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U.S. DEPARTMENT OF AGRICULTURE

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Examining the Decline in U.S. Per Capita Consumption of Fluid Cow's Milk, 2003–18

Hayden Stewart, Fred Kuchler, Diansheng Dong, and Jerry Cessna

USDA Economic Research Service
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Abstract

USDA, Economic Research Service data reveal a persistent, downward trend in U.S. per capita consumption of fluid cow's milk. Using data collected between 2003 and 2018 through the National Health and Nutrition Examination Surveys (NHANES), we identify changes over time in the amounts of fluid cow's milk consumed by children, teenagers, and adults as well as the amounts each age group drinks as a beverage, pours into cereal, and adds to other types of beverages like tea and coffee. Results reveal that U.S. consumers of all ages are drinking less milk and milk drinks. Children are also consuming less milk with cereal. These declines prevent individuals from consuming a diet more in line with Federal recommendations. They also appear to reflect a combination of demographic and generational changes in the U.S. population as well as changes in the competitiveness of fluid cow's milk and cereal with other beverages and breakfast options.

Keywords: dairy products, diet quality, dietary trends, nutrition, fluid milk, yogurt, cheese, National Health and Nutrition Examination Surveys (NHANES), U.S. Department of Agriculture, USDA, Economic Research Service, ERS

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U.S. DEPARTMENT OF AGRICULTURE

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Examining the Decline in U.S. Per Capita Consumption of Fluid Cow's Milk, 2003–18

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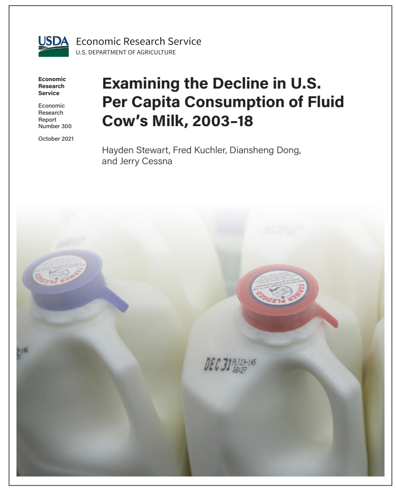
What Is the Issue?



U.S. per capita consumption of fluid cow's milk has been decreasing for over 70 years. During the previous decade, it fell at a faster rate than it did during each of the previous six decades. USDA, Economic Research Service (ERS) data show that the average rate of decrease was 1.0 percent per year over the 2000s. During the 2010s, it was 2.6 percent per year.

About 90 percent of the U.S. population does not consume enough dairy products to meet Federal dietary recommendations, and declining per capita consumption of fluid cow's milk prevents these individuals from consuming a diet more line in with those recommendations. According to the Federal *Dietary Guidelines for Americans, 2020–2025*, children aged 2 through 10 years should consume 2 to 3 cup-equivalents of dairy products per day (with specific quantities based on age, gender, and level of physical activity). Individuals older than age 10 should consume 3 cup-equivalents. Consuming 1 cup of cow's milk, 1 cup of fortified soy beverage, 1 cup of yogurt, 1.5 ounces of natural cheese, or 2 ounces of processed cheese contributes 1 cup-equivalent toward meeting daily dairy recommendations. Although U.S. per capita consumption of cheese and yogurt increased threefold since 1970, trends in fluid cow's milk consumption prevent overall dairy intake from rising much above 1.5 cup-equivalents per person per day.

Using data collected between 2003 and 2018 through the National Health and Nutrition Examination Surveys (NHANES), we disaggregate trends in U.S. fluid cow's milk consumption into changes over time in the amounts that individuals drank as milk and in milk drinks, poured into cereal, and added to other types of beverages like tea and coffee. We also investigate each of these trends separately for children, teenagers, and adults.

ERS is a primary source of economic research and analysis from the U.S. Department of Agriculture, providing timely information on economic and policy issues related to agriculture, food, the environment, and rural America.

What Did the Study Find?

Drinking is the primary way that people consume fluid cow's milk. Defining this type of usage to include drinking plain and flavored milk as well as malted milk, eggnog, kefir, hot chocolate, and other milk-based beverages, we found:

- In 2003–04, individuals drank about 0.57 cup-equivalents of milk and milk drinks per person, per day. That number fell to 0.53 cup-equivalents in 2009–10 and to 0.33 cup-equivalents in 2017–18.
- Consumption was down among children, teenagers, and adults.

Another way people consume fluid cow's milk is by pouring it into cold or hot cereal. We found:

- In 2003–04, individuals used about 0.23 cup-equivalents of milk in cereal per person, per day. That number fell to 0.21 cup-equivalents in 2009–10 and to 0.17 cup-equivalents in 2017–18.
- Per capita milk consumption with cereal was down primarily among children.

A third way that people consume fluid cow's milk is by adding it to other types of beverages like coffee and tea. In 2017–18, individuals consumed about 0.07 cup-equivalents per person per day this way, about the same amount as in 2003–04.

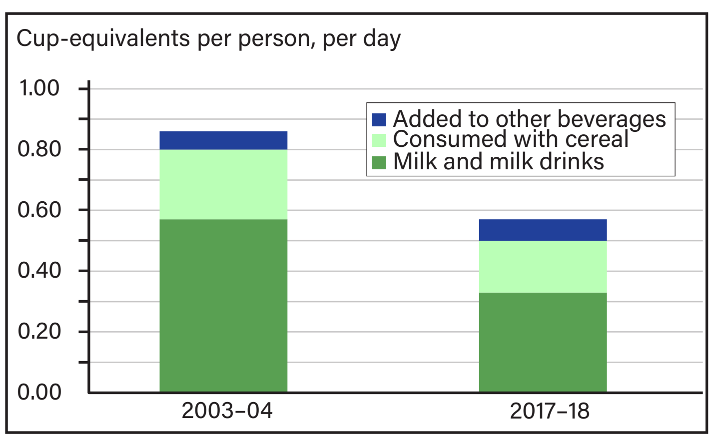
Many factors contribute to declining fluid cow's milk consumption, including demographic and generational changes in the U.S. population. Younger generations who grew up drinking less milk as children appear to consume less at all ages. However, even after accounting for demographic and generational changes, there is still a downward trend in consumption over the survey period. This decrease appears to reflect changes in the competitiveness of cow's milk compared to other beverages at retail stores, as well as the competitiveness of cereal compared to other breakfast options.

How Was the Study Conducted?

Milk consumption was measured using dietary recall data collected through the National Health and Nutrition Examination Surveys (NHANES), an ongoing, nationally representative U.S. survey designed to assess health and nutritional status. For the study, we pooled consumer data from eight survey cycles: 2003–04, 2005–06, 2007–08, 2009–10, 2011–12, 2013–14, 2015–16, and 2017–18. We examined consumption by children (ages 12 and under), teenagers (ages 13 through 19), and adults (ages 20 and older). Statistical models were also estimated for each age group to separate consumption trends associated with demographic and generational change from those most likely associated with other factors.

From 2003–04 to 2017–18, U.S. consumers drank less milk and milk drinks per capita and poured less milk into cereal, but they continued to consume about the same amount of milk with other beverages, such as coffee or tea

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–18.



Examining the Decline in U.S. Per Capita Consumption of Fluid Cow's Milk, 2003–18

Introduction

The types of foods people eat in the United States and how we consume those foods are constantly evolving. The USDA, Economic Research Service (ERS) creates an annual data series that allows analysts to track long-run consumption trends for more than 200 commodities, including fluid cow's milk, cheese, and red meat. (USDA-ERS, 2021).[1] These data reveal that U.S. per capita fluid cow's milk consumption has been trending downward since about the mid-1940s, and it fell at a faster rate during the 2010s than it did during each of the previous six decades[2] (note: in this report, "milk" hereafter refers to fluid cow's milk unless otherwise stated).[3] Milk consumption per person fell at an average annual rate of 1.0 percent during the 2000s (figure 1). It then fell at an average annual rate of 2.6 percent during the 2010s.[4]

About 90 percent of individuals do not consume enough dairy products to meet Federal dietary recommendations (USDA and DHHS, 2020). According to the Federal *Dietary Guidelines for Americans, 2020–2025*, children ages 2 through 10 years should consume 2 to 3 cup-equivalents of dairy products per day (with specific quantities based on age, gender, and level of physical activity) while those older than age 10 need to consume 3 cup-equivalents. Consuming 1 cup of cow's milk, 1 cup of fortified soy beverage, 1 cup of yogurt, 1½ ounces of natural cheese, or 2 ounces of processed cheese contributes 1 cup-equivalent toward meeting daily dairy recommendations. Although individuals increased their per capita consumption of cheese and yogurt threefold since 1970 (USDA-ERS, 2021), the downward trend in fluid cow's milk consumption has prevented overall dairy intake from rising much above 1.5 cup-equivalents per person per day (USDA-ERS, 2021).[5]

[1]USDA, Economic Research Service (ERS) uses data on the amounts of foods available for human consumption to proxy for actual consumption. For beverage milks, the data represent quantities sold by fluid processors. ERS food availability data are available back to 1909. Loss-adjusted food availability data, which more closely approximates consumption, are available back to 1970.

[2]U.S. per capita availability fell by 7.4 percent between 1950 and 1959, 8.4 percent in the 1960s, 9.9 percent in the 1970s, 5.4 percent in the 1980s, 10.9 percent in the 1990s, 7.9 percent in the 2000s, and 20.2 percent in the 2010s.

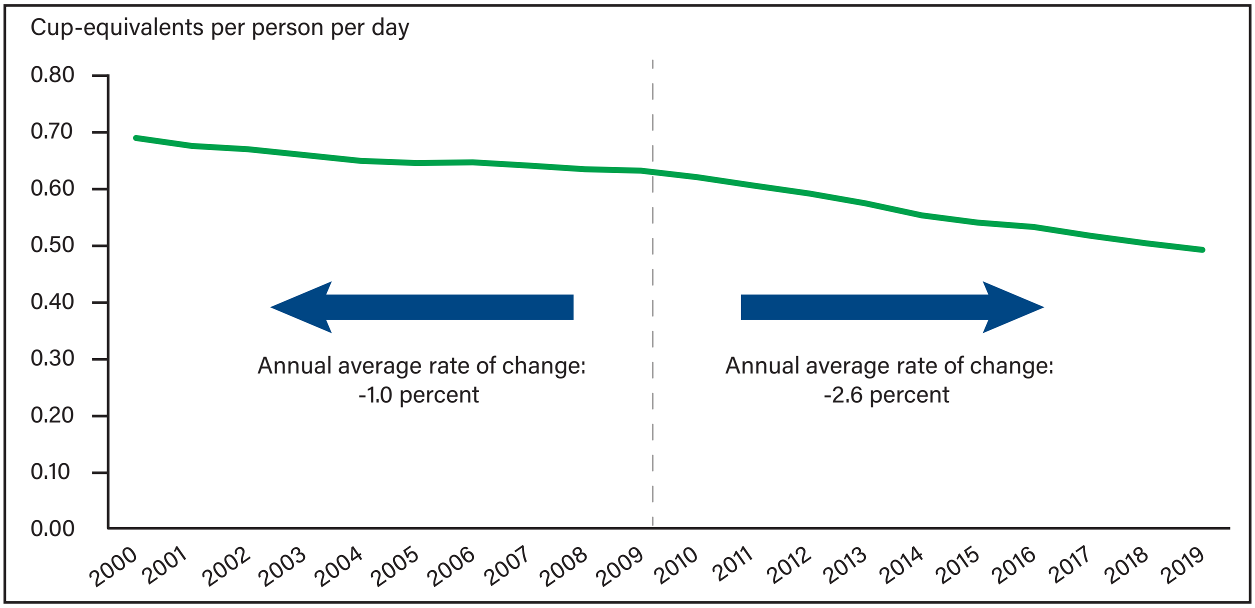
[3]Our focus in this study is on U.S. per capita consumption of fluid cow's milk. We consider how changes in the consumption of other products could affect overall dairy intake, but we exclude those products from the main empirical analysis. This includes plant-based milk alternatives. Among those products, only soy beverages fortified with calcium are comparable enough to dairy milk to be considered a dairy equivalent by the *Dietary Guidelines for Americans, 2020-2025.* Consuming almond, coconut, cashew, hemp, oat, rice, and other types of plant-based milk alternatives does not count toward an individual's dairy intake goals. Sales of soy beverages have notably been falling in recent years and, as of 2019, accounted for only about 1 percent of the combined cow's milk and milk alternatives market (Dairy Management Inc., 2019).

[4]This change in the rate of decrease may substantially alter consumers' current and future intake of fluid cow's milk. If the annualized rate of decrease remains at 2.6 percent, per capita consumption would fall by half in 26.7 years. If the annualized rate of decrease were to revert to 1 percent, it would take 69.3 years for per capita consumption to fall by half.

[5]ERS food availability data show that in the late 1970s and early 1980s, U.S. total dairy intake, including the consumption of fluid milk and other dairy products, averaged between 1.44 and 1.48 cup-equivalents per person per day. By the mid-1980s, it had increased slightly and remained between 1.52 and 1.57 cup-equivalents per person per day throughout the remainder of the 1980s, 1990s, and the 2000s, as rising per capita yogurt and, in particular, cheese consumption were generally sufficient to offset decreases in per capita fluid milk consumption.

Figure 1

U.S. per capita consumption of fluid cow's milk fell at a faster rate in the 2010s than during the 2000s



Source: USDA, Economic Research Service Food Availability (Per Capita) Data System, loss-adjusted food availability data for all beverage cow's milk.

The rate of decline in U.S. per capita milk consumption was faster in the 2010s than in the 2000s despite the promotional efforts of public- and private-sector organizations. USDA encourages milk drinking through its National School Lunch and School Breakfast programs; the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC); and the Special Milk Program. Schools participating in the National School Lunch Program, for example, must offer students 1 cup of milk with each lunch.

Dairy farmers, dairy importers, and fluid milk processors promote dairy products through two checkoff programs[6] under the oversight of USDA's Agricultural Marketing Service (AMS). The Dairy Research and Promotion Program is a national producer and importer program for dairy product promotion, research, and nutrition education (USDA, AMS, National Dairy Promotion and Research Board, 2021). To fund the program, U.S. dairy farmers pay an assessment of 15 cents per hundredweight (cwt) on their milk production, and importers pay 7.5 cents per cwt on dairy products imported into the United States on a milk-equivalent basis. The Fluid Milk Processor Promotion Program, by contrast, develops and finances a generic advertising program to maintain and expand markets and uses for fluid milk products produced in the United States (USDA, AMS, Fluid Milk Processors Promotion Board, 2021). Fluid milk processors pay an assessment of 20 cents per cwt on fluid milk processed and marketed in consumer-type packages.

Previous studies suggest demographic and generational changes in the U.S. population are likely responsible for the persistent decline in per capita milk consumption (Stewart et al., 2012, 2013; Sebastian et al., 2010; Beydoun et al., 2008; Looker et al., 1993). Some demographic groups tend to consume more milk than others, but these groups are decreasing as a share of the overall U.S. population. Non-Hispanic Whites tend to consume more milk than other racial and ethnic groups (Beydoun et al., 2008; Looker et al., 1993). Children and teenagers tend to consume more than adults (Sebastian et al., 2010). It is plausible that per capita milk consumption declined because the United States is now racially and ethnically more diverse and older. Between 2010 and 2019, individuals younger than 10 years decreased from 13.1 percent to 12.1 percent

[6]A checkoff program collects funds from the producers of a particular agricultural commodity and uses these funds to promote and conduct research on that commodity.

of the U.S. population while those aged 10 through 19 years decreased from 13.8 percent to 12.6 percent (U.S. Department of Commerce, Bureau of the Census, 2021).[7] Over the same period, non-Hispanic Whites decreased from 63.7 percent to 60.0 percent of the population (U.S. Department of Commerce, Bureau of the Census, 2021).

Preferences for milk also depend on individuals' experiences while growing up. Using household purchase data, Kuhns and Saksena (2017) found that households headed by members of younger generations exhibited less demand for milk. Purchase levels were lowest among those headed by Millennials (i.e., individuals born after 1980). Using dietary intake surveys collected by USDA between the 1970s and the 2000s, Stewart et al. (2012, 2013) demonstrated that individuals born in the 1970s drank less milk in their teens, twenties, and thirties than those born in the 1960s at the same age points. People born in the 1980s and 1990s are drinking even less milk in their adulthood than those born in the 1970s. As successive generations of children and teenagers grew up less accustomed to consuming milk than their preceding generation, they developed different life-long habits. It follows that the replacement of older generations with newer ones along with aging and increased ethnic and racial diversity explain some of the decrease in U.S. per capita milk consumption.

The goals of this study are to understand who in the U.S. population is consuming less fluid cow's milk, identify how their consumption patterns changed, and evaluate alternative explanations for why per capita consumption fell at a faster rate in the 2010s than in the 2000s. Demographic and generational changes in the U.S. population are gradual and are not likely responsible for all of the recent faster rate of decline. We examined changes over time in the amounts of milk that individuals drank as milk and in milk drinks, poured into cereal, and added to other types of beverages like tea and coffee. We also investigated each of these trends separately for children (ages 12 and under), teenagers (ages 13 through 19), and adults (ages 20 and older). Finally, we estimated statistical models to measure the same trends while controlling for generational change, the declining proportion of children and teenagers, and the declining proportion of non-Hispanic Whites in the U.S. population. If, after accounting for these phenomena, we continue to find a downward trend in milk consumption, then other explanations must be considered. The data used for our analysis are centered on 2009 to 2010, when an obvious break occurred in long-run consumption trends (figure 1).

[7]The American Community Survey is an ongoing survey administered by the U.S. Department of Commerce, Bureau of the Census that provides data on the social and economic characteristics of the U.S. population. An online search tool is available for obtaining annual data.

A Variety of Factors Could Be Responsible

Many factors could cause U.S. per capita consumption of fluid cow's milk to fall in addition to demographic and generational changes in the population. We considered factors raised by researchers, industry analysts, policy advocates, the media, and economic theory. These include competition between milk and alternative beverages through product innovations, decreases in cereal consumption, changes in school lunch and breakfast programs, and changes in retail prices. In this report, these types of developments are called changes in the "food environment."

Consumers face a diverse array of choices when they shop for food. Manufacturers constantly introduce new products.[8] Consumers themselves also change. Their preferences can evolve over time, with some—including perhaps people of all ages, geographies, and ethnicities—choosing different mixes of beverages. Nutritionists have long feared that sugar-sweetened beverages (SSBs), in particular, are replacing milk.[9] Fisher et al. (2001) suggested that children's milk consumption may decrease with exposure to soft drinks. Hanson et al. (2005) similarly found that dairy intake was lower among girls in homes where soft drinks were available. However, in recent years, U.S. per capita consumption of SSBs has also declined. Using data on individuals' beverage choices between 2003 and 2014, Bleich et al. (2018) identified simultaneous decreases in milk, 100 percent juice, and SSBs consumption. In another study, using data collected between 2013 and 2018, Stewart et al. (2021) examined households' purchases of milk, soft drinks, 100 percent juice and juice drinks, bottled water, and coffee and tea drinks. Competition between milk and these other major beverage categories was found to have little impact on milk sales over those years.

Products known to compete with fluid cow's milk include plant-based milk alternatives, such as "almond milk" and "soy milk." Using retail scanner data, Stewart et al. (2020) confirmed that sales of these beverages negatively affect purchases of fluid cow's milk. However, given that the increase in their sales is much smaller than the decrease in sales of fluid cow's milk, plant-based milk alternatives can only explain a small share of overall sales trends. Sales of plant-based milk alternatives may be contributing to, but are not likely to be, a primary driver of sales trends for fluid cow's milk.[10] Other beverage categories that may compete with fluid cow's milk include energy drinks, sports drinks, and waters with fruit flavoring. Although sales of any one of these product categories are also likely too small to explain much of the overall, long-run decline in per capita milk consumption, perhaps, growth in a number of them may collectively explain a significant portion of why milk consumption fell at a quicker rate in the 2010s than in the 2000s.

To retain existing customers and win others, dairy industry companies also develop new products. Analysis of retail scanner data provided by Information Resources, Inc. (IRI) reveals that fluid milk processors offer thousands of milk and milk drinks differentiated by fat content, package size, flavor, and other characteristics. Lactose-free products are available for the lactose intolerant, as well as acidophilus milk, a probiotic drink. Some cow's milk has added DHA omega-3 fatty acids.[11] Some cow's milk is further labeled USDA

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[8]Martinez and Levin (2017) estimated that food manufacturers launched 32,600 to 53,061 new products per year between 2009 and 2012.

[9]SSBs broadly include carbonated soft drinks, fruit drinks, and energy drinks, among others.

[10]*Dietary Guidelines for Americans, 2020-2025* recommends amounts of food to be eaten from each of the five major food groups. Fortified soy milk is currently included in the Dairy Group because fortification yields a product high in calcium and other nutrients that are found in dairy products (but not saturated fat and cholesterol). Other plant-based milk alternatives are not included in the Dairy Group. Whether consumers are aware of these distinctions is an open research question. *Consumer Reports* concluded from the results of its 2018 survey that consumers are divided in their opinions about distinctions between cow and plant-based products: 26 percent of respondents answered that plant-based alternatives contain less of some key nutrients than cow's milk and 27 percent said more, with 20 percent saying nutrients are the same (Consumer Reports, 2018). Further complicating the matter is the ongoing shift in the plant-based market from dominance of soy products to almond products, making it difficult to guess what consumers were thinking when they were surveyed.

[11]Docosahexaenoic acid (DHA) is one type of omega-3 fatty acid. It is naturally found in fish and other seafood.

Organic and/or non-GMO (from a cow whose diet did not include genetically modified crops). Some packaging calls attention to cows as pasture-raised or grass-fed. Covington (2017) reported his local supermarket stocked more than 100 different products in its fluid milk case. With extensive product differentiation, milk manufacturers might discover products that better align with consumers' preferences.[12]

Declining consumption of breakfast cereals is a separate issue facing the dairy industry. Milk and breakfast cereals are complements. The two are commonly eaten together. However, breakfast bars, breakfast meals offered by fast-food chains, yogurt, and other morning time options are substitutes for breakfast cereal, reducing sales of cereal and milk (Wells, 2017; Peltz, 2016). Breakfast cereal manufacturers, in turn, have launched new products, including some designed for "on-the-go" consumption that can be eaten without milk (Wells, 2017).

Changes have also occurred in the types of milk that children can receive at school. The Healthy, Hunger-Free Kids Act (HHFKA) of 2010 sought to improve child nutrition.[13] Beginning with the 2012–13 school year, USDA requires schools participating in its free and subsidized lunch and breakfast programs to serve children a healthier mix of vegetables, more whole grains, and lower-fat milks.[14] Schools cannot offer whole or reduced-fat (2 percent milkfat) milk. Only low-fat (1 percent) or skim milk (less than 0.5 percent milkfat) can be served. Initially, if milk was flavored (e.g., chocolate), the program only allowed skim milk. The USDA later changed the rules to allow low-fat flavored milk.[15] Some journalists and policy advocates argued that these regulations reduce student milk consumption (e.g., Robinson and Mulvany, 2019; Leach, 2018). If students are unhappy with school meals, they are more likely to bring bagged lunches that are less likely to include milk than school meals. Furthermore, if students do not like the type of milk they receive in school lunches, they are not required to drink it, possibly resulting in food waste.

Food prices are yet another aspect of the food environment that could influence milk consumption patterns. Data from the Bureau of Labor Statistics' Consumer Price Index (CPI) reveal how prices evolved for different types of food. Examining the CPI for whole milk and the CPI for nonalcoholic beverages and beverage materials[16] from 2003 through 2018 reveals that prices for whole milk products are more volatile than prices for most other types of beverages (see appendix 1 for details). However, a clear upward or downward trend in their relative prices cannot be determined. Relative price changes likely caused some fluctuation in milk consumption, but existing evidence offers no suggestion that relative prices are a primary driver of long-run consumption trends.

Overall, it appears the downward trend in per capita milk consumption may be difficult to reverse because of demographic and generational changes. The competitiveness of milk compared to other beverages at retail stores and in schools and the competitiveness of cereal compared to other breakfast options could cause the rate of decline to be faster or slower.

[12]Dairy products, excluding yogurt, represented 5.1 percent to 5.6 percent of all new product entries identified by Martinez and Levin (2017) between 2009 and 2012, or approximately 1,800–2,700 new, non-yogurt dairy products per year.

[13]The HHFKA authorized funding and set policy for USDA's core child nutrition programs: the National School Lunch Program, the School Breakfast Program; the Special Supplemental Nutrition Program for Women, Infants, and Children; the Summer Food Service Program; and the Child and Adult Care Food Program (Public Law No: 111-296).

[14]The Federal Register publishes nutrition requirements for school lunches and breakfasts in the Code of Federal Regulations (CFR). Those for lunches are available in 7 CFR 210.10 and those for breakfasts are in 7 CFR 220.8.

[15]For the 2017–18 school year, low-fat flavored milk was allowed for States that could demonstrate hardship by documenting a reduction in student milk consumption or an increase in school milk waste (USDA, Food and Nutrition Service, 2017). Beginning with the 2018–19 school year, the requirement to demonstrate hardship was removed, allowing schools across the country to serve low-fat flavored milk (82 Fed. Reg. 56707).

[16]Roasted coffee, instant coffee, and tea are included among beverage materials.

Food Consumption Diaries Provide Needed Data on Dietary Trends

USDA, Economic Research Service (ERS) developed the Food Availability (Per Capita) Data System (FADS) to track long-run consumption trends for key commodities. The FADS reveals that U.S. per capita milk consumption has been trending downward at an increased rate in recent years (figure 1).[17] However, these are highly aggregated data for the U.S. population as a whole. They do not reveal who is consuming less milk, such as adults, teenagers, or children. The data also do not break out consumption trends according to how consumers use foods, such as the amounts of milk consumed as a beverage, eaten with cereal, or poured into coffee and tea drinks. For this type of information, food purchase and food consumption data must be considered.

The National Consumer Panel (NCP) is a key source of data on food purchases in the United States.[18] Members of the NCP record what they bought after each shopping occasion at a supermarket, convenience store, or warehouse club store, among others (Muth et al., 2016). This information can be combined with data on each household's race, ethnicity, age, family structure, income, and geographic location, as well as data on purchased products' prices. Stewart et al., (2020) and Stewart et al., (2021) used weekly NCP data from the mid-2010s to study trends in milk demand. They identified a persistent downward trend in milk purchases over that period. However, food purchase data do not reveal how foods were consumed or which household members consumed them. NCP data also lack information on foods purchased at foodservice outlets, including restaurants and schools.

The National Health and Nutrition Examination Survey (NHANES) is a key source of data on U.S. food consumption patterns. Each year about 5,000 individuals report their economic and demographic characteristics as well as their health and nutrition status. They may also participate in What We Eat in America (WWEIA), a USDA-supported dietary intake module. Participants complete two 24-hour dietary recalls on nonconsecutive days. USDA's Automated Multiple Pass Method is used to help them recall each food and beverage consumed (USDA, Agricultural Research Service, 2021). These data offer a unique perspective on how participants consume food, how much they eat, when they eat, and by whom. For example, an individual might report consumption of chocolate milk in the daytime while at home and eating a sandwich. The data do not tell us about how they bought the food or the cost. It could be unclear if milk was purchased as ready-to-drink flavored milk, as plain milk to which the consumer added chocolate powder or syrup, or even as dry milk to which the consumer added both water and chocolate powder or syrup. To obtain a sample of participants representative of the civilian, non-institutionalized U.S. population, the NHANES uses a complex, multistage, probability sampling design.[19] Data are released in 2-year survey cycles.

[17]The name of the data product reflects ERS' methodology that relies on information about the amounts of foods available for human consumption to proxy for actual consumption (see footnote 1).

[18]Two marketing research firms, Information Resources, Inc. (IRI) and The Nielsen Company, maintain the NCP as an operational joint venture.

[19]Descriptive statistics must be calculated using survey weights for those estimates to be representative of the U.S. population. Sample weights account for differential probabilities of selection, survey nonresponse, and differences between the final sample distribution and the target population distribution. Testing hypotheses about the magnitude of descriptive statistics further requires an estimate of variance. Details of the underlying sample design are not publicly released to protect participants' identities. Masked variance units (MVUs) are instead provided. Use of these MVUs produces variance estimates that closely approximate what would have been estimated using actual sample design information.

To investigate U.S. milk consumption trends over the 2000s and 2010s, data were pooled on individuals from eight NHANES survey cycles (i.e., NHANES 2003–04, 2005–06, 2007–08, 2009–10, 2011–12, 2013–14, 2015–16, and 2017–18).[20] Collectively, these data span 16 years, providing a cross-section and longitudinal perspective on 69,531 individuals. These data show that the U.S. population aged, had a reduction in the percentage of non-Hispanic Whites, and was better educated and less likely to have often consumed fluid cow's milk while growing up (table 1).[21] In the 2003–04 survey cycle, 68 percent reported having often consumed milk as a child aged 5 through 12 years; 58 percent reported doing so as a teenager aged 13 through 17. By 2017–18, these percentages fell to 60 percent and 44 percent. NHANES data corroborate the analysis of USDA, ERS food availability data and past research using scanner data that show U.S. consumers have been drinking increasingly less over time. Table 2 and figure 2 show trends in per capita U.S. consumption disaggregated by type of usage based on the data.

Table 1
Selected demographic characteristics of the U.S. population

	2003–04	2007–08	2013–14	2017–18
Ratio of family income to poverty	2.805	2.885	2.744	2.899
	(0.084)	(0.100)	(0.114)	(0.064)
Non-Hispanic White	0.704	0.675	0.622	0.592
	(0.037)	(0.036)	(0.036)	(0.028)
College-educated (adults only)	0.233	0.247	0.300	0.302
	(0.018)	(0.022)	(0.019)	(0.024)
Household size (number of people)	3.293	3.343	3.452	3.430
	(0.053)	(0.055)	(0.062)	(0.055)
Age (years)	37.196	37.471	37.732	38.726
	(0.476)	(0.544)	(0.536)	(0.561)
Female	0.510	0.521	0.507	0.511
	(0.008)	(0.007)	(0.007)	(0.010)
Child (ages 12 and younger)	0.155	0.152	0.164	0.156
	(0.006)	(0.007)	(0.009)	(0.006)
Teenager (ages 13 through 19)	0.106	0.103	0.095	0.094
	(0.007)	(0.005)	(0.004)	(0.006)
Often drank milk when aged 5 to 12 years (adults only)	0.677	0.668	0.671	0.602
	(0.013)	(0.019)	(0.009)	(0.014)
Often drank milk when aged 13 to 17 years (adults only)	0.580	0.566	0.555	0.444
	(0.015)	(0.017)	(0.012)	(0.019)

Notes: Standard errors in parentheses. All estimates are weighted. The standard errors of those estimates corrected for complex survey design using the masked variance units in the National Health and Nutrition Examination Survey (NHANES) public use data files.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–18.

[20]Excluded from the analysis are infants who reportedly consumed human milk.

[21]Data for alternating cycles are provided for ease of exposition.

Table 2a

Proportion of individuals who consumed fluid cow's milk on a given day by type of usage

	2003–04	2005–06	2007–08	2009–10	2011–12	2013–14	2015–16	2017–18
Proportion who consumed milk and milk drinks	0.31 (0.02)	0.30 (0.01)	0.30 (0.02)	0.31 (0.01)	0.29 (0.01)	0.26 (0.01)	0.24 (0.01)	0.22 (0.01)
Proportion who consumed milk with cereal	0.23 (0.01)	0.26 (0.01)	0.24 (0.01)	0.26 (0.01)	0.25 (0.01)	0.23 (0.01)	0.21 (0.01)	0.19 (0.01)
Proportion who consumed milk in other beverages	0.11 (0.01)	0.12 (0.01)	0.11 (0.01)	0.14 (0.01)	0.11 (0.01)	0.11 (0.01)	0.11 (0.01)	0.12 (0.01)

Notes: Standard errors in parentheses. All estimates have been weighted and the standard errors of those estimates corrected for complex survey design using the masked variance units (MVUs) available with the National Health and Nutrition Examination Survey (NHANES) public use data files.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–18.

Table 2b

Average daily amount of fluid cow's milk consumed in cup-equivalents by individuals

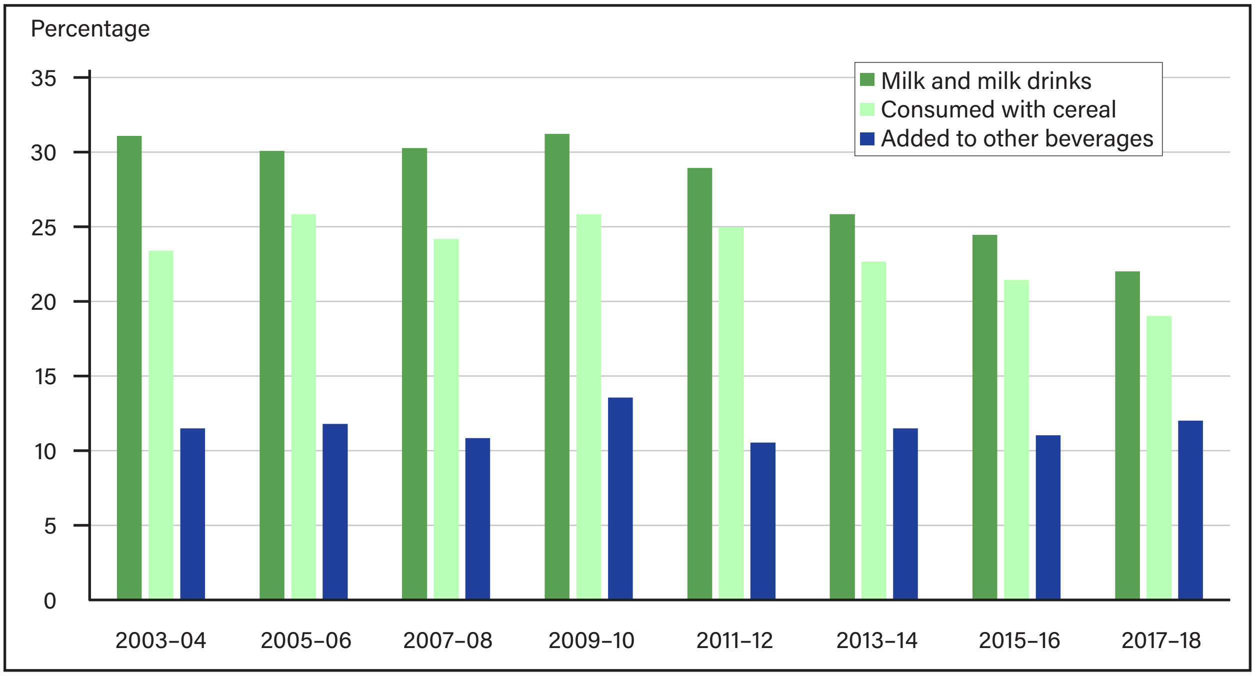
	2003–04	2005–06	2007–08	2009–10	2011–12	2013–14	2015–16	2017–18
Average amount consumed in milk and milk drinks	0.57 (0.04)	0.54 (0.03)	0.49 (0.03)	0.53 (0.02	0.47 (0.02)	0.42 (0.02)	0.36 (0.03)	0.33 (0.02)
Average amount consumed with cereal	0.23 (0.01)	0.21 (0.01)	0.19 (0.01)	0.21 (0.01)	0.21 (0.01)	0.19 (0.01)	0.17 (0.01)	0.17 (0.01)
Average amount consumed in other beverages	0.06 (0.01)	0.06 (0.01)	0.05 (0.004)	0.07 (0.005)	0.06 (0.004)	0.06 (0.01)	0.06 (0.01)	0.07 (0.005)

Notes: Standard errors in parentheses. All estimates have been weighted and the standard errors of those estimates corrected for complex survey design using the masked variance units (MVUs) available with the National Health and Nutrition Examination Survey (NHANES) public use data files.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–18.

Figure 2a

Percentage of individuals who consumed fluid cow's milk on a given day by year and type of use

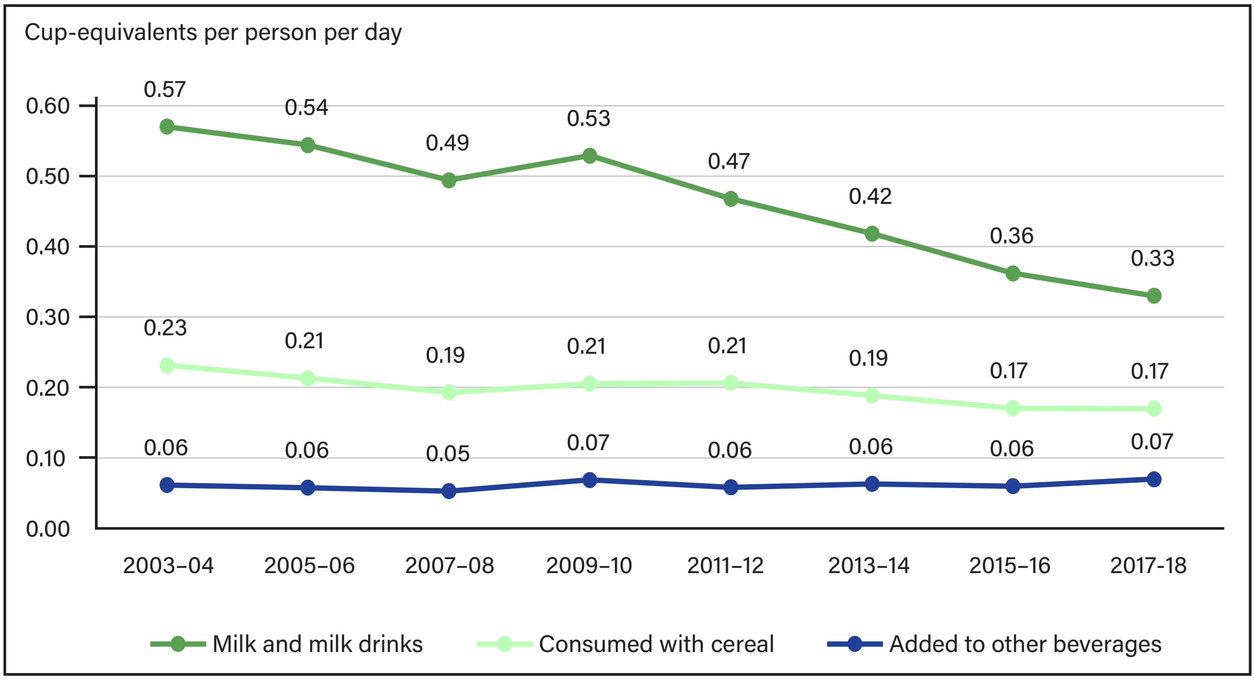


Note: All estimates have been weighted.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–2018.

Figure 2b

Individuals' average daily consumption of fluid cow's milk measured in cup-equivalents by year and type of use



Note: All estimates have been weighted.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–2018.

Comparing Two Sample Means

A two-sample t-test is a statistical test used for comparing two groups. Such tests were used to evaluate differences in average milk consumption between participants in different survey cycles, differences in average consumption between different age groups, and differences in proportions. In all cases, the test statistic is the difference in means or proportions relative to (divided by) the sample standard deviation. We assumed that data from the two samples were independent. This allowed us to calculate the sample standard deviation as the square root of the test statistic's pooled variance. The pooled variance equals the sum of each mean's or proportion's individual variance. For this report, results are determined to be statistically significant if the null hypothesis of a zero difference can be rejected at the 5-percent level.

Milk and Milk Drinks

Drinking is the primary way that people use fluid cow's milk. We define this type of usage to include drinking white milk, flavored milk, buttermilk, malted milk, eggnog, kefir, hot chocolate, reconstituted dry milk, evaporated milk, cocoa with dry milk and added water, dairy-based smoothies, milkshakes, milk fruit drinks, and other milk beverages included among dairy milk and dairy milk drinks in USDA's Food and Nutrient Database for Dietary Studies (FNDDS).[22] [23] This database converts products NHANES participants consume into gram amounts and their nutrient values. Of course, milk drinks also contain non-milk ingredients. USDA's Food Patterns Equivalents Database (FPED) was used to estimate the amount of cow's milk in cup-equivalents in each product.[24] [25]

The proportion of consumers drinking milk and/or milk drinks on a given day was relatively constant from 2003–04 through 2009–10, fluctuating between 30 and 31 percent (table 2a). However, in the second half of the study period, the proportion declined, falling to 22 percent in 2017–18. The average amount consumed per day—including individuals who drank no milk or milk drinks—was 0.57 cup-equivalents in 2003–04 compared with 0.33 in 2017–18 (table 2b). This decrease is statistically significant (see box, "Comparing Two Sample Means").

Milk With Cereal

Another way people use fluid cow's milk is by pouring it into cereal. We define this type of usage to include milk added to hot and cold cereals. On a given day in 2003-04, about 23 percent of individuals did so compared with 19 percent in 2017–18 (table 2a). The average amount consumed in cereal—including individuals who did not consume any milk this way—was 0.17 cup-equivalents in 2017–18 compared with 0.23 in 2003–04 (table 2b). This decrease is statistically significant (see box, "Comparing Two Sample Means").

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[22] This is broader than the definition of fluid cow's milk underlying figure 1 and those used in past studies like Stewart et al. (2012, 2013), but we believe it better captures tastes and preferences for the product.

[23] Excluded from the analysis are yogurt drinks, goat's milk, soy beverages, and other plant-based milk alternatives.

[24] Estimates of the amount of milk in multi-ingredient foods, such as milkshakes and smoothies, include the amount of milk present in those products' ingredients, such as ice cream or half-and-half. The ingredients used to make a milkshake, for example, could include ice cream, and the ingredients used to make that ice cream could further include milk. If so, the estimate of the amount of milk in the milkshake would include the amount of milk in the ice cream plus any additional milk used to make the milkshake.

[25] Estimates of the amount of cow's milk in these products do not include cream as a product or ingredient. The FPED instead treats fat naturally present in dairy products more than 1.5 grams per cup-equivalent as a solid fat.

Milk Added to Other Beverages

Adding it to other beverages is a third way that people use milk. We define this type of use to include milk added to tea and coffee drinks not included among dairy milk and dairy milk drinks in USDA's Food and Nutrient Database for Dietary Studies.[26] On a given day in 2017–18, about 12 percent of individuals added milk to another type of beverage. The average amount consumed this way—including individuals who drank none this way—was 0.07 cup-equivalents. Both estimates were not significantly different from 2003–04 (see box, "Comparing Two Sample Means").

[26]We used the Food Patterns Equivalents Database to estimate the amount of milk in these other beverages. As with milk and milk drinks (see footnotes 24 and 25), our estimates exclude cream as a product or ingredient but include the amount of any milk present in a products' ingredients. The ingredients used to make a coffee drink, for example, could include half-and-half. If so, the estimate of the amount of milk in the drink would include the amount of milk in the half-and-half plus any additional milk also used to make the drink.

A Deeper Look at Consumption Trends

Generational change and trends in the Nation's demographic composition, such as aging, are gradual processes. These factors are not likely responsible for abruptly increasing the rate at which per capita fluid cow's milk consumption decreased after 2009–10 (figure 1): Other factors must have contributed. To further explore how usage patterns changed, we used NHANES data to separately examine consumption trends for children (ages 12 and under), teenagers (ages 13 through 19), and adults (ages 20 and older). This part of our analysis was entirely longitudinal. Consumption trends for each age group were examined without consideration of explanatory factors other than time.

In addition to the above, we also used statistical models that predict an individual's milk consumption while controlling as best as possible for demographic and generational change. Such models reveal more than a simple, unconditional time trend. They effectively net out the impacts of demographic and generational change and reveal trends in usage because of other factors. In other words, if the models reveal a significant trend that cannot be explained by demographic and generational change alone, then something else is influencing choices. That influence could be the result of something in the broad category denoted as the food environment. If, after controlling for demographic and generational changes in the population, for example, we find that consumers increasingly turned away from milk and milk drinks, then competition from other beverages and changes in school meal programs may be causing milk consumption to fall at a higher rate. By contrast, if individuals consumed less milk with cereal, then declining sales of cereal might be responsible. If model results indicate that consumption trends are diffused across different types of use and different age groups after controlling for demographic and generational change, then a variety of developments in the food environment are likely working together to reduce milk consumption.

For each age group and each type of usage, we estimated a statistical model that predicts individuals' consumption as a function of selected explanatory variables. Trying to use food diary data in a single equation, however, to explain the ways individuals make food choices is problematic. When asking respondents about food consumed over a short period (like a day used in NHANES), many respondents report zero consumption even for the most reported food. Looking at the distribution of amounts consumed, zero consumption values pile up for numerous reasons. Some individuals do not consume animal products at all, including milk, and some consume milk but not every day. This is likely the case in our data in table 2a and figure 2a. Using Cragg's (1971) double-hurdle model addresses that problem. This model allowed us to associate quantities consumed with other variables even when a large proportion of individuals did not report consuming a positive amount of the food for possibly more than one reason. Variations of Cragg's (1971) model have been applied in past studies of consumer demand for milk (Stewart et al., 2012; Dong et al., 2004) and seafood (Yen and Huang, 1996), as well as non-food goods and services like saltwater recreational fishing (Chi, 2017).

A review of existing research helped identify a set of explanatory variables for the models that would best control for the effects of demographic and generational change on milk consumption. Following Stewart et al. (2012, 2013), Sebastian et al. (2010), Beydoun et al. (2008), and Looker et al. (1993), the double-hurdle models for teenagers and children included an individual's age, race, ethnicity, gender, household size, and if dietary intake was reported for a weekend or weekday.[27] The models for adults also included educational attainment and if they often drank milk as a child and as a teenager.[28] Generational change is a driver of

[27]Means for key explanatory variables are available in table 1.

[28]NHANES asks survey participants if they often drank fluid cow's milk as a child and as a teenager. We include these variables in the model for adults to account for the effects of generational change. We do not include them in models for children and teenagers, as we assume that they have yet to form the habits that will later define their generations.

long-run trends in milk consumption. Lower levels of consumption among more recent generations reflect in part different life-long habits learned while growing up. Finally, for all models and all age groups, we included seven binary variables to indicate participation in the 2005–06, 2007–08, 2009–10, 2011–12, 2013–14, 2015–16, or 2017–18 survey cycles. Each of these variables equals 1 for individuals who participated in that survey cycle and 0 for all others. No binary variable indicates participation in the 2003–04 survey; this allowed us to compare consumption levels during other periods to 2003–04.[29]

Cragg's (1971) model was estimated using our NHANES data.[30] Additional details about the model and estimation procedures are provided in appendix 2. However, because the estimated coefficients are not easy to interpret, we further calculated each explanatory variable's unconditional marginal effect.[31] These effects measure the expected change in milk consumption given a change in an explanatory variable while holding all the other variables constant. For example, the marginal effect for the variable indicating a survey participant's gender measures the difference in expected consumption between men and women.

Of primary interest in this study are our seven binary variables that indicate participation in a specific NHANES survey cycle. We interpreted each of these variable's unconditional marginal effect as a measure of consumption trends because of factors other than demographic and generational changes in the U.S. population compared to 2003–04.[32] The marginal effect of the 2017–18 survey cycle variable, for example, represents how much a similar-appearing individual's consumption in 2017-–18 would be expected to change if we had instead observed the individual in 2003–04.

Americans in All Age Groups Are Drinking Less Milk and Milk Drinks

Children consume the most milk and milk drinks per capita, followed by teenagers and adults (table 3 and figure 3). NHANES data, examined longitudinally, revealed that on a given day in 2017–18, about 53 percent of children consumed milk this way compared to 27 percent of teenagers and 14 percent of adults. The average amount children consumed—including those who drank no milk or milk drinks—was 0.79 cup-equivalents versus 0.40 for teenagers and 0.23 for adults. These differences between age groups were statistically significant for 2017–18 (see box, "Comparing Two Sample Means").

Longitudinal examination of NHANES data also revealed decreasing per capita milk and milk drink consumption for all age groups. Children's consumption of milk and milk drinks decreased 26 percent from 1.07 cup-equivalents per person per day in 2003–04 to 0.79 in 2017-18. Consumption was down 49 percent among teenagers and 47 percent among adults. These changes over time were statistically significant for each age group (see box, "Comparing Two Sample Means").

[29]We also considered adding interaction terms between the survey cycle variables and other explanatory variables in the model, including those for income, gender, race, and ethnicity, but these interaction terms did not substantially improve model fit nor did they affect key results.

[30]Following DuMouchel and Duncan (1983), we corrected our variance estimates for complex survey design using the public-release MVUs, but we did not use sample weights. Some researchers argue for using sample weights when the relationship between their model's dependent and explanatory variables is not likely identical for all population segments. It is possible, for example, that changes over time in milk consumption vary between genders or between higher and lower-income individuals. DuMouchel and Duncan (1983) encouraged researchers to instead ask whether their model is correctly specified. Adding missing variables, including interaction terms, can serve to identify the relationships of interest for each population segment. However, in this study, when we added interaction terms, they proved to be statistically insignificant, as noted in footnote 29.

[31]We report each explanatory variable's average effect. Unconditional marginal effects were calculated for all individuals in the sample, and the average across individuals was then calculated.

[32]This interpretation is possible because we did not include a binary variable that indicates if an individual participated in the NHANES 2003–04.

Table 3a

Proportion of individuals who consumed milk and milk drinks on a given day by age group

	2003–04	2005–06	2007–08	2009–10	2011–12	2013–14	2015–16	2017–18
Children	0.64	0.60	0.63	0.67	0.66	0.61	0.55	0.53
	(0.03)	(0.02)	(0.02)	(0.01)	(0.03)	(0.02)	(0.03)	(0.01)
Teenagers	0.36	0.34	0.38	0.39	0.38	0.38	0.32	0.27
	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
Adults	0.23	0.23	0.23	0.23	0.20	0.17	0.18	0.14
	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)

Notes: Standard errors in parentheses. All estimates have been weighted and the standard errors of those estimates corrected for complex survey design using the masked variance units (MVUs) available with the National Health and Nutrition Examination Survey (NHANES) public use data files.

Children = ages 12 and younger, Teenagers = ages 13 through 19, and Adults = ages 20 and older.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–18.

Table 3b

Average daily consumption of milk and milk drinks in cup-equivalents

	2003–04	2005–06	2007–08	2009–10	2011–12	2013–14	2015–16	2017–18
Children	1.07	0.94	0.94	1.10	0.99	0.92	0.83	0.79
	(0.07)	(0.05)	(0.05)	(0.03)	(0.06)	(0.03)	(0.05)	(0.02)
Teenagers	0.79	0.71	0.68	0.73	0.74	0.63	0.52	0.40
	(0.09)	(0.07)	(0.06)	(0.08)	(0.07)	(0.06)	(0.05)	(0.04)
Adults	0.43	0.44	0.38	0.39	0.33	0.30	0.26	0.23
	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)

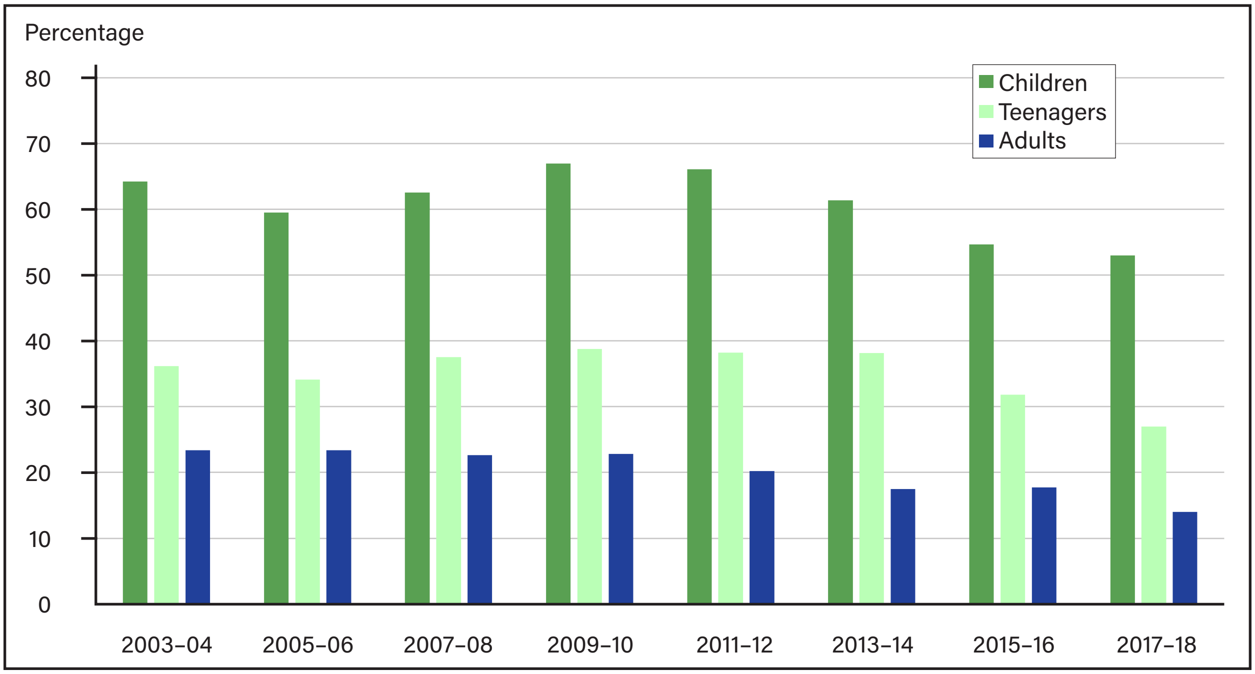
Notes: Standard errors in parentheses. All estimates have been weighted and the standard errors of those estimates corrected for complex survey design using the masked variance units (MVUs) available with the National Health and Nutrition Examination Survey (NHANES) public use data files.

Children = ages 12 and younger, Teenagers = ages 13 through 19, and Adults = ages 20 and older.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–18.

Figure 3a

Percentage of individuals who drank milk and/or milk drinks on a given day by year and age group



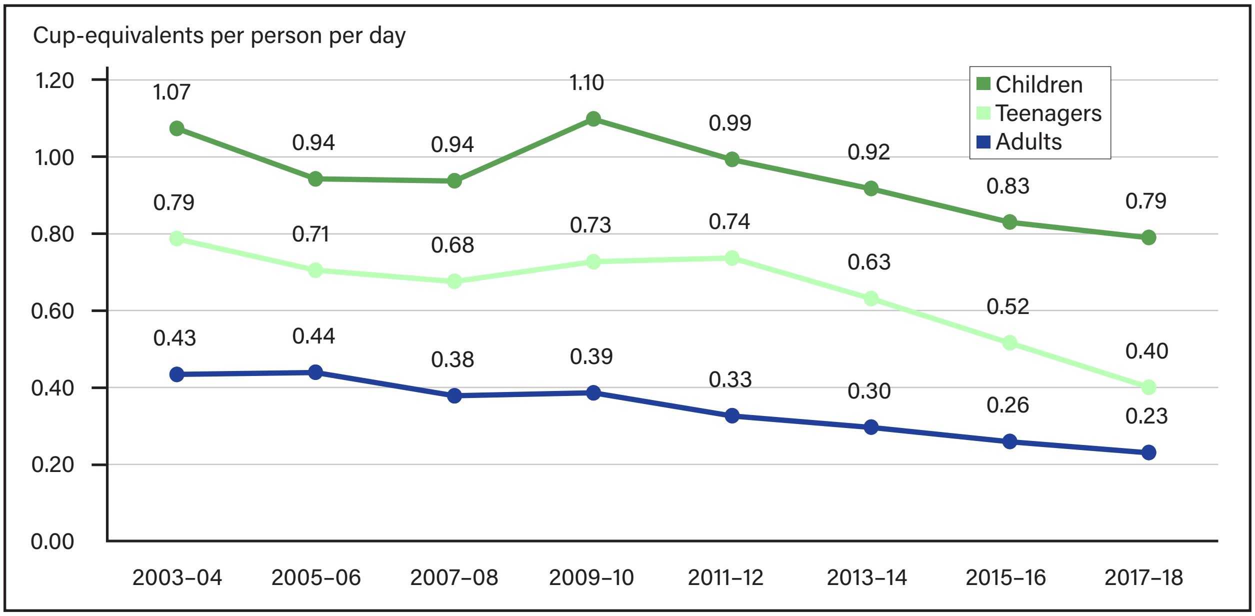
Note: All estimates have been weighted.

Children = ages 12 and younger, Teenagers = ages 13 through 19, and Adults = ages 20 and older.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–2018.

Figure 3b

Individuals' average daily consumption of milk and milk drinks measured in cup-equivalents by year and age group



Note: All estimates have been weighted.

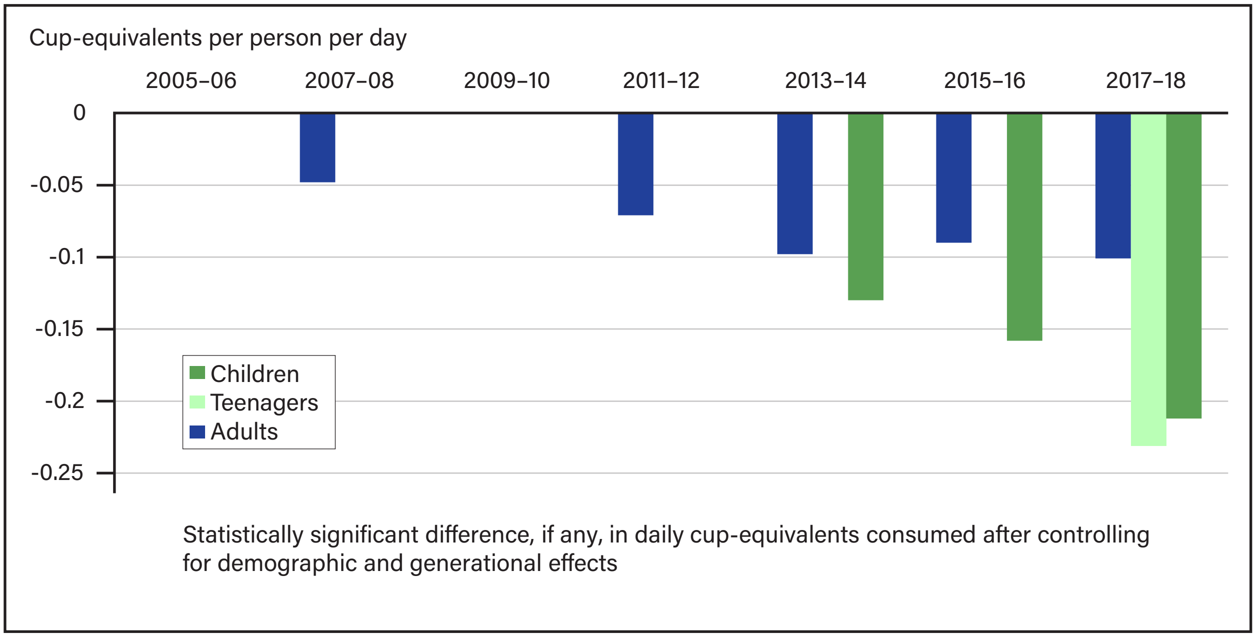
Children = ages 12 and younger, Teenagers = ages 13 through 19, and Adults = ages 20 and older.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–2018.

Controlling as much as possible for demographic and generational change, our model results continue to show that people of all ages reduced their per capita consumption of milk and milk drinks from 2003–04 to 2017–18 (table 4 and figure 4).[33] For example, we estimated a child consumed about 0.21 cup-equivalents fewer milk and milk drinks in 2017–18 than in 2003–04 because of factors other than demographic and generational changes explicitly accounted for in our model. Sizable decreases in consumption were also evident among the other age groups.[34]

Figure 4

Individuals are consuming less milk and milk drinks than they did in 2003–04 even after controlling for demographic and generational changes in the U.S. population



Notes: Marginal effects of explanatory variables indicating National Health and Nutrition Examination Survey (NHANES) survey cycle (see table 4). Only statistically significant results are shown.

Children = ages 12 and younger, Teenagers = ages 13 through 19, and Adults = ages 20 and older.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–2018.

[33]The marginal effect of the binary variable that indicates participation in the 2017–18 survey cycle is negative and statistically significant at the 5-percent level for all age groups.

[34]We performed pairwise t-tests to determine whether all three age groups reduced their consumption of milk by about the same amount in all recent survey cycles. For these tests, we assumed that our results for the different age groups were independent and used the pooled sample variance. Marginal effects for participation in the 2017–18 NHANES suggest that decreases in expected milk and milk drink consumption may have been greater in size for children and teenagers than for adults. However, when looking at those for participation in the 2015–16 NHANES and the 2013–14 NHANES, no significant differences exist across the age groups. Overall, we conclude that all age groups are drinking less milk, even after accounting for other variables in the model, but it is unclear if those decreases differ in size.

Table 4

Marginal effects of explanatory variables on an individual's expected daily consumption of milk and milk drinks

	Children	Teenagers	Adults
Ratio of family income to poverty	0.003	0.024**	-0.009**
	(0.004)	(0.007)	(0.002)
Non-Hispanic White (0/1)	0.209**	0.293**	0.151**
	(0.024)	(0.038)	(0.013)
Age (years)	-0.044**	-0.033**	-0.0007*
	(0.003)	(0.011)	(0.0003)
Female (0/1)	-0.083**	-0.160**	-0.079**
	(0.012)	(0.016)	(0.006)
Household size (number of people)	0.009*	0.017*	0.012**
	(0.005)	(0.006)	(0.003)
Weekend (0/1)	-0.221**	-0.193**	-0.004
	(0.015)	(0.027)	(0.007)
College educated (0/1)	N/A	N/A	-0.044**
			(0.010)
Often drank milk when aged 13 to 17 years (0/1)	N/A	N/A	0.213**
			(0.020)
Often drank milk when aged 5 to 12 years (0/1)	N/A	N/A	0.067**
			(0.016)
Participated in 2005–06 NHANES (0/1)	0.001	0.010	-0.002
	(0.057)	(0.060)	(0.024)
Participated in 2007–08 NHANES (0/1)	-0.014	-0.034	-0.048*
	(0.058)	(0.067)	(0.02)
Participated in 2009–10 NHANES (0/1)	0.045	-0.052	-0.037
	(0.056)	(0.050)	(0.019)
Participated in 2011–12 NHANES (0/1)	-0.063	0.049	-0.071**
	(0.054)	(0.075)	(0.023)
Participated in 2013–14 NHANES (0/1)	-0.130*	-0.061	-0.098**
	(0.050)	(0.046)	(0.018)
Participated in 2015–16 NHANES (0/1)	-0.158**	-0.119	-0.090**
	(0.058)	(0.062)	(0.017)
Participated in 2017–18 NHANES (0/1)	-0.212**	-0.231**	-0.101**
	(0.047)	(0.043)	(0.017)

N/A = Not Applicable

Notes: * Indicates statistically significant at the 5-percent level. ** Indicates statistically significant at the 1-percent level. Standard errors in parentheses. (0/1) indicates a binary variable, where 0 indicates false and 1 indicates true.

NHANES = National Health and Nutrition Examination Survey. Children = ages 12 and younger, Teenagers = ages 13 through 19, and Adults = ages 20 and older.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey-What We Eat In America (NHANES-WWEIA) data, 2003–2018.

Our results further underscore the important role school meals play in promoting milk consumption. Children and teenagers drink about 0.20 cup-equivalents less milk on weekends (table 4). Other study results confirm that reduced consumption during youth is associated with reduced consumption throughout adulthood. Having consumed milk often as a child is associated with drinking 0.07 cup-equivalents more milk and milk drinks as an adult. Having consumed milk often as a teenager is associated with drinking 0.21 cup-equivalents more milk and milk drinks as an adult.[35]

Finally, it appears that consumption estimates fluctuate from one survey cycle to another. Children's consumption of milk and milk drinks, for example, appears to have increased from 2007–08 to 2009–10 (tables 3b and 4 and figure 3b). However, we note that most differences between adjacent survey cycles are not statistically significant. Such differences may reflect genuine variability in U.S. consumers' food choices, or they may reflect sampling variability (i.e., how much an estimate would vary between samples of different individuals).

Consumption With Cereal Also Down, Especially Among Children

Children and teenagers consume more fluid cow's milk with cereal than adults (table 5 and figure 5). Longitudinal examination of NHANES data revealed that, on a given day in 2017–18, about 32 percent of children and 21 percent of teenagers consumed milk with cereal compared to 16 percent of adults. The average amounts they consumed—including those who consumed no milk with cereal—were 0.25 and 0.22 cup-equivalents versus 0.15 for adults. Differences for 2017–18 in amounts consumed between children and adults were statistically significant while those between children and teenagers were not (see box, "Comparing Two Sample Means").

Longitudinal examination of NHANES data also revealed that many people were eating less milk with cereal. Per capita daily consumption with cereal fell 35 percent among children from 0.39 cup-equivalents in 2003–04 to 0.25 in 2017–18. Consumption was also down 19 percent among teenagers and 20 percent among adults. These changes over time were statistically significant for children and adults but not for teenagers (see box, "Comparing Two Sample Means").

Table 5a

Proportion of individuals who consumed milk with cereal on a given day by age group

	2003–04	2005–06	2007–08	2009–10	2011–12	2013–14	2015–16	2017–18
Children	0.414 (0.020)	0.418 (0.019)	0.389 (0.022)	0.377 (0.017)	0.409 (0.016)	0.350 (0.020)	0.323 (0.017)	0.318 (0.015)
Teenagers	0.256 (0.021)	0.270 (0.014)	0.264 (0.019)	0.259 (0.023)	0.232 (0.021)	0.267 (0.024)	0.263 (0.025)	0.208 (0.017)
Adults	0.193 (0.010)	0.224 (0.011)	0.209 (0.010)	0.234 (0.010)	0.220 (0.011)	0.198 (0.007)	0.184 (0.013)	0.155 (0.010)

Notes: Standard errors in parentheses. All estimates have been weighted and the standard errors of those estimates corrected for complex survey design using the masked variance units (MVUs) available with the National Health and Nutrition Examination Survey (NHANES) public use data files.

Children = ages 12 and younger, Teenagers = ages 13 through 19, and Adults = ages 20 and older.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–2018.

[35]Previous research shows that individuals form the habit of consuming or not consuming much milk in childhood and carry that habit forward throughout their adult life (e.g., Stewart et al., 2012, 2013). According to current results, if someone continues to drink milk often throughout their childhood and through their teenage years, the effect on future consumption will be much greater.

Table 5b

Average daily amount of milk consumed with cereal in cup-equivalents

	2003–04	2005–06	2007–08	2009–10	2011–12	2013–14	2015–16	2017–18
Children	0.385	0.319	0.280	0.257	0.295	0.243	0.240	0.250
	(0.026)	(0.020)	(0.014)	(0.016)	(0.018)	(0.022)	(0.019)	(0.017)
Teenagers	0.286	0.259	0.249	0.219	0.239	0.244	0.251	0.223
	(0.028)	(0.015)	(0.022)	(0.024)	(0.022)	(0.018)	(0.033)	(0.022)
Adults	0.192	0.185	0.168	0.193	0.184	0.171	0.144	0.146
	(0.014)	(0.010)	(0.010)	(0.008)	(0.010)	(0.009)	(0.010)	(0.011)

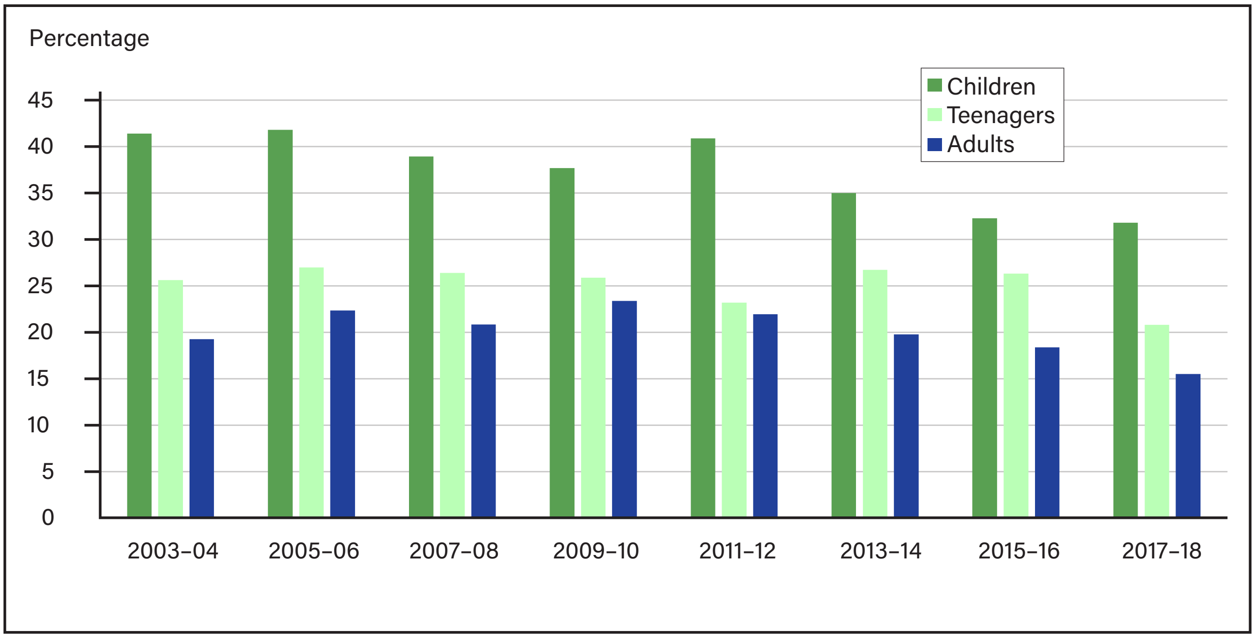
Notes: Standard errors in parentheses. All estimates have been weighted and the standard errors of those estimates corrected for complex survey design using the masked variance units (MVUs) available with the National Health and Nutrition Examination Survey (NHANES) public use data files.

Children = ages 12 and younger, Teenagers = ages 13 through 19, and Adults = ages 20 and older.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–2018.

Figure 5a

Percentage of individuals who consumed milk with cereal on a given day by year and age group



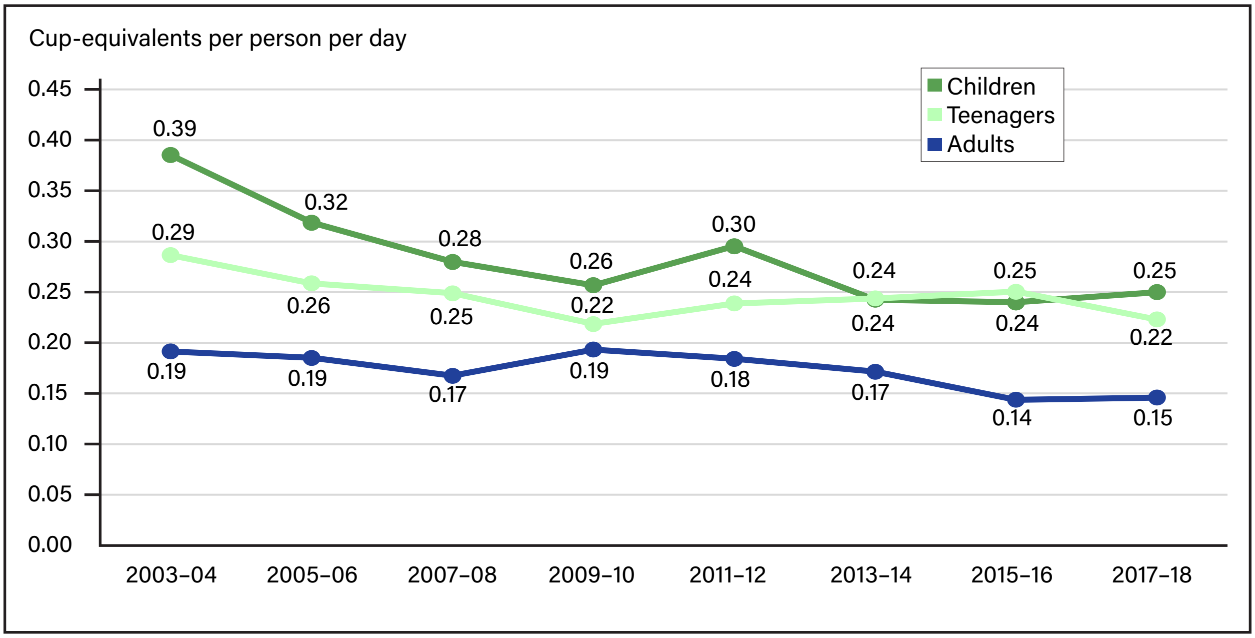
Note: All estimates have been weighted.

Children = ages 12 and younger, Teenagers = ages 13 through 19, and Adults = ages 20 and older.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–2018.

Figure 5b

Individuals' average daily consumption of milk with cereal measured in cup-equivalents by year and age group



Note: All estimates have been weighted.

Children = ages 12 and younger, Teenagers = ages 13 through 19, and Adults = ages 20 and older.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–2018.

Controlling as much as possible for demographic and generational changes in the U.S. population, we continued to find the consumption of fluid cow's milk with cereal decreased among children to a greater extent than it did among teenagers and adults (table 6 and figure 6). A child consumed an estimated 0.10 cup-equivalents less milk with cereal in 2017–18 than in 2003–04 because of factors other than demographic and generational changes explicitly accounted for in our model. The estimated marginal effect was somewhat smaller for adults (-0.03 cup-equivalents) and statistically insignificant for teenagers.[36]

As with the consumption of milk and milk drinks, milk consumption with cereal appears to fluctuate from survey cycle to survey cycle. However, differences between adjacent survey cycles were not generally statistically significant. The estimated differences may reflect genuine variability in food choices, or they may reflect sampling variability.

[36]We performed pairwise t-tests to determine whether all three age groups had reduced their consumption of fluid milk by about the same amount in all recent survey cycles. For these tests, we assumed that results for the different age groups were independent and used the pooled sample variance. We could consistently reject the null hypothesis of equally sized marginal effects for children versus adults as well as children versus teenagers.

Table 6

Marginal effects of explanatory variables on an individual's expected daily consumption of milk with cereal

	Children	Teenagers	Adults
Ratio of family income to poverty	-0.014**	-0.002	-0.003*
	(0.002)	(0.003)	(0.001)
Non-Hispanic White (0/1)	-0.059**	0.004	0.046**
	(0.007)	(0.016)	(0.005)
Age (years)	0.020**	-0.022**	0.001**
	(0.001)	(0.004)	(0.0001)
Female (0/1)	-0.026**	-0.067**	-0.043**
	(0.005)	(0.009)	(0.003)
Household size (number of people)	0.014**	0.015**	-0.00002
	(0.002)	(0.004)	(0.001)
Weekend (0/1)	-0.028**	-0.002	-0.023**
	(0.006)	(0.012)	(0.004)
College educated (0/1)	N/A	N/A	0.003
			(0.007)
Often drank milk when aged 13 to 17 years (0/1)	N/A	N/A	0.056**
			(0.007)
Often drank milk when aged 5 to 12 years (0/1)	N/A	N/A	0.025**
			(0.008)
Participated in 2005–06 NHANES (0/1)	-0.020*	-0.014	0.007
	(0.012)	(0.022)	(0.012)
Participated in 2007–08 NHANES (0/1)	-0.047**	-0.064**	-0.016
	(0.011)	(0.018)	(0.011)
Participated in 2009–10 NHANES (0/1)	-0.055**	-0.058**	0.004
	(0.013)	(0.019)	(0.011)
Participated in 2011–12 NHANES (0/1)	-0.040**	-0.063**	-0.018
	(0.012)	(0.021)	(0.011)
Participated in 2013–14 NHANES (0/1)	-0.093**	-0.056**	-0.022*
	(0.014)	(0.016)	(0.010)
Participated in 2015–16 NHANES (0/1)	-0.080**	-0.037	-0.030**
	(0.014)	(0.029)	(0.011)
Participated in 2017–18 NHANES (0/1)	-0.097**	-0.044	-0.032**
	(0.010)	(0.025)	(0.010)

N/A = Not Applicable

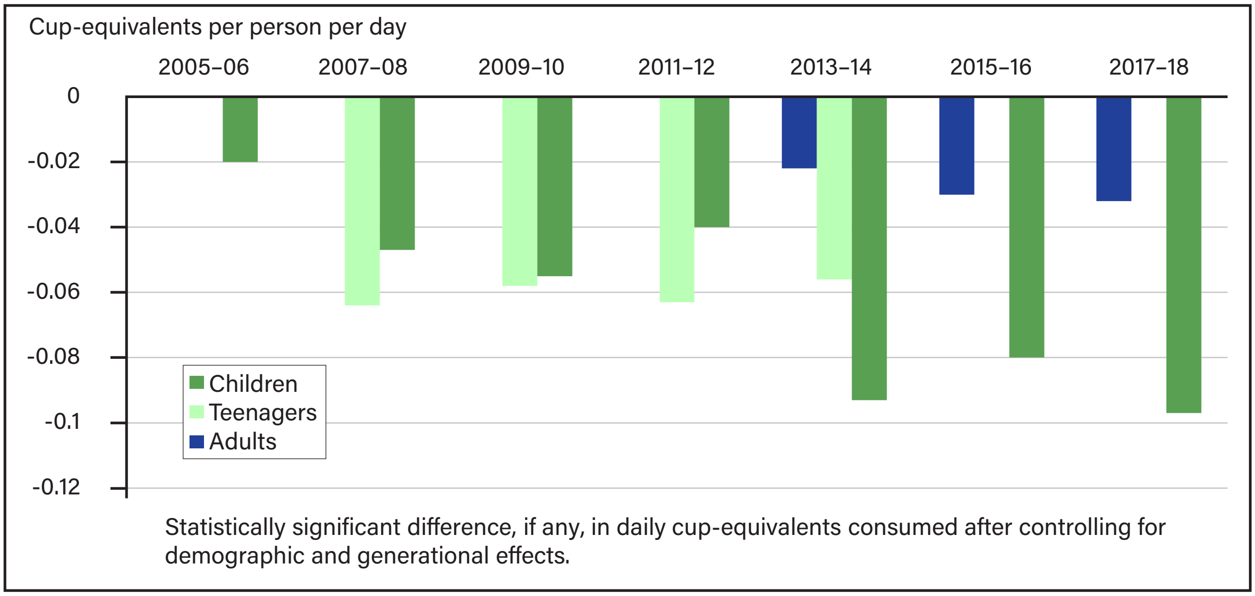
Notes: * Indicates statistically significant at the 5-percent level. ** Indicates statistically significant at the 1-percent level. Standard errors in parentheses. (0/1) indicates a binary variable, where 0 indicates false and 1 indicates true.

NHANES = National Health and Nutrition Examination Survey.

Children = ages 12 and younger, Teenagers = ages 13 through 19, and Adults = ages 20 and older.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey-What We Eat In America (NHANES-WWEIA) data, 2003–18.

Figure 6
Individuals are consuming less milk with cereal than they did in 2003–04 even after controlling for demographic and generational changes in the population



Notes: Marginal effects of explanatory variables indicating National Health and Nutrition Examination Survey (NHANES) survey cycle (see table 6). Only statistically significant results are shown.

Children = ages 12 and younger, Teenagers = ages 13 through 19, and Adults = ages 20 and older.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–2018.

No Clear Trends in the Amount of Milk Americans Add to Other Beverages

Adults add the most fluid cow's milk to other types of beverage, such as coffee and tea; teenagers and children follow (figure 7 and table 7). Our longitudinal examination of NHANES data revealed that, on a given day in 2017–18, about 15 percent of adults consumed milk this way compared to 5 percent of teenagers and 2 percent of children. The average amount consumed by adults—including those who consumed none this way—was 0.09 cup-equivalents versus 0.04 for teenagers and 0.01 for children. These differences for 2017–18 between age groups were statistically significant (see box, "Comparing Two Sample Means").

Unlike consumption trends for milk consumed with cereal or as milk and milk drinks, we see no evidence of a downward or upward trend for consumption in other types of beverages across any age group. Results at the beginning and end of the study period were not statistically different for any age group (see box, "Comparing Two Sample Means"). Furthermore, because we observed no trends in consumption, we also did not try to isolate the portion of trends most likely attributable to changes in the food environment.

Table 7a

Proportion of individuals who consumed milk in another beverage on a given day

	2003–04	2005–06	2007–08	2009–10	2011–12	2013–14	2015–16	2017–18
Children	0.009	0.024	0.021	0.012	0.013	0.008	0.019	0.019
	(0.002)	(0.006)	(0.007)	(0.004)	(0.003)	(0.002)	(0.004)	(0.004)
Teenagers	0.047	0.029	0.052	0.049	0.052	0.058	0.047	0.054
	(0.01)	(0.006)	(0.011)	(0.011)	(0.008)	(0.01)	(0.009)	(0.012)
Adults	0.147	0.15	0.134	0.172	0.131	0.142	0.135	0.152
	(0.014)	(0.01)	(0.01)	(0.008)	(0.013)	(0.008)	(0.01)	(0.008)

Notes: Standard errors in parentheses. All estimates have been weighted and the standard errors of those estimates corrected for complex survey design using the masked variance units (MVUs) available with the National Health and Nutrition Examination Survey (NHANES) public use data files.

Children = ages 12 and younger, Teenagers = ages 13 through 19, and Adults = ages 20 and older.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–2018.

Table 7b

Average daily amount of milk consumed in another beverage in cup-equivalents

	2003–04	2005–06	2007–08	2009–10	2011–12	2013–14	2015–16	2017–18
Children	0.005	0.015	0.009	0.007	0.006	0.005	0.008	0.009
	(0.002)	(0.005)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)
Teenagers	0.034	0.014	0.028	0.036	0.037	0.038	0.028	0.039
	(0.01)	(0.003)	(0.006)	(0.01)	(0.007)	(0.007)	(0.005)	(0.008)
Adults	0.077	0.073	0.065	0.086	0.072	0.077	0.074	0.092
	(0.012)	(0.007)	(0.005)	(0.006)	(0.004)	(0.007)	(0.008)	(0.007)

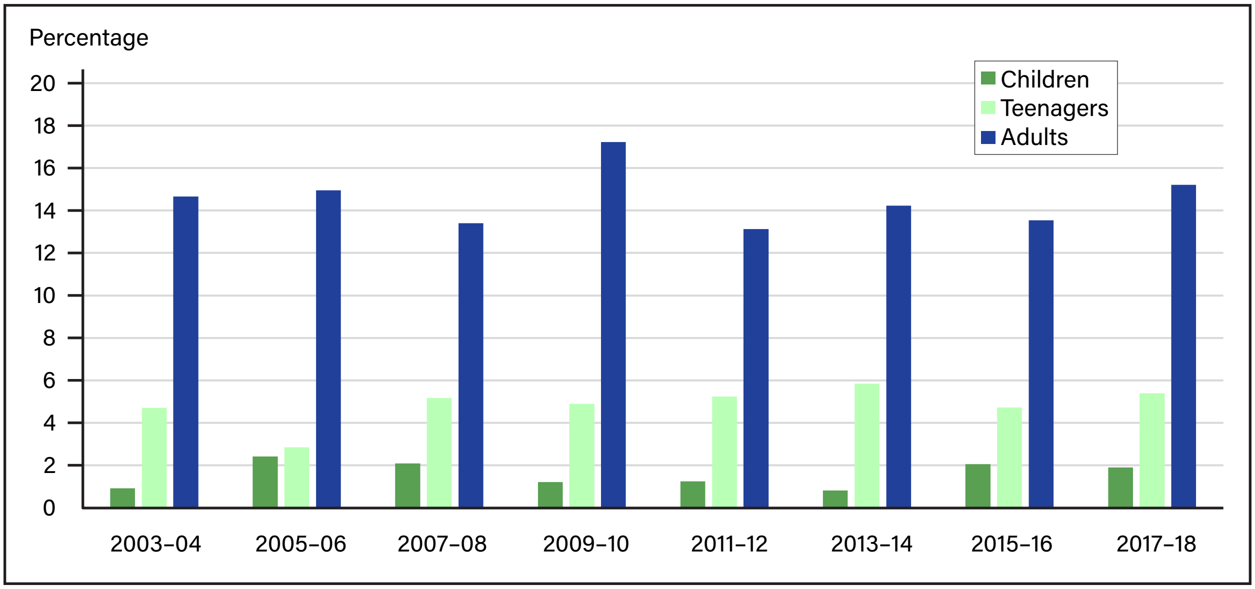
Notes: Standard errors in parentheses. All estimates have been weighted and the standard errors of those estimates corrected for complex survey design using the masked variance units (MVUs) available with the National Health and Nutrition Examination Survey (NHANES) public use data files.

Children = ages 12 and younger, Teenagers = ages 13 through 19, and Adults = ages 20 and older.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–2018.

Figure 7a

Percentage of individuals who consumed milk in another beverage on a given day by year and age group



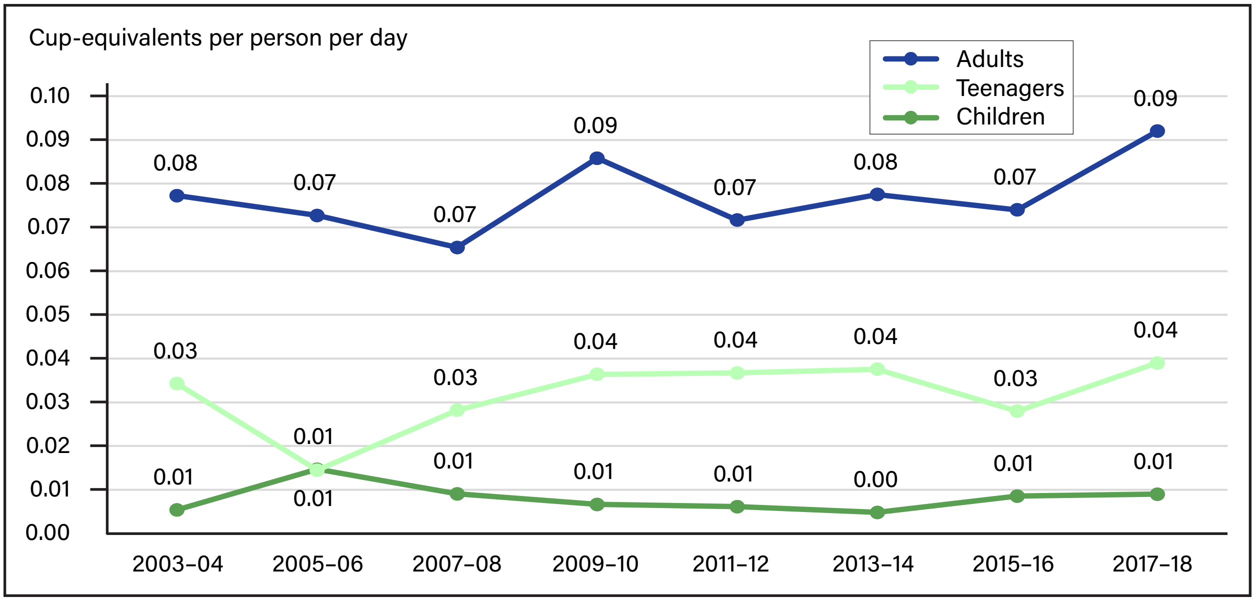
Note: All estimates have been weighted.

Children = ages 12 and younger, Teenagers = ages 13 through 19, and Adults = ages 20 and older.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–2018.

Figure 7b

Individuals' average daily consumption of milk in other beverages measured in cup-equivalents by year and age group



Note: All estimates have been weighted.

Children = ages 12 and younger, Teenagers = ages 13 through 19, and Adults = ages 20 and older.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–2018.

A Brief Look at Where Young People Consume Milk and Milk Drinks

Our results show people of all ages are consuming less milk and milk drinks. From a dietary quality perspective, decreases among children and teenagers are of particular concern since reduced consumption during youth is associated with reduced consumption throughout one's adult life. Questions also exist about how the HHFKA affected child nutrition. Research shows that the Act had some positive effects on school meal quality. Bergman et al. (2014) examined school lunches chosen and consumed by children at four elementary schools in Washington State before and after implementation of the HHFKA. The researchers concluded that foods consumed post-HHFKA contained fewer calories, less carbohydrates, less cholesterol, and more dietary fiber. However, they also found that children consumed less calcium. The researchers speculated that because all four schools operated "offer versus serve" systems in which students can choose which menu items to place on their trays, more students may have decided against drinking milk as part of their lunches. Some members of the media and policy advocates also question whether changes in school meal programs may have reduced students' milk consumption (Robinson and Mulvany, 2019; Leach, 2018).

As a final exercise, we took a brief look at where children (aged 6 through 12) and teenagers (aged 13 through 18) were consuming milk and milk drinks.[37] Both groups clearly reduced their at-home consumption (figure 8 and table 8), including foods and beverages purchased at retail stores. At-home consumption among children decreased 44 percent from 0.67 cup-equivalents per person per day in 2003–04 to 0.37 in 2017–18. At-home consumption among teenagers decreased 65 percent from 0.70 cup-equivalents per person per day in 2003–04 to 0.25 in 2017–18. Both changes were statically significant (See box, "Comparing Two Sample Means").

Our results are inconclusive with respect to milk consumption at school. The amounts children and teenagers consumed in schools in 2017–18 were not statistically less than what those same age groups reported in 2003–04 and most other survey cycles (see box, "Comparing Two Sample Means"). However, a more sophisticated analysis would be needed to definitively resolve this question. We leave that to future research.

Table 8a

Average daily amount of milk and milk drinks consumed by children in cup-equivalents by location, source, and year

	2003–04	2005–06	2007–08	2009–10	2011–12	2013–14	2015–16	2017–18
Food at home	0.665	0.551	0.427	0.641	0.548	0.484	0.394	0.373
	(0.066)	(0.051)	(0.031)	(0.043)	(0.062)	(0.048)	(0.048)	(0.043)
School	0.257	0.270	0.284	0.287	0.281	0.307	0.253	0.202
	(0.050)	(0.034)	(0.044)	(0.028)	(0.039)	(0.044)	(0.030)	(0.033)
Other places	0.030	0.037	0.042	0.048	0.038	0.071	0.075	0.045
	(0.009)	(0.012)	(0.016)	(0.008)	(0.009)	(0.011)	(0.027)	(0.011)

Notes: Standard errors in parentheses. All estimates have been weighted and the standard errors of those estimates corrected for complex survey design using the masked variance units (MVUs) available with the National Health and Nutrition Examination Survey (NHANES) public use data files.

Children = ages 6 through 12 years, and Teenagers = ages 13 through 18 years.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–2018.

[37]This effectively restricts the sample to include the sub-population of individuals most likely to benefit from and be affected by changes to school meal programs.

Table 8b

Average daily amount of milk and milk drinks consumed by teenagers in cup-equivalents by location, source, and year

	2003–04	2005–06	2007–08	2009–10	2011–12	2013–14	2015–16	2017–18
Food at home	0.703	0.666	0.579	0.600	0.588	0.490	0.359	0.248
	(0.088)	(0.085)	(0.081)	(0.080)	(0.077)	(0.049)	(0.036)	(0.022)
School	0.106	0.051	0.116	0.133	0.117	0.123	0.121	0.097
	(0.025)	(0.005)	(0.036)	(0.025)	(0.026)	(0.017)	(0.020)	(0.028)
Other places	0.012	0.042	0.025	0.019	0.061	0.050	0.039	0.039
	(0.004)	(0.021)	(0.012)	(0.008)	(0.025)	(0.011)	(0.012)	(0.013)

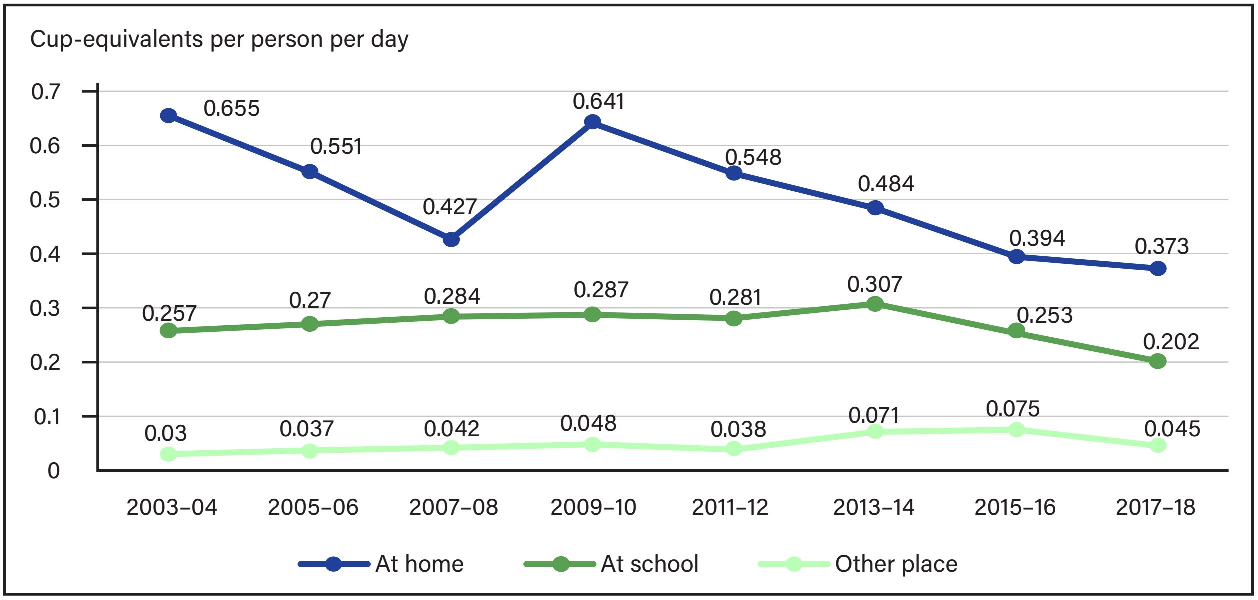
Notes: Standard errors in parentheses. All estimates have been weighted and the standard errors of those estimates corrected for complex survey design using the masked variance units (MVUs) available with the National Health and Nutrition Examination Survey (NHANES) public use data files.

Children = ages 6 through 12 years, and Teenagers = ages 13 through 18 years.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–2018.

Figure 8a

Average amount of fluid cow's milk consumed by children by location, source, and year



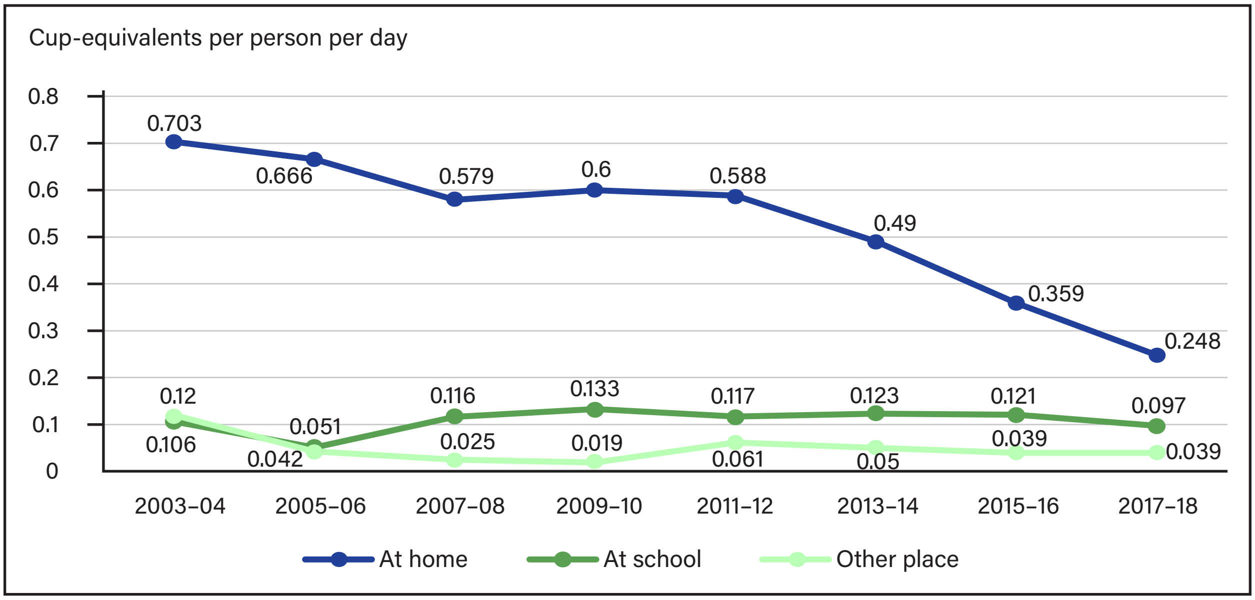
Note: All estimates have been weighted.

Children = ages 6 through 12 years, and Teenagers = ages 13 through 18 years.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–2018.

Figure 8b

Average amount of fluid cow's milk consumed by teenagers by location, source, and year



Note: All estimates have been weighted.

Children = ages 6 through 12 years, and Teenagers = ages 13 through 18 years.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey–What We Eat In America (NHANES-WWEIA) data, 2003–2018.

Conclusions

USDA, Economic Research Service (ERS) data reveal U.S. per capita fluid cow's milk consumption has been trending downward for over 70 years and continued to decrease at an average rate of 1 percent per year during the 2000s and at a faster average rate of 2.6 percent per year during the 2010s (figure 1). Previous studies suggest that demographic and generational changes in the U.S. population are at least partially responsible for the long-run decline. However, these gradual processes are not likely responsible for most of the decline in per capita milk consumption during those two previous decades (figure 1). Other factors must be considered. This study explored the questions: Who in the U.S. population is consuming less milk? How have their consumption patterns changed? What caused the rate of decrease to increase in the 2010s over the 2000s?

National Health and Nutrition Examination Survey (NHANES) data collected from 2003–04 through 2017–18 reveal that people in all age groups are drinking less milk and milk drinks. Children are also eating less milk with cereal. Per capita daily consumption of milk and milk drinks among children was down 26 percent while that with cereal fell 35 percent. Previous research indicates that declines in milk consumption among children and teenagers are associated with reduced consumption throughout adulthood (Stewart et al., 2012, 2013).

Declining fluid milk consumption is a matter of concern for diet quality in the United States. Most people in the United States do not meet dairy recommendations, and the downward trend in fluid milk consumption prevents improvement even as cheese and yogurt consumption increase. Some research indicates that rising cheese consumption reflects the widespread use of cheese in timesaving, commercially prepared foods, such as frozen pizza, as well as the popularity of cheese-rich Italian and Tex-Mex cuisines (Bentley, 2014). ERS food availability data show that from the mid-1980s through the 2000s, U.S. total dairy intake, including the consumption of fluid milk and other dairy products, averaged between 1.52 and 1.57 cup-equivalents per person per day, as increasing per capita yogurt and cheese consumption were generally sufficient to offset decreases in per capita fluid milk consumption. However, given the rate at which per capita fluid milk consumption fell in the 2010s, U.S. dairy intake was below 1.5 cup-equivalents per person per day in both 2018 and 2019.

This study's analytical approach combined a longitudinal analysis of consumption trends with the estimation of a statistical model that controlled for demographic characteristics and an individual's level of milk consumption during youth. Both approaches revealed significant downward trends in consumption over time, suggesting that recent changes in per capita milk consumption cannot be explained by demographic and generational developments in the U.S. population alone. Something else is influencing food choices. The identified trends are consistent with increased competition between fluid cow's milk and other beverages, as well as increased competition between cereal and other breakfast options. Additional research that accounts for products' relative prices, households' incomes, and consumers' tastes and preferences is needed to confirm and explain these results.

Fluid milk processors offer thousands of milk and milk drink products differentiated by fat content, package size, flavor, and other characteristics, including lactose-free milk, acidophilus milk, USDA Organic and/or non-GMO milk, and milk packaging that calls attention to pasture-raised or grass-fed cows. Previous studies sought to identify which of these attributes consumers desire. These include analyses of the premium prices that some households pay for organic products (Carlson and Jaenicke, 2016; Jaenicke and Carlson, 2015) as well as the extent to which households favor local over nonlocal milk (Khanal et al., 2020). A better understanding of why the U.S. population is consuming less fluid cow's milk per capita could help the dairy industry to further improve how it markets products.

Research shows that U.S. consumers are drinking more plant-based milk alternatives, and growth in sales of these products is reducing fluid cow's milk consumption (Stewart et al., 2020). Moreover, "almond milk" and most other milk alternatives do not count toward an individual's recommended dairy intake.[38] Such foods and cow's milk have different nutrient profiles. After comparing cow's milk to 17 plant-based alternatives, Chalupa-Krebzdak et al. (2018) noted that plant-based products generally have lower protein content, lower calcium availability, and higher glycemic index values. A still more complete understanding of how consumption trends affect individuals' diet quality would require a better understanding of what else U.S. consumers are ingesting in lieu of fluid cow's milk as well as those foods' nutrient profiles.

[38]Only fortified soy beverages are sufficiently similar to cow's milk to be considered a dairy equivalent by the *Dietary Guidelines for Americans, 2020–2025.*

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Appendix 1: Relative Price of Milk Versus Other Beverages

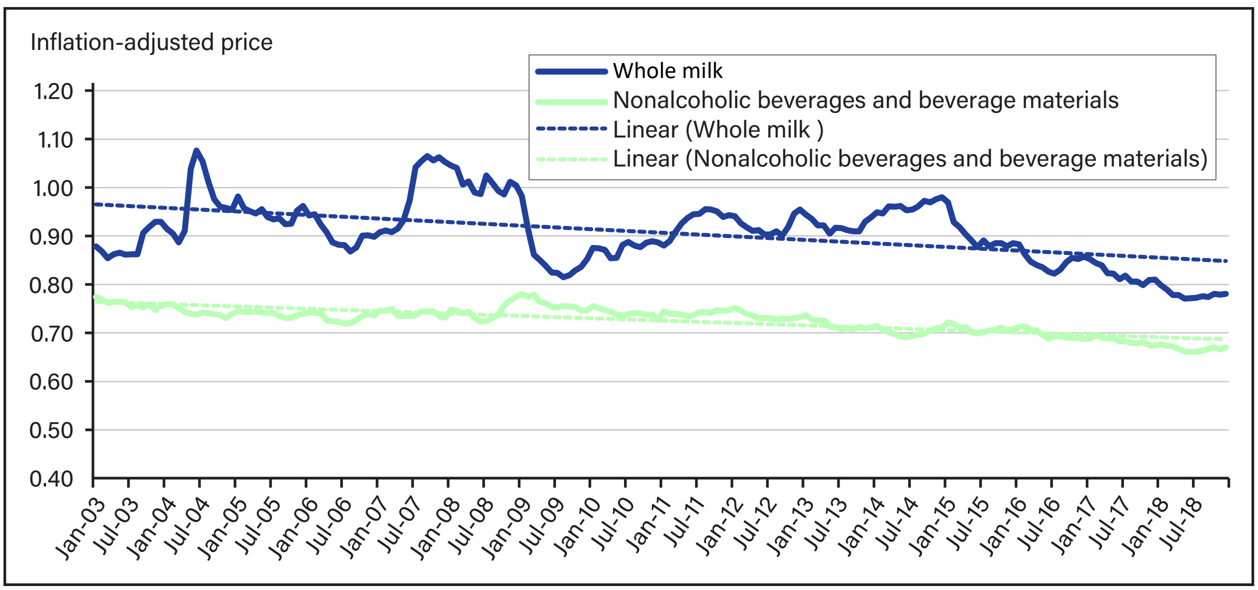
The U.S. Bureau of Labor Statistics (BLS) publishes the Consumer Price Index (CPI) to measure the change over time in the price of a defined market basket of goods and services relative to a base period. Each index's base period value is 100. For example, if a CPI's current year value is 150, then prices for the defined market basket had increased by 50 percent since the base year when the CPI equaled 100. BLS publishes various indexes for different types of food and beverages monthly. Figure A1 examines two of these:

- Whole milk (base year is 1982–84 = 100), and
- Nonalcoholic beverages and beverage materials (base year is 1982–84 = 100).

The data show that prices for whole milk products are more volatile than prices for nonalcoholic beverages and beverage materials. However, after dividing each index by the CPI for all items to control for inflation, we find that the two series exhibited approximately the same downward trend between 2003 and 2018. Given that the inflation-adjusted cost of both market baskets trended downward at about the same rate, we infer that relative prices are approximately the same at the beginning and end of the period studied.

Figure A1

Consumer Price Index (CPI) for whole milk and CPI for nonalcoholic beverages and beverage materials adjusted for inflation using the CPI for all items



Source: USDA, Economic Research Service calculations using January 2003–December 2018 data from the Consumer Price Index for all urban consumers (not seasonally adjusted) from the Bureau of Labor Statistics: all items in U.S. city average (CUUR0000SA0), fresh whole milk (CUUR0000SS09011), and nonalcoholic beverages and beverage materials (CUUR0000SAF114).

Appendix 2: The Double-Hurdle Model and Model Estimates

The double-hurdle model, originally proposed by Cragg (1971), is commonly used if a large portion of the individuals in a survey reported zero consumption of a product. This model provides two reasons why individuals might do so. The participation equation allows for the possibility that some people may not even consider consuming a food as frequently as every day. In the case of fluid milk, some people, including vegans, may never consume it. Neither income nor prices are responsible for this type of zero observation; rather, factors like tastes and preferences decide whether the food enhances individual well-being. A second equation, the level equation, allows for the possibility that even if a person would consider consuming the food on a given day, a high price on the day may prevent it. The correlation between the error terms in each of the two equations is assumed to be zero. Blundell and Meghir (1987) later extended Cragg's (1971) model to allow for dependence between those error terms. We estimated both Blundell and Meghir's (1987) specification and the original specification proposed by Cragg (1971). Results were not substantially different. We report results using Cragg's (1971) original double-hurdle specification. Wooldridge (2010), among others, provides a detailed description of the model.

Applying Cragg's (1971) framework to this study, we modeled the probability that individual i even considered consuming milk as

$$S_i = 1 \text{ if } \boldsymbol{X_i \alpha} + e_i > 0$$

and

$$S_i = 0 \text{ if } \boldsymbol{X_i \alpha} + e_i \leq 0$$

where S_i is a binary variable, $\mathbf{X_i}$ is a row vector of explanatory variables including the person's demographic characteristics, $\boldsymbol{\alpha}$ is a column vector of parameters to be estimated, and e_i is a standard normal error term. Additionally, we modeled the same individual's latent level of consumption, W_i^*, as

$$W_i^* = \boldsymbol{Z_i \beta} + u_i$$

where $\mathbf{Z_i}$ is a vector of explanatory variables including the person's demographic characteristics and economic variables like income and prices, if available, $\boldsymbol{\beta}$ is a vector of parameters to be estimated, and u_i is a normal error term with mean 0 and variance σ^2. Finally, we combine the two equations and denote the observed level of consumption for individual i, W_i, as

$$W_i = W_i^* \text{ if } S_i = 1 \text{ and } W_i^* > 0$$

and

$$W_i = 0 \text{ otherwise.}$$

In words, observed consumption, W_i, will only equal latent consumption, W_i^*, if the individual both considered consuming milk ($S_i = 1$) and did not reach a corner solution ($W_i^* > 0$).

Cragg's (1971) model can be estimated by maximum likelihood using several commercial software packages: we used Stata. Estimation results are below in tables A1 and A2. Most key variables are statistically significant at the 1-percent level and have the expected signs.

Table A1

Estimation results for model of milk and milk drink consumption

	Adults		Teenagers		Children	
	Level equation	Selection equation	Level equation	Selection equation	Level equation	Selection equation
Constant	0.651 (0.352)	-1.379** (0.058)	-1.421 (1.030)	0.807** (0.174)	1.874** (0.108)	0.139* (0.063)
Family income to poverty	-0.158** (0.039)	N/A	0.180** (0.059)	N/A	0.012 (0.017)	N/A
Non-Hispanic White	1.197** (0.189)	0.192** (0.019)	0.859** (0.198)	0.267** (0.034)	0.295** (0.058)	0.205** (0.022)
Age	-0.028** (0.005)	0.002** (0.001)	0.127* (0.054)	-0.087** (0.011)	-0.161** (0.011)	-0.005 (0.003)
Female	-1.353** (0.159)	N/A	-1.198** (0.215)	N/A	-0.322** (0.050)	N/A
Weekend	N/A	-0.011 (0.017)	N/A	-0.333** (0.035)	N/A	-0.349** (0.022)
Household size	N/A	0.029** (0.006)	N/A	0.028** (0.011)	N/A	0.014 (0.008)
College-educated	-0.436** (0.139)	-0.048** (0.018)	N/A	N/A	N/A	N/A
Often drank milk ages 5 to 12	0.037 (0.170)	0.158** (0.027)	N/A	N/A	N/A	N/A
Often drank milk ages 13 to 17	0.950** (0.212)	0.398** (0.025)	N/A	N/A	N/A	N/A
Survey cycle 2005–06	0.207 (0.204)	-0.035 (0.049)	-0.021 (0.246)	-0.022 (0.073)	-0.150 (0.124)	0.064 (0.060)
Survey cycle 2007–08	-0.520* (0.203)	-0.048 (0.048)	-0.237 (0.296)	-0.005 (0.084)	-0.245* (0.123)	0.080 (0.062)
Survey cycle 2009–10	-0.324 (0.193)	-0.047 (0.041)	-0.637* (0.272)	0.053 (0.078)	-0.106 (0.119)	0.117* (0.056)
Survey cycle 2011–12	-0.520* (0.203)	-0.111* (0.051)	-0.221 (0.246)	0.137 (0.101)	-0.438** (0.117)	0.077 (0.068)
Survey cycle 2013–14	-0.341 (0.209)	-0.208** (0.039)	-0.880** (0.253)	0.092 (0.072)	-0.470** (0.121)	-0.028 (0.063)
Survey cycle 2015–16	-0.621* (0.236)	-0.153** (0.036)	-0.670* (0.321)	-0.069 (0.089)	-0.476** (0.129)	-0.077 (0.070)
Survey cycle 2017–18	-0.403 (0.239)	-0.211** (0.038)	-1.066** (0.299)	-0.229** (0.082)	-0.588** (0.129)	-0.132* (0.061)
σ (Model Std. Deviation)	2.314** (0.179)		1.909** (0.107)		1.65** (0.047)	

N/A = Not Applicable

Notes: * Indicates statistically significant at the 5-percent level. ** Indicates statistically significant at the 1-percent level.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey-What We Eat In America (NHANES-WWEIA) data, 2003–2018.

Table A2

Estimation results for model of milk consumption in cereal

	Adults		Teenagers		Children	
	Level equation	Selection equation	Level equation	Selection equation	Level equation	Selection equation
Constant	1.288** (0.100)	-1.537** (0.052)	1.025** (0.327)	0.196 (0.191)	0.348** (0.112)	-0.685** (0.047)
Ratio of income to poverty	-0.036* (0.015)	N/A	-0.013 (0.026)	N/A	-0.089** (0.014)	N/A
Non-Hispanic White	-0.165** (0.039)	0.249** (0.019)	-0.209* (0.094)	0.074 (0.040)	-0.261** (0.043)	-0.078** (0.023)
Age	-0.011** (0.001)	0.008** (0.001)	0.014 (0.020)	-0.073** (0.011)	0.083** (0.009)	0.027** (0.002)
Female	-0.564** (0.065)	N/A	-0.513** (0.089)	N/A	-0.166** (0.035)	N/A
Weekend	N/A	-0.101** (0.015)	N/A	-0.005 (0.036)	N/A	-0.103** (0.022)
Household size	N/A	0.004 (0.006)	N/A	0.046 (0.013)**	N/A	0.058** (0.01)
College-educated	-0.129* (0.059)	0.055** (0.021)	N/A	N/A	N/A	N/A
Often drank milk ages 5 to 12	-0.022 (0.065)	0.100** (0.024)	N/A	N/A	N/A	N/A
Often drank milk ages 13 to 17	0.205** (0.062)	0.179** (0.023)	N/A	N/A	N/A	N/A
Survey cycle 2005–06	-0.211* (0.081)	0.099* (0.039)	-0.289* (0.120)	0.074 (0.051)	-0.137* (0.060)	-0.001 (0.041)
Survey cycle 2007–08	-0.350** (0.085)	0.042 (0.038)	-0.621** (0.142)	0.026 (0.055)	-0.315** (0.063)	-0.006 (0.038)
Survey cycle 2009–10	-0.231** (0.084)	0.093* (0.04)	-0.626** (0.124)	0.056 (0.065)	-0.396** (0.068)	0.003 (0.044)
Survey cycle 2011–12	-0.306** (0.093)	0.019 (0.042)	-0.452** (0.147)	-0.032 (0.071)	-0.252** (0.070)	-0.014 (0.046)
Survey cycle 2013–14	-0.302** (0.088)	-0.002 (0.039)	-0.492** (0.125)	0.008 (0.056)	-0.418** (0.070)	-0.154** (0.052)
Survey cycle 2015–16	-0.254** (0.091)	-0.056 (0.043)	-0.374** (0.124)	0.031 (0.079)	-0.267** (0.078)	-0.176** (0.055)
Survey cycle 2017–18	0.007 (0.080)	-0.148** (0.041)	-0.018 (0.129)	-0.133 (0.069)	-0.298** (0.064)	-0.237** (0.047)
σ (Model Std. Deviation)	0.972** (0.058)		0.949** (0.083)		0.800** (0.062)	

N/A = Not Applicable

Notes: * Indicates statistically significant at the 5-percent level. ** Indicates statistically significant at the 1-percent level.

Source: USDA, Economic Research Service analysis of National Health and Nutrition Examination Survey-What We Eat In America (NHANES-WWEIA) data, 2003–2018.