Shifts in Patterns and Consumption of Beverages Between 1965 and 2002

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Abstract

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Background: Beverage patterning may play a role in partially explaining the rising rates of obesity in the United States, yet little work on overall trends and patterns exits. Our objective was to examine trends and patterns of beverage consumption among U.S. adults.

Methods: We used data from the nationally representative Nationwide Food Consumption Surveys (1965, 1977 to 1978) and the National Health and Nutrition Surveys (1988 to 1994, 1999 to 2002). To examine trends we determined percent consuming and per capita and per consumer caloric intake from all beverages. We used cluster analysis to determine year-specific beverage patterns in 1977 and 2002.

Results: The percentage of calories from beverages significantly increased between 1965 (11.8%), 1977 (14.2%), 1988 (18.5%), and 2002 (21.0%); this represents an overall increase of 222 calories per person per day from beverages, resulting largely from increased intake of calorically sweetened beverages. Beverage patterns in 2002 were more complex than in 1977 and were dominated by a greater number of beverages, reflecting the increase in alcohol, soda, and diet beverages.

Conclusion: Calories from beverages increased substantially from 1965 to 2002, providing a considerable source of daily calories. Given the upward trends in calorically sweetened, nutrient-deficient beverages and the shifts in overall beverage patterns, addressing beverage intake is a salient issue for adults.

Key words: adults, energy intake, eating behaviors, epidemiology, trends

Introduction

There has been a notable increase in American's total energy intake in recent decades observed among all races/ethnicities, ages, and economic levels. It is estimated that ~50% of the increase in daily caloric intake is coming from consumption of calorically sweetened beverages, such as soda (1). To date, research has focused on the rise in calorically sweetened beverages and the decline in milk (1–11). However, shifts in the trends and overall patterns of beverage intake need to be more broadly examined, as these shifts potentially contribute to the rising rates of obesity seen in the United States (12,13).

Recent reviews put forth by the Institute of Medicine Panel on Water and Electrolytes, the Beverage Guidance Panel (2006), and the U.S. 2005 Dietary Guidelines panel have noted excessive added sugar in the U.S. diet from calorically sweetened beverages (12,14,15). This observation has led to outlining recommended beverage patterns (12). The overarching goal of these recommendations is to provide for adequate hydration and nutrient consumption while keeping added calories from beverages at a minimum.

The present study adds to our current understanding of the long-term trends in beverage consumption, including water, by examining intake over a 35-year period and to the larger body of literature on the topic of beverage consumption by examining overall beverage patterns and comparing these patterns over time. Pattern analysis is useful because it provides additional information on the potential combined effect of beverage consumption, which cannot be determined when only the consumption of individual beverages is examined, and it allows for more specific identification of behavior patterns for targeted interventions. Pattern analysis is increasingly utilized in research on the effects of multidimensional exposures on health outcomes.

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Research Methods and Procedures

Participants and Data Source

This study used data on adults 19 years and older from 4 nationally representative surveys of food intake in the U.S. population: United States Department of Agriculture National Food Consumption Surveys (NFCS)[1] of 1965 (NFCS 65, $n = 6360$) and 1977 to 1978 (NFCS 77, $n = 17,096$) and the National Health and Nutrition Examination Surveys (NHANES) 1988 to 1994 (III), $n = 13,629$) and 1999 to 2002 (NHANES 02, $n = 9491$), which contained stratified area probability samples of non-institutionalized U.S. households. Each survey was designed to be nationally representative. Detailed information about each survey and its sampling design has been published previously (16–19).

Dietary Intake

NCFS 65 and NCFS 77. Information on dietary intake was collected over 3 consecutive days using a single interviewer-administered 24-hour recall followed by a self-administered 2-day diet record. Information on all foods and beverages consumed both at and away from home was recorded; 3-day values were averaged.

NHANES III and NHANES 02. For these examinations, a single 24-hour dietary recall was administered by trained dietary interviewers. Respondents reported all foods and beverages consumed (plain drinking water collected separately for NHANES III) for the previous 24-hour time period. For NHANES III, a 4-step automated coding and collection system known as the NHANES III Dietary Data Collection System was used to collect all dietary recall data. For the NHANES 02 survey, the United States Department of Agriculture's automated multiple pass method, a 5-step computerized dietary recall instrument, was used for data collection.

Beverage Groups

Sixteen beverage variables were used in our analyses: water, unsweetened coffee and unsweetened tea (do not contain cream or sugar), low-fat milk (1.5%, 1%, and skim), non-calorically sweetened beverages (diet sodas or other "diet" beverages), fruit juice (100% fruit juice), vegetable juice (100% juice), sports drinks, whole fat milk (≥2%), alcohol (beer, wine, and liquor), soda (calorically sweetened soda only), fruit drinks (beverages containing <100% juice, or with added sweeteners), sweetened coffee, sweetened tea (contain cream and/or sugar), other sweetened beverages (e.g., horchata, a sweetened rice beverage, and coconut milk), and other beverages (e.g., protein-rich meal replacement drinks and instant breakfast shakes).

These beverages were grouped in accordance with the recent beverage guidance system (12), which combined beverages according to 1) their energy and nutrient density, 2) contribution to total energy intake and body weight, 3) contribution to the daily intake of essential nutrients, 4) evidence for beneficial health effects, and 5) evidence for adverse health effects. For example, unsweetened coffee and tea were combined into a single category. This grouping resulted in 6 broad beverage groups, hereafter referred to as Beverage Levels, including water (Level 1), unsweetened coffee and tea (Level 2), low-fat milk (Level 3), non-calorically sweetened (diet) beverages (Level 4), caloric beverages containing nutrients (Level 5), and calorically sweetened beverages (Level 6). These categories are similar to those reported elsewhere (2,20,21).

Statistical Analyses

Trends. Trends are presented as calories per capita per day, percent consuming, and calories per consumer. We used survey commands to account for survey design, weighting, and clustering (Stata 9.2; StataCorp., College Station, TX). All values were adjusted to the 1965 age and gender distribution and are reported as mean (percent) plus standard error. Change in the percent consuming and average caloric intake among consumers was calculated by differencing 2002 and 1965 values (rounded to the nearest whole percent/calorie). To test for statistical differences between years, we used independent 2-sample t tests, with $p \leq 0.01$ set for statistical significance.

Patterns. We elected to compare beverage patterns between 1977 and 2002 because 1) data were collected only in the spring of 1965, and there were concerns about the effect of seasonality on beverage consumption; and 2) data in NFCS 65 lacked demographic information at the level of the individual, precluding comparison across important subgroups of the population.

To generate descriptive patterns of overall beverage consumption, we used non-hierarchical cluster analysis. Cluster analysis uses available data, rather than a priori defined patterns, to create groups of individuals with similar patterns, in this case, similar patterns of beverage consumption in 1977 and in 2002. This method has been described in detail elsewhere (21) and has been used in previous studies of dietary and beverage patterns (20,22–24). At each year, beverage variables were dichotomized due to the large number of non-consumers. However, due to large variation in coffee in 1977 and soda in 2002, these two beverages were categorized into a 3-level variable, providing a more accurate representation of consumption. In 1977, individuals were identified as being non-consumers, medium coffee consumers [<22 fl oz (median amount reported by consumers)], or high coffee consumers (>22 fl oz). Similarly, in 2002, individuals were classified as being non-consumers, medium soda consumers [<19 fl oz (median amount reported by consumers)] or high soda consumers (>19 fl oz).

[1] Nonstandard abbreviations: NFCS, National Food Consumption Surveys; NHANES, National Health and Nutrition Examination Survey.

Clustering was performed on an unweighted sample. We tested a range of 3 to 8 cluster solutions (i.e., patterns of beverage consumption) and clustered on the following beverage variables: unsweetened coffee, unsweetened tea, low-fat milk, diet beverages, whole fat milk, fruit and vegetable juice (combined), alcohol, and soda and fruit drinks (combined). Water and sports drinks were not used because information on intake was not collected in 1977. The most robust and parsimonious cluster solution (containing no less than 5% of the sample in each cluster) was selected as the final solution.

These clusters, which represent overall patterns, or combinations, of beverage intake, were named according to 1) the beverages that dominated each pattern and 2) the beverages that helped differentiate one pattern from another. In one 1977 cluster, for example, 100% of the persons consumed whole fat milk, 24% consumed fruit or vegetable juice, and fewer than 10% of the persons reported consuming any of the other beverages. Since the other clusters had between 30% and 36% of the persons within them consuming fruit and vegetable juice, this variable did not help differentiate between patterns. Thus, this particular cluster was named whole fat milk. Age, race, and gender probabilities were calculated using Stata.

Results

Beverage Trends

From 1965 and 2002, there was a significant, monotonic increase in the per capita total caloric intake from beverages (Table 1), increasing from 236 calories per day in 1965 to 458 calories per day in 2002 ($p < 0.01$). Despite increases in total calories over this same time period (1993 vs. 2185 total calories per day in 1965 and 2002, respectively, $p < 0.01$), the contribution of beverages to overall caloric intake increased as well. In 1965, beverages accounted for roughly 12% of total calories. This increased to 14% in 1977 and 19% in 1989, and by 2002, beverages accounted for 21% of daily caloric intake ($p < 0.01$ comparing each year to each other year). The proportion of calories from beverages has also shifted over time. In 1965, just 17% of the population consumed ≥25% of their daily calories from beverages. By 1989, a full 37% of the population was consuming a quarter of their calories from beverages, with a slight drop in 2002 to 30%.

The changes in the per capita consumption of individual beverages are complex. Soda, fruit drinks, sweetened coffee, and sweetened tea were the only beverages for which there was a monotonic increase in caloric intake between 1965 and 2002 (Table 1). Beverages with the largest change in calorie consumption between 1965 and 2002 were soda (108 calories per day, $p < 0.01$), alcohol (73 calories, $p < 0.01$), whole fat milk (−51 calories, $p < 0.01$), fruit drinks (25 calories, $p < 0.01$), and low-fat milk and fruit juice (19 calories each, $p < 0.01$). Overall, per capita consumption of caloric beverage containing nutrients increased by 45 calories, due to significant increases in alcohol, and all calorically sweetened beverages (soda, fruit drinks, sweetened tea, sweetened coffee, and other sweetened beverages) increased by 153 calories ($p < 0.01$).

Many of these beverages also experienced the greatest change in the percent of the population consuming them (Table 2). Coffee experienced the greatest decline in consumption, with roughly 30% fewer people consuming it in 2002 compared with 1965 ($p < 0.01$), followed by whole-fat milk (−15%, $p < 0.01$). Roughly 20% more people reported consuming soda ($p < 0.01$), 13% more reported consuming alcohol ($p < 0.01$), and 14% more people reported consuming diet beverages and low-fat milk ($p < 0.01$) between the same time-points.

Among consumers, only whole-fat milk contributed fewer overall calories to daily intake, although the absolute amount between 1965 (184 calories) and 2002 (175 calories) was not significant (Table 2). Fruit drinks (199 calories, $p < 0.01$), alcohol (109 calories, $p < 0.01$), and soda (129 calories, $p < 0.01$) contributed significantly more calories in 2002 than in 1965. Per capita water (Beverage Level 1) consumption increased little between 1989 (43 fl oz) and 2002 (45 fl oz), although the average per capita ounces of all beverages consumed increased from 79 fluid ounces in 1989 to 100 fluid ounces in 2002 (Figure 1).

Beverage Patterning

Using cluster analysis, we identified 5 robust beverage patterns in 1977 and 5 in 2002 (Figure 2); each of these patterns was consistently observed across multiple iterations of analyses. In 1977, the 5 beverage patterns were named: 1) soda, high coffee, and whole-fat milk; 2) soda and whole-fat milk; 3) tea and low-fat milk; 4) whole-fat milk; and 5) high coffee. These patterns differed in both the types and combinations of beverages from those that were observed to group together in 2002. Beverage patterns in 2002 were named: 1) juices and tea; 2) coffee, milk, and alcohol; 3) medium soda, coffee, and whole-fat milk; 4) high coffee; and 5) diet beverages and low-fat milk.

In general, beverage patterns in 2002 were more complex, with a greater number of beverages represented both between and within the observed patterns. For example, combinations of 8 beverages dominated patterns in 2002, while just 5 beverages dominated the patterns in 1977. The per capita increases in consumption of certain beverages, namely, soda and diet beverages, is reflected in the 2002 patterns, as these beverages differentiated patterns in 2002 but not in 1977. For example, in 2002, unlike 1977, consumers of diet beverages fell into their own pattern.

Discussion

Overall beverage consumption has changed greatly in the past 40 years. While most of the focus previously has been

Table 1. Per capita caloric consumption by beverage,* 1965 to 2002

	Year			
	1965 (n = 6360)	**1977 (n = 17,096)**	**1988 (n = 13,629)**	**2002 (n = 9491)**
Level 1: Water				
Water	NA	NA	0	0
Level 2: Coffee and Tea				
Coffee	10 (0.13)	9 (0.09)†	3 (0.13)‡¶	9 (0.38)‖**
Tea	1.2 (0.04)	1.3 (0.04)†	0.7 (0.05)‡¶	1.4 (0.11)§**
Total Level 2	11 (0.13)	10 (0.10)†	4 (0.15)‡¶	11 (0.40)‖**
Level 3: Low-fat Milk				
Low-fat milk	6 (0.54)	14 (0.54)†	11 (0.61)‡¶	25 (2.06)§‖**
Level 4: Diet Beverages				
Diet	1.3 (0.25)	0.3 (0.02)†	0.5 (0.04)‡¶	1.2 (0.08)§‖**
Level 5: Caloric Beverages Containing Nutrients				
Fruit juices	20 (0.59)	35 (0.66)†	40 (1.44)‡¶	39 (1.82)§‖
Vegetable juices	0.8 (0.08)	1.1 (0.11)†	0.4 (0.08)‡¶	1.0 (0.20)**
Sports drinks	NA	NA	0.7 (0.11)‡	3 (0.31)§**
Alcohol	26 (1.41)	57 (2.36)†	40 (2.02)‡¶	99 (5.61)§‖**
Whole-fat milk	119 (2.23)	99 (1.96)†	128 (2.34)‡¶	69 (2.07)§‖**
Total Level 5	167 (2.71)	192 (2.70)†	209 (3.04)‡¶	212 (7.00)§‖
Level 6: Calorically Sweetened				
Soda/cola	35 (1.13)	41 (0.97)†	81 (1.93)‡¶	143 (6.77)§‖**
Fruit drinks	13 (0.75)	14 (0.63)†	36 (1.33)‡¶	38 (2.42)§‖
Sweetened coffee	NA	0.2 (0.03)†	0.6 (0.14)‡¶	3 (0.45)§‖**
Sweet tea	NA	9 (0.57)†	13 (1.09)‡¶	14 (1.40)§‖
Other sweetened beverages	3 (0.30)	4 (0.41)†	3 (0.31)¶	5 (0.75)§**
Total Level 6	50 (1.46)	69 (1.38)†	134 (2.40)‡¶	203 (6.97)§‖**
Other beverages††	0.2 (0.07)	0.5 (0.11)†	2.2 (0.30)‡¶	7 (0.87)§
Total beverages	236 (3.15)	285 (2.90)†	360 (3.30)‡¶	458 (7.4)§‖**
Other food	1769 (2.1)	1727 (7.5)†	1815 (14.9)‡¶	1740 (11.1)§**
Total food and beverage	1993 (12.6)	2012 (10.4)†	1945 (44.9)‡¶	2185 (13.8)§‖
% calories from beverages (SE)	11.8 (0.22)	14.2 (0.09)†	18.5 (0.26)‡¶	21.0 (0.20)§‖**
Distribution of beverages as % total intake (SE)				
<15%	66 (0.03)	62 (0.02)†	40 (0.03)‡¶	42 (0.04)§‖
15% to 25%	17 (0.04)	24 (0.02)†	23 (0.03)‡	27 (0.04)§
≥25%	17 (0.04)	14 (0.03)	37 (0.03)‡¶	30 (0.03)§‖**

NA, not applicable; SE, standard error.
* Results are weighted to be nationally representative and are standardized to the 1965 age and gender distribution. Values are reported as mean (SE) or % (SE) as indicated. Fractional calories were used for beverages with very low calorie content (i.e., non-caloric, diet beverages) where rounding to whole numbers does not adequately differentiate.
† Significant difference between 1965 and 1977 ($p < 0.01$).
‡ Significant difference between 1965 and 1989 ($p < 0.01$).
§ Significant difference between 1965 and 2002 ($p < 0.01$).
¶ Significant difference between 1977 and 1989 ($p < 0.01$).
‖ Significant difference between 1977 and 2002 ($p < 0.01$).
** Significant difference between 1989 and 2002 ($p < 0.01$).
†† Category includes meal replacement and nutritional supplements.

Table 2. Mean difference in percent consuming and per consumer caloric intake of beverages between 1965 and 2002

	% consuming*			Calories per consumer*		
Beverage group	1965 (n = 6360)	2002 (n = 9491)	Change†	1965 (n = 6360)	2002 (n = 9491)	Change†
Level 1: Water‡						
Water	NA	89.0 (6.2)	NA	NA	0	NA
Level 2: Coffee and Tea						
Coffee	82.2 (3.7)	48.7 (4.6)§	−34	12 (0.14)	20 (0.6)¶	8
Tea	28.5 (3.9)	15.4 (6.1)§	−13	4 (0.08)	9 (0.7)¶	5
Total Level 2	89.2 (5.3)	58.8 (5.4)§	−30	12 (0.13)	19 (0.5)¶	7
Level 3: Low-fat Milk						
Low-fat milk	4.9 (7.0)	18.6 (9.8)§	14	127 (7.05)	136 (5.5)	9
Level 4: Diet Beverages						
Diet	3.1 (7.5)	17.3 (7.2)§	14	4 (6.86)	7 (0.3)¶	3
Level 5: Caloric Beverages Containing Nutrients						
Fruit juices	23.8 (3.1)	25.8 (5.2)	2.0	86 (1.56)	156 (3.1)¶	70
Vegetable juices	2.5 (8.9)	1.2 (16.2)	−1	31 (1.60)	86 (10.0)¶	55
Sports drinks	NA	1.5 (11.0)	NA	NA	149 (13.7)	NA
Alcohol	9.6 (4.8)	22.8 (6.6)§	13	272 (9.26)	381 (11.6)¶	109
Whole-fat milk	64.7 (2.8)	39.4 (3.6)§	−15	184 (2.88)	175 (3.7)¶	−9
Total Level 5	75.6 (3.1)	66.7 (5.6)§	−9	221 (3.05)	316 (6.6)¶	95
Level 6: Calorically Sweetened						
Sodas/colas	20.8 (3.0)	43.5 (4.7)§	23	167 (3.52)	297 (8.0)¶	129
Fruit drinks	9.3 (5.5)	15.1 (3.4)	6	135 (4.04)	234 (10.7)¶	99
Sweetened coffee‡	NA	2.5 (12.2)	NA	NA	130 (8.2)¶	NA
Sweetened tea‡	NA	8.4 (8.6)	NA	NA	153 (6.8)	NA
Other sweetened beverages	2.3 (8.8)	2.4 (9.2)§	6	132 (7.62)	233 (20.3)¶	101
Total Level 6	29.2 (3.2)	59.6 (4.0)§	31	173 (3.09)	321 (7.1)¶	149
Other beverages**	0.2 (31.0)	2.6 (9.7)	2.4	104 (29.3)	366 (24.9)¶	162

NA, not applicable; SE, standard error.

* Weighted to be nationally representative and are standardized to 1965 age and gender distribution.

† Change calculated as difference between 2002 and 1965. Values may not add due to rounding.

‡ Information on sweetened coffee and sweetened tea was not collected in 1965; information on water was not collected in 1965 or 1977.

§ Significant difference in percent consuming between 1965 and 2002.

¶ Significant difference in mean calories per consumer between 1965 and 2002.

** The "Other beverages" category includes meal replacement and nutritional supplements.

on soft drinks (6–8,11,25), this study adds to the current body of literature on beverage consumption by demonstrating an important role of other beverages, such as alcohol and other types of calorically sweetened beverages, on daily caloric intake. We further add to the literature by comparing the distribution of beverage patterns in the population over time. We report that beverages are now contributing a greater number of total calories to daily intake and represent a larger proportion of daily caloric intake than at any other time in the past, with average Americans consuming 21% of their calories from beverages and nearly 30% consuming a quarter or more of their daily calories in the form of beverages.

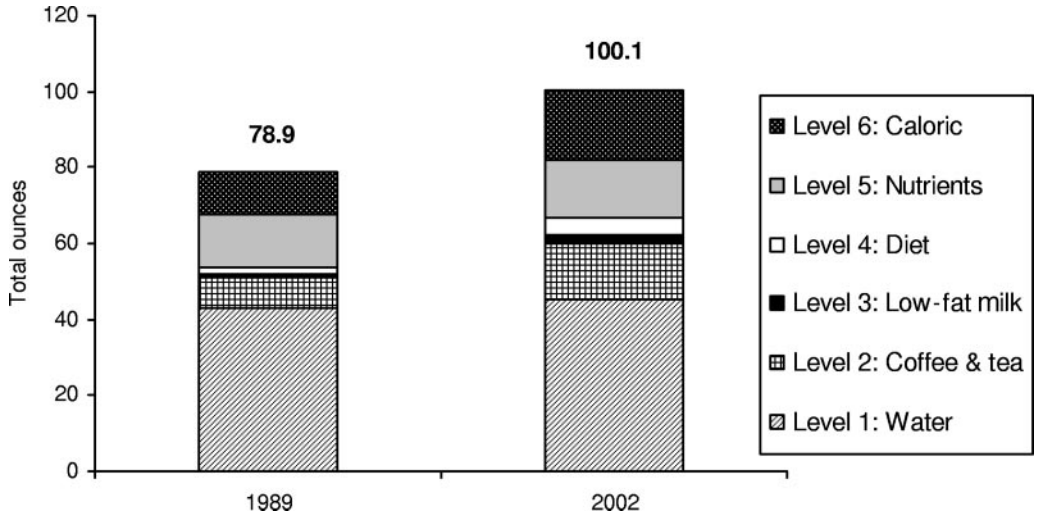

Figure 1: Per capita beverage consumption (fl oz) in 1989 and 2002 presented by beverage levels. To convert ounces to grams, divide by 0.035; to convert fluid ounces to milliliters, multiply by 29.57. Results are weighted to be nationally representative and standardized to the 1965 age and gender distribution. Beverage levels established by the Beverage Guidance System (12): Level 1, water; Level 2, unsweetened coffee and tea (do not contain cream or sugar); Level 3, low-fat milk (1% or skim); Level 4, diet beverages; Level 5, caloric beverages containing nutrients (fruit juice, vegetable juice, whole-fat milk, sports drinks, and alcohol); Level 6, caloric beverages not containing nutrients (soda, fruit drink, sweetened coffee, sweetened tea, and other sweetened beverages).

The trends in consumption and caloric contribution of beverages are complex. Although significantly fewer people consumed whole-fat milk, among consumers, there was no change in caloric intake from this beverage. With fruit drinks, there was not a significant increase in the percent consuming, but there was a significant increase in the caloric intake from this beverage. For soda and alcohol, not only was there a significant increase in the percent of people consuming these beverages, but those who were consuming obtained significantly more calories from these 2 beverages between 1965 and 2002. Furthermore, on average, there was a greater volume of beverages being consumed, with the greatest increase accounted for by calorically sweetened beverages, alcohol, and unsweetened coffee and tea.

Although caffeine is a mild diuretic, the increases in coffee and tea consumption are likely not great enough to

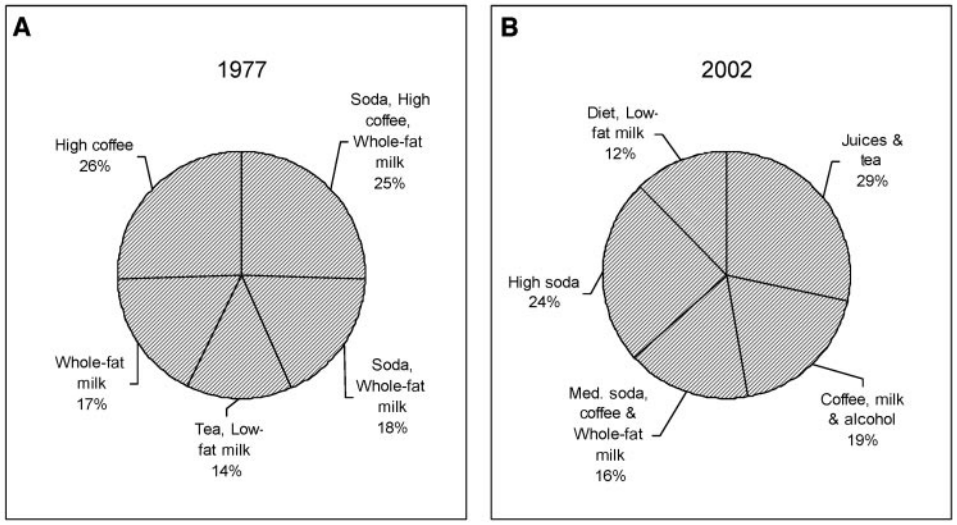

Figure 2: Beverage patterns observed in 1977 and 2002. (A) Beverage patterns observed in 1977. (B) Beverage patterns observed in 2002. Age-, race-, gender-, income-, and BMI-adjusted probabilities; 1977, $n = 17{,}096$; 2002, $n = 9491$.

result in significant increases in health risk. Many human studies indicate that caffeine consumption of up to roughly 500 mg/d does not lead to dehydration or chronic water imbalance (26,27) and that moderate caffeine intake (up to 400 mg/d) is not associated with increased risk of hypertension, heart disease, osteoporosis, or high cholesterol (28). The average amount of coffee and tea reported is equivalent to roughly 236 mg caffeine/d, well below the recommended 400 mg/d level. However, recent increases in the availability of highly caffeinated energy drinks, such as Red Bull (not measured in these data), and the combined effect of consuming an overall beverage pattern dominated by coffee and soda may mean that individuals are reaching these upper limits. As the consumption of these highly caffeinated beverages becomes more prevalent, effects on caffeine intake specifically may be warranted.

The differences in beverage patterns observed between 1977 and 2002 provide additional insight into how consumption has changed. Generally, the patterns in 2002 were dominated by a greater number of beverages, and patterns emerged that were dominated by beverages that did not dominate patterns in 1977, for example, diet beverages. Overall, similar beverages tended to cluster together at each time-point. For example, in 1977 and 2002, there were groups comprised of higher caloric beverages (soda, whole-fat milk, and alcohol) and some patterns comprised of lower or non-caloric beverages (low-fat milk and tea).

What we found, however, is that the patterns dominated by soda were less frequently observed in 1977 than they were in 2002. Furthermore, a larger proportion of the population in 1977 consumed beverages in patterns dominated by whole-fat milk and coffee, beverages that did not appear in patterns of beverage consumption in 2002. These patterns represent important differences in consumption behavior across time and suggest that the potential combined caloric intake from beverages is considerably larger among some individuals compared with others, depending on the combination of beverages being consumed. Finally, understanding patterns of consumption allows for more targeted interventions aimed at changing broader behaviors, rather than relying on narrowly focused intervention messages (29–32), and patterns have served as important tools in health outcomes research.

Interpretation of these results should be viewed cautiously, as methods for collecting dietary intake information changed over the course of the 4 surveys. Most notable is the adoption of the 4-step multiple-pass method for collecting 24-hour dietary recall in NHANES III and the 5-step multiple pass method implemented in NHANES 02. The National Center for Health Statistics of the Centers for Disease Control and Prevention, responsible for conducting the NHANES studies, did not conduct bridging studies to determine if systematic changes in reporting occurred as a result of these methodological changes; thus, possible confounding of time and methodological effects remains. One might speculate that more accurate reporting of beverages as a result of changes to intake methods would artificially inflate intake estimates; however, bridging studies between the 1970s and 1980s found that shifts in total energy and food composition estimates resulting from changes in methodologies did not significantly impact results (33,34). Additional limitations include the fact that dietary intake information was collected over just one season in 1965. In addition, the potential exists for systematic under-reporting by BMI category. Specifically, it has been demonstrated that overweight individuals tend to under-report dietary intake (35–38), which may result in an underestimation of beverage consumption. Given the increasing prevalence of overweight and obesity over time, the magnitude of under-reporting may have also increased, resulting in an underestimation of the upward trends in beverage consumption. Finally, due to recent changes in the availability of certain drinks, specifically caffeinated waters and other caffeinated beverages, we cannot adequately address the effects of changes in consumption of these beverages in the American diet.

Although the mechanisms have not been elucidated, evidence suggests that individuals' compensation for liquid calories is different from compensation for calories from solid foods (39,40). Mattes reported a complete lack of compensation for fluid intake, suggesting that these calories are not readily "registered" for appetite regulation (41). Furthermore, in a 4-week crossover study comparing ingestion of 450 kcal of calorically sweetened fruit drink vs. solid sweetened food (jelly beans), there was a significant increase in body weight during the fluid consumption that was not observed for the solid food (42).

Delineating the role that beverages play in a healthy diet may be a valuable piece of the public health message aimed at stemming obesity rates. Toward this end, the present study improves our understanding of the contribution of beverages to overall caloric intake and the dynamic interactions of beverages as overall patterns of consumption. For the average American, beverages represent a significant source of excess calories providing, for the most part, little added nutritional benefit above what would be obtained by consuming whole foods. To clarify, although consumption of fruit juice provides essential vitamins and nutrients, the added calories and weaker compensatory response elicited by beverages make consumption of fruit juice less desirable than consumption of the fruit itself. The exception may be the consumption of low-fat milk, which may confer health benefits (43–45), especially to certain populations, when it replaces other beverages (46,47), although the evidence is not conclusive (48). While children are mostly targeted for policies regarding access to various beverages, the present study shows that this is also a salient issue for adults.

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