Adults with Healthier Dietary Patterns Have Healthier Beverage Patterns[1,2]

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Abstract

There is an absence of research examining associations between food and beverage intake patterns and most research has centered on soft drinks, whereas research on overall beverage patterns is absent. Using data from the National Health and Nutrition Examination Survey 99–02 for adults aged 19 y and older, we independently examined beverage and food intake patterns, as well as their interrelations. Cluster analysis generated mutually exclusive intake patterns for beverages and foods. Multinomial logistic regression models provided the odds of a given beverage pattern for each food pattern; we then compared the probability of a given beverage pattern for each food pattern. Six beverage and 6 food patterns emerged. Beverage patterns revealed that calorically sweetened, noncaloric, and diet beverages tended to be consumed independently of one another. Being in the Snacks and High-Fat Foods cluster increased the odds of being in the Coffee and Soda (odds ratio (OR): 1.62 [95% CI: 1.27–2.06]) or Nutrients and Soda (OR: 1.51 [95% CI: 1.14–2.00]) beverage clusters and decreased the odds of being in the Water and Tea (OR: 0.51 [95% CI: 0.52–0.97]) cluster relative to the odds of being in the Water, Coffee, and Tea cluster. The opposite was true for the Vegetable pattern. Furthermore, persons who had a healthier food pattern had a higher probability of having a noncaloric beverage pattern than persons who did not. Increasing awareness of both the contribution of calorie-containing beverages to overall energy intake and dietary patterns associated with these beverages helps inform policies targeted at reducing energy intake in the population. J. Nutr. 136: 2901–2907, 2006.

Introduction

Over the past few decades, the average American's diet shifted considerably. On the whole, Americans are consuming more total energy per day, with dietary energy coming from foods higher in total and saturated fat, cholesterol, total energy, and added sugars (1,2), such as salty snack food, pizza, soft drinks, and fast food fare such as french-fries and hamburgers (3). Furthermore, beverages now account for ~21% of average daily total energy intake and beverage patterns are showing a similar shift to higher calorie, lower nutritional value drinks (4–6). To date, much of the literature on trends in beverage intake has focused on either the increase in calorically sweetened beverages, observed across all age groups, or the concurrent decrease in milk products (5). However, for some age groups, particularly adults, alcohol and other beverages also represent important elements in the total energy from beverages (6). There is a growing body of literature longitudinally linking consumption of caloric beverages with increased weight gain or the development of chronic diseases such as obesity and diabetes (7–11).

Numerous clinical studies report very little adjustment in food intake when beverages are consumed; beverages have weak satiety properties and elicit poor dietary compensation (12–16). Recent reviews, including the Institute of Medicine Panel on Water and Electrolytes, the Beverage Guidance Panel, and the U.S. Dietary Guidelines 2005 Panel noted excessive added sugar in the U.S. diet from calorically sweetened beverages (6,17,18). Fluid consumption is an essential contributor to water balance, as only ~20% of U.S. fluid needs are provided by food sources. However, among adults 19 y and older, the contribution of fluids to meeting the recommended daily allowances (RDAs) for essential nutrients is minimal, except for milk (28% RDA calcium; ≥9% vitamin A and potassium) and vegetable and fruit juices (23% RDA vitamin C) (18). This balance between energy and nutrient content from beverage represents a critical component in delineating the role of beverages in a healthy diet, as recently addressed by the Beverage Guidance Panel's publication on this topic (6).

In light of the absence of research examining the associations between relative contributions of beverages and foods to total energy intake, this paper builds on the current body of literature by attempting to link the two. This paper examines current beverage intake among U.S. adults by defining distinct clusters of beverage consumers, describes the sociodemographic factors associated with these beverage clusters, and explores associations between particular beverage and food clusters.

Methods

Study sample. The NHANES design is a stratified, multistage probability sample of the civilian, noninstitutionalized U.S. population (19). This study used data from individuals 19 y and older with completed

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dietary and medical examination components of the 1999–2002 surveys, thus providing a valid survey weight for the 4-y period. A final sample of 9491 individuals was used in this analysis.

Measurement of dietary data. The objective of the NHANES dietary component was to obtain detailed dietary consumption information. Each participant completed a single 24-h recall. Details of the NHANES computer assisted dietary interview system, probes, response options, and food composition table are provided elsewhere (20). The computer assisted dietary interview system was linked to the USDA Food and Nutrient Database for Dietary Studies, which updated information on weights and food measures for fast foods and individually sized products in 2004 (21). For a subsample of participants, we collected a second follow-up 24-h recall; however, only the first was publicly available for use with the combined NHANES 1999–2002 dataset.

Food group descriptions. The University of North Carolina-Chapel Hill food grouping system was used to examine food and beverage consumption (22). This system aggregates foods from the USDA nutrient composition tables into 74 nutrient-based subgroups according to fat and fiber content. To generate meaningful food patterns, the number of variables used in cluster analysis must be limited. We examined various alternatives for reducing the number of food and beverage variables and ultimately grouped variables sharing behavioral consumption characteristics (i.e., combining soda and fruit drinks into a single category). Based on this work, and in a separate article (23), we found that many of the food groupings did not facilitate differentiation of beverage patterns; thus, it was most convenient to use them as a combined group, for example using a bread group instead of individual high-fat and low-fat bread groups. Also, our goal was to examine the relation between key food and beverage items that were representative of overall patterns, not to generate the most detailed food and beverage patterns possible.

In the end, we included 14 food and 9 beverage groups in analyses. These variables were selected because they were representative of both healthy and less healthy diets and accounted for all foods and beverages consumed by our sample. These variables are similar to those reported in an analysis of water and food consumption patterns (23). The food and beverage groups used in cluster development are shown in the online supplemental materials.

Measurement of covariates. We conducted a combination of in-home and in-person interviews to gather information on demographic, socioeconomic, and anthropometric factors such as annual income (defined as percent poverty to income ratio [PIR]), education (less than high school, completed high school, more than high school), race/ethnicity (White; non-Hispanic Black; Mexican American; Other race, Hispanic; and Other race, non-Hispanic), and BMI (kilogram/meter^2). Other race and Hispanic and Other race, non-Hispanic are referred to as Other Races hereafter.

Cluster development. To inform our clusters, we examined weighted data regarding the percentage of participants consuming each beverage, amount consumed (kilojoules and milliliters), and distribution of selected demographic factors among consumers. Guided by these findings, cluster analysis was performed on an unweighted sample for beverages, treated as dichotomous (consumed yes/no) variables due to large numbers of nonconsumers, and foods, treated as continuous, standardized Z-scores, independently (SAS FASTCLUS, version 8.2; Research Triangle Institute). The purpose of cluster analysis is to place individuals into mutually exclusive groups, or clusters, as suggested by the data and not defined a priori, such that individuals in a given cluster are distinctly similar to one another and distinctly different from individuals in other clusters with respect to their mean consumption of foods and beverages. This method has been employed in previous studies of dietary patterns (for example, see 23–26).

FASTCLUS uses Euclidean distances to create cluster centroids based on least squares estimation. Optimal specifications for initial cluster centers were identified by conducting 1,000 iterations of cluster procedures, by which initial group centers were randomly generated. Iterations that produced the largest r^2 values indicated the best fit for the data and maximized the inter-to intra-cluster variability ratio (27).

To determine the most appropriate cluster solution, we compared cluster membership across increasingly complex cluster solutions, increasing from 3 to 8 clusters. If the more complex solution broke clusters into meaningful subgroups, this solution was favored. Additionally, to maintain within-cluster reliability, a cluster could contain no <4% of the sample. Comparing and describing the entire distribution of all beverage (or food) groups in a given cluster aided interpretation of the clusters. For foods, Z-scores of ±2.0 were considered significantly different; ±1.0 were considered as having clear differentiation; ±0.5 to ±1.0 indicated possible differentiation. Clusters were then named accordingly. For example, a cluster with food group Z-scores of 3.917 for Fruits, 0.225 for Low-Fat Dairy, and <0.100 for all other food groups is identified as a Fruit and Low-Fat Dairy food cluster. Our final solutions included 6 beverage and 6 food clusters. These represented the most robust patterns and maximized inter-cluster variability and intra-cluster correlation. Clusters were named according to *1*) the beverages that contributed most to intake within a single cluster and *2*) the beverages that allowed us to differentiate a single cluster from the remaining 5.

Statistical analysis. To explore the relation between particular food and beverage clusters, we used multinomial logistic regression models, controlling for important demographic factors, with Stata 9.1. The multinomial logistic regression command fits a maximum likelihood, multinomial logistic regression model, which allows for multiple comparisons across all outcomes. To test whether there was an interaction of age with food pattern, we entered the appropriate cross-product term into the model and performed a Wald Chunk Test. As a group, the interaction terms were not statistically significant and were not included in the final model ($P > 0.10$).

Using the coefficients derived from the fully adjusted regression model, we used the STATA PREDICT command to evaluate, for each participant, the probability of falling into 1 of the 6 beverage clusters, given that the individual was in 1 of 6 food clusters. With categorical outcomes, the PREDICT command produces the probability of an event (outcome) based on *1*) model parameters and *2*) adjustments made by the researcher. For example, using the multinomial logistic regression-derived coefficients, we can estimate the probability of being in the Water and Tea or Soda beverage cluster, given that 1 was also in the Fast Food or Vegetable food cluster. We then compared the estimated probability of being in a given beverage cluster between persons who either were or were not in a given food cluster. For example, we compared the probability of being in the Soda' cluster between persons who were in the Vegetable cluster with persons who were not in this cluster. In this way, such simulations provide some sense of how changing food intake, by changing the food cluster into which the individual falls, may affect beverage consumption.

Results

The final sample of adults ($n = 9{,}491$) were primarily white (47.9%), Mexican American (24.5%), and black (19.5%). Just under one-half were male (47%) and two-thirds had at least a high school education. PIR was equally distributed between low (<180% PIR; 36.9%) and high (>350% PIR; 33.9%). Overweight and obesity were prevalent at 64% of the population. Nearly one-third (29.5%) of the sample consumed >25% of their total daily energy intake from beverages, whereas 56.8% consumed ≥15% of daily total energy intake from beverages.

Current consumption patterns. Water was the most commonly consumed beverage (88% of adults; **Table 1**), followed by coffee, soda, whole-fat milk, fruit juices, and alcohol. Calorically sweetened beverages (soda and fruit drinks) and caloric beverage with nutrients (fruit and vegetable juice, alcohol, and whole-fat milk) were each consumed by ~60% of adults, whereas noncalorically sweetened beverages (diet beverages) were consumed by less than one-fifth of adults.

For all beverages but water, per capita consumption greatly underestimated the per consumer amounts. For example, per

TABLE 1 Daily beverage consumption patterns of U.S. adults aged 19 y and older[1]

Beverage group	Total energy, *kJ*		Volume consumed, *mL*		Percent consuming[2]
	Per capita	Per consumer	Per capita	Per consumer	
Level 1: Water					
Water	0	0	1349.7 ± 18.7	1522.9 ± 19.7	88.6 ± 0.006
Level 2: Coffee and tea					
Coffee, unsweetened	12.2 ± 0.4	49.0 ± 1.4	324.5 ± 7.8	660.4 ± 12.8	49.1 ± 0.011
Tea, unsweetened	2.7 ± 0.2	29.9 ± 1.8	109.7 ± 5.3	738.4 ± 25.1	14.9 ± 0.007
Total Level 2	14.9 ± 0.5	48.5 ± 1.3	434.2 ± 14.7	760.3 ± 18.9	
Level 3: Low-fat milk					
Low fat milk	62.4 ± 3.4	570.1 ± 21.6	73.8 ± 3.0	367.5 ± 11.2	20.1 ± 0.014
Level 4: Noncalorically sweetened					
Noncalorically sweetened (diet) drinks	1.9 ± 0.1	22.4 ± 1.0	136.0 ± 5.7	779.0 ± 21.9	17.5 ± 0.010
Level 5: Calorie-containing with nutrients					
Fruit juices	214.3 ± 6.2	665.1 ± 14.4	91.0 ± 2.7	349.3 ± 7.1	26.1 ± 0.010
Vegetable juices	2.6 ± 0.5	319.8 ± 47.2	4.7 ± 0.7	332.5 ± 29.5	1.4 ± 0.002
Sports drinks	15.1 ± 1.7	599.0 ± 41.6	14.1 ± 1.7	700.7 ± 55.1	2.0 ± 0.002
Alcohol	179.2 ± 10.4	1463.5 ± 66.8	213.6 ± 9.5	929.6 ± 34.3	23.0 ± 0.011
Whole-fat milk	463.9 ± 9.8	920.8 ± 15.2	107.9 ± 3.3	347.3 ± 8.1	31.1 ± 0.009
Total level 5	875.2 ± 15.5	1249.3 ± 19.4	431.3 ± 12.2	691.3 ± 14.1	
Level 6: Calorically sweetened					
Soda/colas[3]	526.0 ± 11.2	1091.0 ± 18.0	373.9 ± 9.2	811.9 ± 15.7	46.0 ± 0.010
Fruit drinks	244.0 ± 8.6	956.6 ± 25.8	91.7 ± 4.1	611.1 ± 19.5	15.0 ± 0.004
Coffee, sweetened	6.8 ± 1.0	486.9 ± 39.7	8.8 ± 0.9	364.3 ± 22.5	2.7 ± 0.003
Tea, sweetened	32.5 ± 2.3	512.6 ± 25.4	87.5 ± 5.4	872.6 ± 39.4	10.0 ± 0.007
Other sweetened beverages[4]	36.6 ± 3.1	997.2 ± 51.2	8.6 ± 0.9	314.3 ± 22.4	2.7 ± 0.003
Total level 6	846.0 ± 14.6	1279.6 ± 18.4	570.5 ± 19.6	928.6 ± 21.9	
Other beverages[5]	21.3 ± 3.7	1590.0 ± 198.8	5.0 ± 0.7	259.7 ± 28.0	1.9 ± 0.001
Total beverages	1821.6 ± 21.0	—	3000.6 ± 24.8	—	—
Other food	6849.8 ± 66.52	—	—	—	99.9
Total, beverage and food	8671.4 ± 70.49	—	—	—	100.0

[1] Using NHANES 1999–2001 data, results weighted to be nationally representative. Values are mean ± SEM; n = 9491.
[2] Values are proportion ± SEM, excluding small sample of persons who reported no beverage consumption.
[3] Also includes smoothies.
[4] Includes ethnically specific beverages such as horchata and atole, hot chocolate, and other flavored milk beverages.
[5] Includes meal replacement and nutritional supplement drinks such as Slim Fast and other instant breakfast.

capita consumption of soda was 373.9 mL, but 811.9 mL among consumers. The effect was even greater for unsweetened tea (109.7 mL vs. 738.4 mL), diet beverages (136.0 mL vs. 779.0 mL), and vegetable juice (4.7 mL vs. 332.5 mL). Similar patterns can be observed for mean energy intake from each group.

Food and beverage clusters. Our final cluster solution resulted in 6 robust beverage patterns, which were observed across multiple iterations of analyses. The final beverage clusters include: Water and Tea; Coffee, Tea, and Water; Coffee and Soda; Coffee and Soda; Diet; Nutrients and Soda; and Soda (**Table 2**).

TABLE 2 Mean consumption of beverages by beverage cluster[1]

Clusters	Beverage variables, *mL*								
	Water	Coffee[2]	Tea[2]	Low-fat milk	Diet	Nutrients[3]	Alcohol	Soda/fruit drink	Other caloric[4]
Water and tea	1525.1[5]	0	156.3[5]	92.2	0	313.4	254.9	0	157.1
Coffee, water, and tea	1308.9[5]	602.9[5]	103.7[5]	77.7	0	228.6	187.3	0	87.0
Diet	1313.7	334.7	88.5	86.5	710.4[5]	159.2	116.4	9.7	74.7
Coffee and soda	119.1	551.5[5]	55.5	35.7	23.9	188.4	176.3	354.0[5]	82.16
Nutrients and soda	1295.0	0	9367.0	34.6	24.8	488.3[5]	117.3	794.0[5]	90.7
Soda	1235.6	0	52.0	47.9	49.9	0	121.4	986.5[5]	105.2

[1] Values are reported as means.
[2] Unsweetened coffee and tea.
[3] Fruit and vegetable juice, whole-fat milk.
[4] Calorically sweetened coffee and tea; other energy containing beverages such as horchata; sports drinks.
[5] Indicates beverage variables that differentiated and were used to name the beverage clusters.

Of particular interest is the clear differentiation between consumers of calorically sweetened and noncalorically sweetened beverages; there were no clusters in which both of these beverages are the predominant beverages consumed.

These 6 clusters differed with respect to many socioeconomic and demographic characteristics as well (**Table 3**). Older persons (aged 50 and older) were more likely to be in the Coffee and Soda and the Coffee, Tea, and Water clusters, whereas younger persons were much more likely to be in the Soda and Nutrients and Soda clusters. Compared with the other race/ethnic groups, a higher proportion of White, non-Hispanics were in the Coffee, Tea, and Water and the Diet clusters, whereas a higher proportion of Black non-Hispanics were in the Water and Tea, Soda and Nutrients, and Soda clusters. Differences by income and education are not as distinct as the racial measures; however, there was a higher proportion of persons with less than a high school education in the Coffee and Soda cluster, and the Soda cluster had a higher proportion of lower income persons than those with higher incomes. The groups with the higher proportion of energy from beverages were the Coffee and Soda, Nutrients and Soda, and Soda groupings; each had about a one-quarter of individuals with >25% of energy from these beverages.

The final solution for the selected food groups also resulted in 6 mutually exclusive, nonoverlapping clusters that included: Fast Food; Vegetables; Fruits and Low-/Med-Fat Dairy; Norm; Cereal and Low-Fat Meats; and Snacks and High-Fat Foods (this includes candy, salty snacks, and high-fat meats). Mean Z-scores for each food group by cluster are presented in **Table 4**.

TABLE 3 Distribution of sociodemographic characteristics among U.S. adults aged 19 y and older, by beverage cluster[1]

	Beverage cluster					
Demographic characteristics	Water and tea	Coffee, tea, and water	Diet	Coffee and soda	Nutrients and soda	Soda
Percent in cluster	13.6	18.8	13.8	22.5	14.0	17.3
Gender, %						
Male	12.2	18.2	11.8	25.5	15.1	17.2
Female	14.8	19.4	15.7	19.7	13.1	17.3
Age, %						
19–29 y	18.3	3.8	5.2	11.7	25.6	35.3
30–49 y	11.8	15.0	15.4	24.7	15.0	18.0
50–64 y	12.0	26.2	18.8	27.4	7.0	8.5
65 y	14.4	37.0	13.9	23.5	6.5	4.7
Race/ethnicity, %						
White, non-Hispanic	12.2	21.3	16.7	22.6	12.4	14.8
Black, non-Hispanic	17.5	9.0	4.7	16.9	21.9	29.9
Mexican American	13.0	11.4	7.7	26.5	21.7	19.6
Other Race, Hispanic and Non	16.5	16.4	8.5`	28.5	11.7	18.4
Education, %						
<High School	14.8	18.3	8.5	26.2	13.4	18.9
High School/GED[2]	11.0	17.9	13.2	25.6	14.9	17.4
>High School	14.4	19.5	16.3	19.5	13.9	16.4
PIR, %						
<180	16.3	16.4	8.3	21.6	15.4	22.1
180–350	12.4	17.5	12.2	23.7	15.7	18.5
>350	12.6	21.7	19.4	22.2	11.6	12.6
Energy from beverages, %						
<15	18.3	26.4	23.4	16.0	4.7	11.3
15–25	10.4	15.6	9.2	28.6	18.0	18.2
>25	9.7	10.7	4.1	26.4	24.0	25.1
BMI, %						
Underweight (<18.5)	18.2	22.2	7.5	21.0	14.5	16.7
Normal (18.5–24.9)	15.2	19.5	10.8	21.7	15.1	17.7
Overweight (25.0–29.9)	12.5	19.8	13.6	25.6	13.8	14.7
Obese (≥30.0)	12.3	16.3	18.3	20.1	12.8	20.1

[1] Results weighted to be nationally representative; values are percent of demographic characteristics; values sum across rows; n = 9491.
[2] Completed 12 y of education (HS) or obtained general equivalency diploma (GED).

Odds of beverage cluster membership. The odds of being in a given beverage cluster differ between by food cluster (**Fig. 1**). Being in the Snacks and High-Fat Foods cluster increased the odds of being in the calorically sweetened beverage clusters [Coffee and Soda: odds ration (OR) = 1.62; 95% CI = 1.27–2.06; $P < 0.001$; Nutrients and Soda: OR = 1.51; 95% CI = 1.14–2.00; $P = 0.004$] and decreased the odds of being in the Water and Tea cluster (OR = 0.71; 95% CI = 0.52–0.97; $P <$ 0.001) relative to the odds of being in the Coffee, Tea, and Water beverage cluster. We observed similar patterns for persons in the Fast Food cluster, with an increase in the odds of being in the 3 calorically sweetened beverages clusters (Coffee and Soda; Nutrients and Soda; and Soda) compared with the Coffee, Tea, and Water cluster. Persons who were in the Vegetable cluster, on the other hand, were less likely to be in the Soda cluster (OR = 0.46; 95% CI = 0.27–0.77; $P = 0.004$) and there was a decrease in the odds of being in the noncaloric (Diet) cluster compared with the Coffee, and Tea, and Water cluster, although the results just reached statistical significance (OR = 0.63; 95% CI = 0.40–1.00; $P = 0.05$).

Likelihood of being in a given beverage cluster. The predicted probabilities for being in a given beverage cluster differed between persons who were and who were not in the same food cluster (**Fig. 2**, *A–D*). Among persons in the Fast Food and High-Fat Food and Snacks clusters, the overall patterns were similar: there was an increase in the predicted probability of being in the calorically sweetened beverage clusters (Coffee and Soda; Nutrients and Soda; and Soda) compared with persons who were not in these 2 food clusters. Those who were not in the Fast Food or High-Fat Foods and Snacks clusters had a higher probability of being in the water-dominated (Water and Tea; Coffee, Tea, and Water) and Diet clusters.

By comparison, the patterns observed for the Vegetable and Fruit and Low-Fat Dairy food clusters were quite different. For persons in these clusters, there was an increase in the predicted probability of being in the noncaloric clusters (Water and Tea; Coffee, Tea, and Water). On the other hand, persons who were not in the Vegetable and Fruit and Low-Fat Dairy clusters had a higher probability of being in the Soda and Diet beverage clusters.

Discussion

The overall beverage pattern of American adults is dominated by high energy intake from calorically sweetened beverages such as soft drinks, fruit drinks, alcohol, and high-fat milk, resulting in a total intake of 1.82 MJ/d (roughly 21% of energy) from beverages with little to no nutritional value. For example, although 20 and 26% of the population report consuming low-fat milk

TABLE 4 Mean Z-score of food groups by food cluster[1]

	Food clusters					
Food group	Fast food	Vegetables	Fruit and low-fat dairy	Normal	Cereal and low-fat meats	Snacks and high-fat foods
Salty snacks[2]	0.082	−0.094	−0.062	−0.126	−0.188	0.647[12]
Desserts[3]	−0.008	−0.006	−0.084	−0.015	−0.091	0.162
Low-/med-fat dairy[4]	−0.116	0.106	0.225[12]	0.003	−0.006	−0.024
High-fat dairy[5]	−0.045	−0.068	0.016	−0.143	−0.091	0.714[12]
Fast foods[6]	2.313[12]	−0.293	−0.165	−0.295	−0.312	−0.205
Low-fat meats[7]	−0.260	0.049	0.059	−0.048	0.426[12]	0.073
High-fat meats	−0.147	−0.133	−0.153	−0.230	−0.126	1.259[12]
Fruits	−0.189	−0.066	3.917[12]	−0.191	−0.131	−0.190
Vegetables[8]	−0.254	3.721[12]	0.007	−0.179	−0.074	0.199
Candy	0.132	−0.035	−0.052	−0.094	−0.114	0.397[12]
Fats and oils[9]	−0.112	0.141	0.018	−0.079	−0.045	0.400
Cereal[10]	−0.320	0.127	−0.086	−0.285	2.419[12]	−0.248
Bread[11]	−0.189	−0.106	0.003	−0.220	−0.183	1.230[12]

[1] Values are mean Z-scores of individual food group consumption.
[2] Includes potato chips, pretzels, and popcorn.
[3] Includes cookies, cakes and pies, and gelatins.
[4] Includes low-fat (1.5%) and skim milk, cheese, cottage cheese, and yogurt products.
[5] Includes 2% and whole milk, cheese, and yogurt products as well as malted milkshakes, ice cream, and other cream items.
[6] Includes french fries, hamburgers, pizza, and Mexican fast food items.
[7] Includes low-fat beef, pork, and luncheon meats.
[8] Excludes french fries.
[9] Includes butter, margarine, and vegetable oils.
[10] Includes ready-to-eat cereals.
[11] Includes low- and high-fat breads, such as bagels and croissants.
[12] Indicates food groups that dominate and were thus used to name each food cluster.

and fruit juice, respectively, these 2 beverages each account for roughly 350 mL of intake, whereas soft drinks provide 812 mL for the 46% of persons who are consumers. Most experts have explored the role of soft drinks and fruit drinks, the major calorically sweetened beverages, but have ignored other critical elements of the overall beverage consumption pattern. Moreover, there has been a lack of understanding of how beverages are associated with each other and who is consuming them. This has led to vague recommendations to increase intake of water, tea, coffee, and even noncalorically sweetened beverages. In this paper, we examine overall beverage patterns and examine the correlation of these patterns with diet.

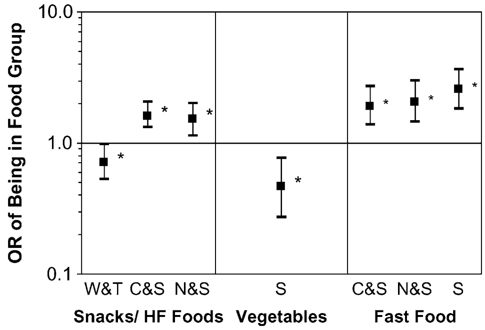

Figure 1 Odds ratio of being in a given beverage cluster based on being in a given food cluster. Results are from multinomial logistic models controlling for age, race, gender, income, and overweight status. Results are weighted to be nationally representative. Values represent OR ± SE, n = 9491. Beverage cluster abbreviations: W&T, Water and Tea; C&S, Coffee and Soda; N&S, Nutrients and Soda; S, Soda. *Differences within food cluster, compared with Coffee, Tea, and Water Cluster; $P < 0.001$.

We identified 6 mutually exclusive groups of beverage consumers whose overall patterns of beverage intake were distinctly different from one another. Despite many distinctions between these patterns, there was 1 key element that did not differentiate the clusters. Alcohol, representing roughly 10% of adult energy intake from beverages, was evenly distributed across the clusters, whereas other key beverages, including water, tea, coffee, and diet soft drinks, clustered independently of one another.

Persons in the 3 beverage patterns dominated by noncalorically sweetened beverages (Coffee, Tea, and Water; Water and Tea; and Diet) consumed less energy from beverages than persons who consumed 1 of the beverage patterns dominated by calorically sweetened beverages (Soda, Soda and Coffee, and Soda and Nutrients), which is not surprising given recent literature on the topic (3–5,28). These results provide insights into possible steps adults might take to reduce overall energy intake by reducing the amount of energy consumed from beverages.

The food clusters examined in this article are comparable to those reported elsewhere (10,29,30). Although studies of dietary intake using cluster analyses can be difficult to compare directly due do variations in cluster names, number of derived food clusters, and food group inclusions, there are many similarities. Regardless of the number of clusters reported, at least 1 cluster tends to define healthier eating patterns (characterized by greater consumption of vegetables, low-fat dairy products, and/or whole grains) and 1 defines less healthy eating patterns (characterized by greater consumption of desserts, high-fat foods, or fast food/convenience items). Newby et al. termed these "Healthy Pattern" and "Sweets Pattern," respectively (31), whereas Quatromoni et al. assigned names based on dietary quality, calling them "Heart Healthy" and "Empty Calorie" (32). Our food groups were named according to the foods that contributed the greatest amount to total intake as well as serving as unique identifiers

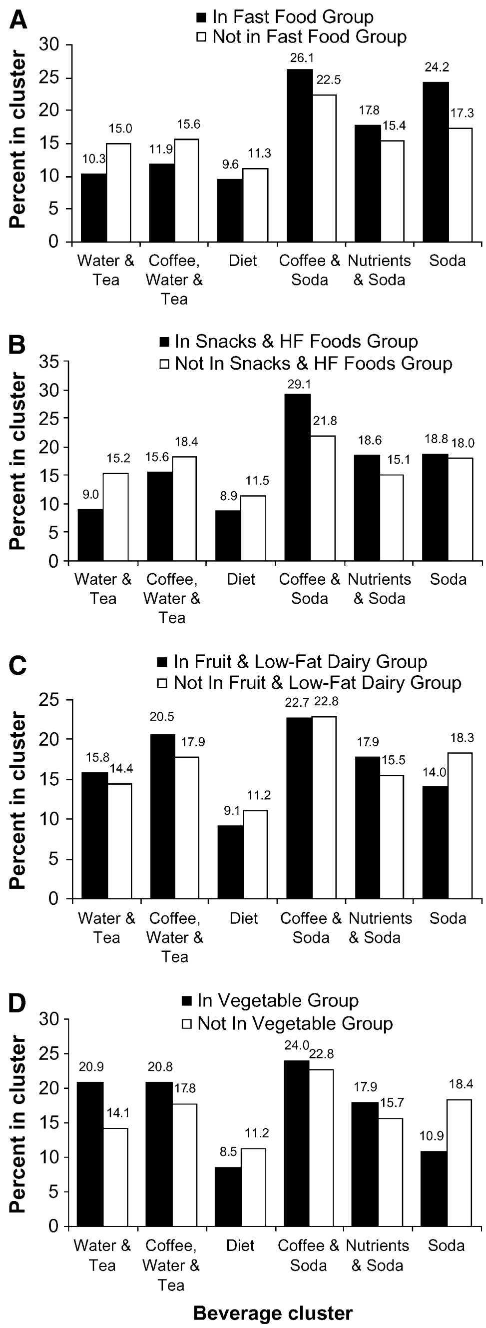

Figure 2 Being in the Fast Food *n* = 1014 (*A*), Snacks and High-Fat Foods *n* = 1299 (*B*), Vegetables *n* = 418 (*C*), and Fruit and Low-Fat Dairy *n* = 415 (*D*) food clusters compared with not being in those clusters is linked with differential probability of consuming noncalorically sweetened beverages. Predicted probabilities are obtained from multinomial logistic models controlling for age, race, gender, income, education, and overweight status. Results are weighted to be nationally representative.

between clusters. The parallels observed between our clusters and those reported in other studies give credence to our cluster groupings and may be suggestive of a general consistency in dietary patterns across of range of populations and study years.

We recognize that it is unrealistic to assume that food and beverage decisions are made independently. Therefore, we examined the associations between beverage and food intake by running multinomial logistic models of beverage cluster on food cluster. In general, we report that being in an unhealthy food cluster increased the probability that you were also in an unhealthy beverage cluster, and vice versa. For example, persons who were in the Fast Food cluster were more likely to be in the Soda Cluster, whereas persons in the Vegetable food cluster were less likely to be in this same beverage group. Furthermore, persons who were in one of the more unhealthy food clusters also had a smaller predicted probability of being in one of the healthier (noncaloric) beverage clusters compared with persons who were not in the unhealthy food clusters.

Consumption of individual beverages varies according to food cluster, even when persons in different food clusters are in the same beverage cluster. For example, compared with persons not in these clusters, those who were in the Vegetable and Fast Food clusters had an increased probability of being in the Nutrient and Soda group. This is contrary to what would be expected given that healthier food clusters are associated with healthier beverage clusters. A closer look at the actual consumption of the beverages in the Nutrient and Soda cluster, however, shows that whereas persons in the Vegetable and Fast Food clusters consumed nearly equal amounts of fruit and vegetable juice (nutrients: 502.8 mL), those in the Vegetable cluster consumed an average of 561.9 mL of soda, whereas those in the Fast Food cluster consumed an average of 798.5 mL of soda. Thus, people in a given beverage cluster consumed a different percentage of beverages within that cluster depending on food cluster.

We add to the current body of literature of dietary patterns by demonstrating that overall dietary patterns exist, even when consumption of foods and beverages are considered independent of one another. When food intake was used as a predictor of beverage intake, the patterns were similar to those found when food and beverage variables are clustered together.

There are several strengths and limitations with this study. Dietary intake was assessed using a single 24-h recall, which is not representative of usual intake at the level of the individual. However, our results were weighted to be nationally representative, which allows us to more readily draw conclusions about patterns in the general population. Further, we use a recognized method for elucidating patterns based on characteristics described by the data, rather than defining intake based on a priori patterns of dietary intake. Cluster analysis has been criticized for being too subjective, which we minimized by testing a range of final clusters (from 3 to 8 groups), specifying initial cluster centers that maximized the inter-to-intra cluster variability ratio before running the cluster program, and using predefined guidelines for selecting and naming final cluster solutions. Specifying initial cluster centers and using predefined guideline for selecting and naming clusters differentiates our methods from other cluster analyses of dietary patterns.

The Beverage Guidance Panel, the Institute of Medicine, and the USDA Dietary Guidelines groups all note the need to reduce intake of refined carbohydrates, particularly caloric sweeteners (33–36). This analysis has demonstrated that particular populations tend to be consumers of calorically sweetened beverages, and that these populations differ from those who are consuming noncaloric and diet beverages. Further, consumption of sweetened beverages seems to be closely linked to less healthy eating patterns, such as those defined by high-fat foods, fast foods, and snacks. This is disconcerting because both calorically sweetened beverages and fast food/high-fat foods have been shown to be associated with overweight and long-term weight gain, thus increasing the risk of adverse health outcomes among these particular populations.

There are important implications of these findings. First, increasing awareness of the role that beverages play in overall energy intake may help promote the substitution of noncaloric beverage for calorically sweetened ones. Second, this work has identified a clear target for intervention messages: consumers of less healthy foods. Targeting policies or programs at this audience may be the best method for decreasing energy intake from beverages and have the greatest impact on behavior change, especially leading to reduced energy intake, because food and beverage consumption appear to be intimately linked.

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