (including juice), total whole fruit, berries, other whole fruit, and fruit juice, U.S., 2007–2012

| | % of population with usual intakes below recommended amount | Mean usual intake per day ± SE Cup equivalents | Percentiles ± SE | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 10th | 25th | 50th | 75th | 90th | 95th |
| Total fruit | 81.8%[a] ± 0.35 | 1.23 ± 0.01 | 0.14 ± 0.00 | 0.33 ± 0.01 | 0.76 ± 0.01 | 1.59 ± 0.02 | 2.86 ± 0.04 | 3.96 ± 0.05 |
| Total whole fruit | 77.7%[b] ± 0.64 | 0.68 ± 0.01 | 0.12 ± 0.00 | 0.26 ± 0.01 | 0.53 ± 0.01 | 0.93 ± 0.01 | 1.43 ± 0.02 | 1.80 ± 0.03 |
| Berries | n.a. | 0.07 ± 0.00 | 0.00 ± 0.00 | 0.00 ± 0.00 | 0.02 ± 0.00 | 0.07 ± 0.00 | 0.17 ± 0.01 | 0.27 ± 0.01 |
| Other whole fruit | n.a. | 0.61 ± 0.01 | 0.10 ± 0.00 | 0.23 ± 0.01 | 0.48 ± 0.01 | 0.83 ± 0.01 | 1.28 ± 0.02 | 1.60 ± 0.03 |
| Fruit juice | n.a. | 0.32 ± 0.01 | 0.03 ± 0.00 | 0.08 ± 0.00 | 0.20 ± 0.00 | 0.43 ± 0.01 | 0.77 ± 0.02 | 1.06 ± 0.02 |

*Source*: National Health and Nutrition Examination Survey, 2007–2012, 2 days dietary data ($N$ = 22 135). n.a. = not applicable. [a] Recommended amount is at least 2 cups per day (1). [b] Recommended amount is at least 1 cup per day (1).

**Table 2** Estimated distributions of amounts of total fruit (including juice), berries, other whole fruit, and fruit juice consumed on consumption days only, U.S., 2007–2012

| | % of population consuming on a given day | Mean intake on consumption days ± SE Cup equivalents | Percentiles ± SE | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 10th | 25th | 50th | 75th | 90th | 95th |
| Total fruit | 73.0% | 1.43 ± 0.01 | 0.08 ± 0.01 | 0.43 ± 0.01 | 1.06 ± 0.02 | 2.01 ± 0.02 | 3.08 ± 0.04 | 3.96 ± 0.06 |
| Whole fruit | 58.2% | 1.17 ± 0.01 | 0.07 ± 0.00 | 0.35 ± 0.01 | 0.86 ± 0.02 | 1.66 ± 0.02 | 2.50 ± 0.03 | 3.26 ± 0.06 |
| Berries | 18.2% | 0.34 ± 0.01 | 0.02 ± 0.00 | 0.05 ± 0.00 | 0.12 ± 0.01 | 0.49 ± 0.02 | 0.89 ± 0.04 | 1.24 ± 0.06 |
| Other whole fruit | 53.6% | 1.15 ± 0.01 | 0.07 ± 0.00 | 0.38 ± 0.01 | 0.84 ± 0.02 | 1.66 ± 0.02 | 2.45 ± 0.03 | 3.22 ± 0.07 |
| Fruit juice | 41.9% | 0.82 ± 0.04 | 0.02 ± 0.00 | 0.10 ± 0.00 | 0.51 ± 0.01 | 1.12 ± 0.05 | 1.98 ± 0.04 | 2.62 ± 0.06 |

*Source*: National Health and Nutrition Examination Survey, 2007–2012, Day 1 dietary data ($N$ = 25 514).

Table 3 Estimated mean daily intakes of total fruit (including juice), berries, other whole fruit, and fruit juice by demographic characteristics, U.S., 2007–2012

| | | | Whole fruit | | |
|---|---|---|---|---|---|
| | | Total fruit Cup equivalents | Berries | Other fruit | Fruit juice |
| Sex and Age, y | Percent of population | Mean ± SE | Mean ± SE | Mean ± SE | Mean ±SE |
| **Girls and boys** | | | | | |
| 2–5 | 5.6% | 1.45 ± 0.04 | 0.07 ± 0.01 | 0.75 ± 0.02 | 0.62 ± 0.02 |
| 6–11 | 8.3% | 1.15 ± 0.03 | 0.06 ± 0.01 | 0.69 ± 0.03 | 0.39 ± 0.01 |
| 12–17 | 8.5% | 0.98 ± 0.05 | 0.04 ± 0.01 | 0.56 ± 0.03 | 0.36 ± 0.03 |
| All children | 22.4% | 1.16 ± 0.02 | 0.05 ± 0.00 | 0.66 ± 0.02 | 0.44 ± 0.01 |
| **Women** | | | | | |
| 18–40 | 15.7% | 0.89 ± 0.03 | 0.06 ± 0.01 | 0.49 ± 0.02 | 0.33 ± 0.02 |
| 41–64 | 17.3% | 0.97 ± 0.03 | 0.08 ± 0.01 | 0.64 ± 0.02 | 0.23 ± 0.01 |
| ≥65 | 7.2% | 1.13 ± 0.03 | 0.08 ± 0.01 | 0.77 ± 0.03 | 0.27 ± 0.02 |
| All women | 40.1% | 0.97 ± 0.02 | 0.07 ± 0.00 | 0.60 ± 0.01 | 0.28 ± 0.01 |
| **Men** | | | | | |
| 18–40 | 16.2% | 1.01 ± 0.04 | 0.04 ± 0.01 | 0.51 ± 0.03 | 0.44 ± 0.03 |
| 41–64 | 15.6% | 1.01 ± 0.04 | 0.06 ± 0.01 | 0.65 ± 0.03 | 0.29 ± 0.02 |
| ≥65 | 5.7% | 1.22 ± 0.04 | 0.08 ± 0.01 | 0.79 ± 0.03 | 0.35 ± 0.02 |
| All men | 37.5% | 1.05 ± 0.02 | 0.06 ± 0.00 | 0.61 ± 0.02 | 0.36 ± 0.01 |
| **Race/ethnicity** | | | | | |
| White, non-hispanic | 65.5% | 1.00 ± 0.02 | 0.08 ± 0.00 | 0.62 ± 0.01 | 0.29 ± 0.01 |
| Black, non-hispanic | 12.2% | 1.03 ± 0.02 | 0.03 ± 0.00 | 0.49 ± 0.02 | 0.50 ± 0.02 |
| Other race, non-hispanic | 6.7% | 1.19 ± 0.05 | 0.04 ± 0.00 | 0.78 ± 0.04 | 0.36 ± 0.02 |
| Hispanic | 15.7% | 1.16 ± 0.02 | 0.03 ± 0.00 | 0.66 ± 0.02 | 0.45 ± 0.02 |
| **Income (% poverty level)** | | | | | |
| ≤130 | 24.5% | 0.97 ± 0.02 | 0.03 ± 0.00 | 0.52 ± 0.01 | 0.41 ± 0.02 |
| 131–185 | 10.5% | 0.97 ± 0.03 | 0.05 ± 0.01 | 0.55 ± 0.02 | 0.36 ± 0.02 |
| 186–299 | 15.9% | 0.97 ± 0.03 | 0.06 ± 0.01 | 0.57 ± 0.02 | 0.32 ± 0.02 |
| 300–499 | 20.7% | 1.02 ± 0.03 | 0.07 ± 0.01 | 0.63 ± 0.02 | 0.30 ± 0.01 |
| ≥500 | 21.5% | 1.18 ± 0.03 | 0.10 ± 0.01 | 0.75 ± 0.03 | 0.30 ± 0.01 |
| **Education (adults)** | | | | | |
| <High school | 9.3% | 0.76 ± 0.03 | 0.03 ± 0.00 | 0.45 ± 0.02 | 0.27 ± 0.02 |
| High school graduate | 16.9% | 0.86 ± 0.03 | 0.04 ± 0.01 | 0.53 ± 0.02 | 0.28 ± 0.02 |
| Some college | 23.2% | 1.01 ± 0.03 | 0.07 ± 0.01 | 0.58 ± 0.02 | 0.34 ± 0.02 |
| College graduate or higher | 20.8% | 1.26 ± 0.03 | 0.10 ± 0.01 | 0.80 ± 0.03 | 0.33 ± 0.02 |
| **Total population** | 100.0% | 1.04 ± 0.01 | 0.06 ± 0.00 | 0.62 ± 0.01 | 0.34 ± 0.00 |

*Source*: National Health and Nutrition Examination Survey, 2007–2012, Day 1 dietary data ($N$ = 25 514).

earlier Food Guide Pyramid, also had higher intakes of total fruit and berries ($p$ = 0.02 for fruit and $p$ < 0.001 for berries). Those who had some idea of the recommended amounts to eat for fruits, vegetables, protein foods, and whole grains had higher intakes of berries ($p$ < 0.001), but no difference was found for total fruit intake.

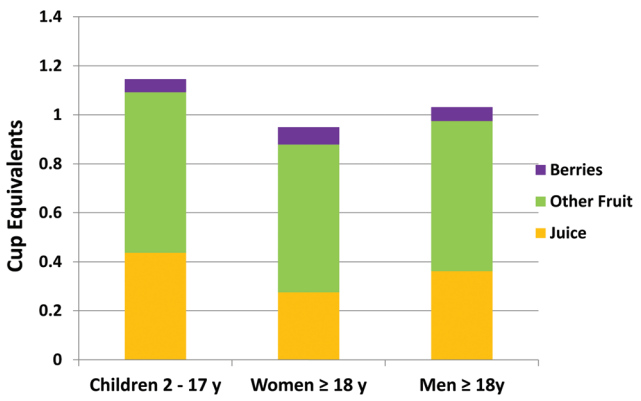


Fig. 1 Estimated mean daily intakes of total fruit, berries, other whole fruit, and fruit juice by children, women, and men, U.S., 2007–2012. Source: National Health and Nutrition Examination Survey, 2007–2012, Day 1 dietary data ($N$ = 25 514).

Individuals with a higher frequency of having fruit available in the home had higher intakes of both total fruit and berries compared to those who had fruit at home less often ($p$ < 0.001). Those who had soft drinks and other fruit-flavored drinks available at home more often had lower fruit and lower berry intakes ($p$ < 0.001). Those who considered nutrition to be important, used the Nutrition Facts panel, and used the list of ingredients on the food label had higher intakes of both total fruit and berries ($p$ < 0.001). On the other hand, consideration of price, ease of preparation, or how well food stays fresh when stored was not associated with a difference in total fruit or berry intake.

## Discussion

The health benefits of consuming fruit are inarguable. The DGA recommends consuming 2 cups of fruits per day;

 

Table 4 Estimated mean daily intakes of total fruit and berries by selected food-related attitudes and behaviors, adults, U.S., 2007–2010

| | | | Total fruit Cup equivalents | Berries |
|---|---|---|---|---|
| Question | Response | % of adults | Mean ± SE | Mean ± SE |
| In general, how healthy is your overall diet? | Excellent or very good | 31.7% | 1.29 ± 0.03*** | 0.10 ± 0.01*** |
| | Other | 68.3% | 0.90 ± 0.02 | 0.05 ± 0.00 |
| There is no reason for me to make changes to the things I eat. | Strongly or somewhat agree | 19.5% | 1.11 ± 0.04 | 0.06 ± 0.01 |
| | Other | 80.5% | 1.00 ± 0.02 | 0.06 ± 0.00 |
| How often does your family have fruits available at home? | Always or most of the time | 85.4% | 1.09 ± 0.02*** | 0.07 ± 0.00*** |
| | Other | 14.6% | 0.63 ± 0.03 | 0.03 ± 0.01 |
| How often does your family have soft drinks, fruit-flavored drinks, or fruit punch available at home? | Always or most of the time | 54.2% | 0.91 ± 0.02*** | 0.05 ± 0.00*** |
| | Other | 45.8% | 1.15 ± 0.03 | 0.08 ± 0.01 |
| Heard of MyPyramid, Food Pyramid or Food Guide Pyramid? | Yes | 65.5% | 1.04 ± 0.02* | 0.08 ± 0.01*** |
| | Other | 34.5% | 0.98 ± 0.03 | 0.04 ± 0.00 |
| Have you looked up or tried MyPyramid? | Yes | 21.2% | 1.20 ± 0.04*** | 0.11 ± 0.01*** |
| | Other | 78.8% | 0.96 ± 0.02 | 0.05 ± 0.00 |
| How many cups of fruits would you say a man/woman of your age and physical activity should eat each day for good health? | Reported cups (yes) | 62.3% | 1.04 ± 0.02 | 0.08 ± 0.01*** |
| | Other (Refused, Don't Know) | 37.7% | 0.99 ± 0.03 | 0.04 ± 0.00 |
| How many cups of vegetables, including dark green, orange, starchy, and other vegetables, would you say a {man/woman} of your age and physical activity should eat each day for good health? | Reported cups (yes) | 62.8% | 1.04 ± 0.02 | 0.08 ± 0.01*** |
| | Other (Refused, Don't Know) | 37.2% | 0.99 ± 0.03 | 0.04 ± 0.00 |
| How many ounces of meat and beans would you say a {man/woman} of your age and physical activity should eat each day for good health? | Reported ounces (yes) | 58.3% | 1.03 ± 0.02 | 0.08 ± 0.01*** |
| | Other (Refused, Don't Know) | 41.7% | 1.01 ± 0.03 | 0.04 ± 0.00 |
| How many ounces of "whole grains" would you say a {man/woman} of your age and physical activity should eat each day for good health? | Reported ounces (yes) | 51.8% | 1.03 ± 0.03 | 0.08 ± 0.01*** |
| | Other (Refused, Don't Know) | 48.2% | 1.01 ± 0.03 | 0.04 ± 0.00 |
| When you buy food from a grocery store or supermarket, how important is "price"? | Very or somewhat important | 73.4% | 1.02 ± 0.02 | 0.07 ± 0.00 |
| | Other | 26.6% | 1.01 ± 0.04 | 0.06 ± 0.01 |
| How about "nutrition"? | Very or somewhat important | 79.0% | 1.04 ± 0.02*** | 0.07 ± 0.00*** |
| | Other | 21.0% | 0.93 ± 0.04 | 0.04 ± 0.00 |
| How about "taste"? | Very or somewhat important | 81.0% | 1.03 ± 0.02 | 0.07 ± 0.00*** |
| | Other | 19.0% | 0.98 ± 0.04 | 0.04 ± 0.01 |
| How about "how easy the food is to prepare"? | Very or somewhat important | 63.6% | 1.03 ± 0.02 | 0.07 ± 0.01 |
| | Other | 36.4% | 1.01 ± 0.03 | 0.06 ± 0.01 |
| How about "how well the food keeps after it's bought"? | Very or somewhat important | 71.5% | 1.02 ± 0.02 | 0.07 ± 0.00 |
| | Other | 28.6% | 1.01 ± 0.03 | 0.06 ± 0.01 |
| How often do you use the Nutrition Facts panel when deciding to buy a food product? | Always or most of the time | 33.5% | 1.22 ± 0.03*** | 0.09 ± 0.01*** |
| | Other | 66.5% | 0.92 ± 0.02 | 0.05 ± 0.00 |
| How often do you use the list of ingredients on a food label when deciding to buy a food product? | Always or most of the time | 24.7% | 1.26 ± 0.04*** | 0.09 ± 0.01*** |
| | Other | 75.3% | 0.94 ± 0.02 | 0.06 ± 0.00 |
| How often do you use package information on health claims about the benefits of nutrients or foods when deciding to buy a product? | Always or most of the time | 22.7% | 1.17 ± 0.04*** | 0.07 ± 0.01 |
| | Other | 77.3% | 0.98 ± 0.02 | 0.06 ± 0.00 |

*Source*: National Health and Nutrition Examination Survey, Day 1 dietary data, and Flexible Consumer Behavior Survey, 2007–2010 ($N$ = 17 575). Compared with "Other" group, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

however, guidance beyond *total amount* is limited to whole *vs.* juice form.[1,3] Moreover, recommendations do not account for differences in types of fruits based on nutritional or other beneficial properties; and not all fruits are the same in this regard. For example, berries have a distinctive nutritional and phytochemical composition[4–6] with documented health-promoting properties,[7–13] suggesting they should be consumed regularly. Previous work has indicated that total fruit intake is about 1 cup per d on average (~1/2 the recommendation); however, the amount of berries consumed is unclear. Therefore, the objective of the present study was to assess berry intake in the U.S. relative to total fruit consumption. As part of this objective, we were also interested in understanding who consumes berries (*e.g.*, men/women, younger/older, Blacks/Whites) and how much they consume as well as attitudes and behaviors related to berry intake compared to total fruits. The present study confirms previous knowledge that fruit intake is low and remains below recommendations.[22] New findings indicate that berry intake is especially low, comprising ~10% of total intake, which may suggest fruit intake diversity is also minimal. Children 2 to 5 years consume the highest amount of total fruit with whole fruit contributing 57% and juice contributing 43% of consumption, and whole berries constitute only 5% of fruit consumption in this age group. The level of berry consumption declines as children age with the 12 to 17 years group consuming only 0.04 cup equivalent per d compared to age 2 to 5 years who consume 0.07 cup equivalent per d. By contrast, total fruit intake increases

with age in the adult population, independent of sex, with the highest intake in people 65 and older. Berry consumption follows the same patterns with the highest consumption as juice occurring for children 2 to 5 years and the highest whole fruit consumption in older adults. Even though no age group is meeting fruit intake recommendations, children and older adults are eating greater amounts of fruits, whereas teens and younger adults are eating less. A significant factor, especially for older children and teens, may be the lack of fruit availability at their main meals. Studies indicate that when families eat together with fruit present, consumption goes up.[23] Interestingly though, while younger children are being fed fruits and berries, this does not seem to correspond to higher intakes in the population age group (20–50 years) who are likely feeding these children. It is not entirely clear why this is the case; however, educating this age group of child-rearing adults that fruit and berry intake is healthy for all ages may be helpful. Research to uncover the appropriate motivational targets for this age group will be required to support public health goals to increase fruit intake.

The present study found that family income and education, which are highly correlated, are strongly associated with both total fruit consumption and berry consumption. Total fruit intake and berry intake increase as income level and educational level increases; although the largest increase (20–25%) appears to be in the group with incomes ≥500% above the poverty level and in those with college graduate or higher education achievement. These results have been reported previously for fruit, but this is the first report for berry consumption.[24] Lower economic status is associated with lower fruit intake in general, and the same is true for berry intake. Recent reports suggest that part of this difference may be due to the perceived higher cost of fruits for people in a lower economic status.[25,26] Interventional studies with low income consumers indicate that subsidies may help to increase both fruit and vegetable consumption.[27] The observation that fruit juice intake increases and whole fruit intake declines as income and education level decreases is also likely associated with perceived costs and economic constraints.[24] There may be a perception that fruit juice is a less expensive option to eating whole fruit. A modeling study by Monsivais and Rehm (2012)[28] indicated that replacing fruit juice with whole fruit increases the cost of the diet; however, whole frozen and canned fruits are typically less expensive than fresh, providing economical options for consumers at any income level. Hence, total fruit and berry intake can be increased by utilizing multiple forms of fruit available in the market place. Additionally, issues with transportability, storage, or concerns about waste can be addressed by including frozen, canned, dried, and juice forms of fruit in their grocery carts, all of which will help consumers meet total fruit recommendations and diversify fruit intake consistent with health at an affordable price.

Limited information is available regarding attitudes and behaviors associated with fruit intake, and no information is available regarding attitudes and behaviors associated with berry intake. The NHANES offered an opportunity to link attitudes and behaviors with intake. The present study found that importance of nutrition (Very/somewhat important *vs.* Other/less important) and viewing one's diet as healthy (Excellent/very good *vs.* Other/less than or equal to good) is associated with significantly greater intake of total fruit and of berries. The mean intakes were ~12% and 43% higher for total fruit, respectively, and 70% and 96% higher for berry intake, respectively. Likewise, knowledge of nutritional guidance and use of the food labels (Nutrition Facts or Ingredient lists) were associated with greater intake of total fruit and of berries. Knowledge of dietary guidance was associated with greater berry intake than in the case of total fruit intake. Having heard of or having looked up MyPyramid, which was the dietary guidance graphic in existence at the time of this survey, was associated with nearly 2-fold or higher mean berry intake and 6–30% higher total fruit intake. Adults who had knowledge of fruit and vegetable intake recommendations had twice the berry consumption compared to persons who indicated not having knowledge of the dietary recommendations, while total fruit intake did not differ. Those who used food labels always or most of the time had higher berry intake (~64% more berries) and higher fruit intake (~33% more fruit) compared to those who were infrequent or non-users of food labels. Overall, these results suggest that dietary guidance and food labeling may have a role in increasing intake of berries.

In addition to the influence of dietary guidance and labeling on berry intake, a main factor associated with fruit intake behavior was having fruit in the home. When fruit was in the home, mean total fruit intake was greater by ~73% and berry intake greater by 130% when compared to having fruit in the home less often. Having soft drinks and fruit punch at home was associated with lesser amounts of total fruit and berry intake. When considering strategies to increase fruit intake and diversify intake, just getting berries and fruit into the home appears to have a great impact on intake. Educational activities that result in more homes with fruit available may have important implications for total fruit intake. Common barriers to fruit intake, including price and shelf-life, did not significantly impact means of total fruit or berry intake as has been suggested by others.[29]

The study has strengths and limitations. The strengths were that the surveys collected detailed dietary intake records, and the analysis provides robust estimates for the U.S. population and subpopulations. The most recent three cycles of NHANES were included in the analysis. The estimates included total fruit intake comprised of whole fruit, fruit juice, and fruit that is part of mixed foods; whereas many previous reports do not disaggregate mixed foods and, therefore, may underestimate fruit intake. A unique aspect and strength of the analysis was the use of the Food Patterns Equivalent Database for identifying and quantifying total intake of fruit and fruit juice and the close examination of food item descriptions to identify and parse out the berries. In addition to dietary intake data, attitudes and behaviors associated with fruit and berry intake were examined. The main limitation is the possibility of misreporting during the 24 h recall.

 

## Conclusion

Understanding berry intake in the context of total fruit intake and the factors associated with it, are key to building strategies to meet public health goals of increased intake, but also to elevate awareness of the need to increase variety of fruits consumed. While dietary guidance presently does not specify subcategories of fruit to consume, a major fruit category, berries, are consumed at very low levels. This may not be ideal given the distinctive nutrient and phytochemical composition and associated health benefits of consuming berries. To our knowledge, this is the first time that berries have been examined in such detail in terms of (1) berries as a sub-category of total fruit, (2) berry consumption by demographic subgroups, and (3) attitudes and behaviors associated with berry (and fruit) consumption. Berries are available year-round in a variety of forms that could contribute to increased variety of fruit intake and help fill the fruit intake gap. The behavioral results suggest that getting fruit in homes could have a significant impact on total fruit and especially berry intake. Likewise, use of Nutrition Facts and ingredient labeling was associated with greater total fruit and berry intake, while awareness of an "amount" of fruit associated with good health was associated with a significant increase in berry intake. Collectively, these results suggest that food labeling and dietary guidance are factors related to fruit intake in general and berry intake specifically. Furthermore, the emerging data on the health benefits of berries make a compelling case for understanding current intake and finding ways to increase availability of fruits and berries in the home, which may help to increase and diversify fruit intake in the diets of Americans.

## Conflicts of interest

There are no conflicts of interest to declare for any authors.

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