Water and Food Consumption Patterns of U.S. Adults from 1999 to 2001

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Abstract

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Objective: High water consumption has been proposed as an aid to weight control and as a means of reducing the energy density of the diet. This study examines the relationship between water consumption and other drinking and eating patterns.

Research Methods and Procedures: The National Health and Nutrition Examination Survey 1999 to 2001, with responses from 4755 individuals ≥18 years of age, provides the data for this cross-sectional analysis. A cluster analysis was performed using z-scores of specific food and beverage consumption to examine patterns. A multinomial logit analysis was used to examine sociodemographic characteristics of each dietary pattern and to examine the effects of water consumption on the likelihood of consuming a non–dairy caloric beverage. All results were weighted to be nationally representative and controlled for design effects.

Results: Within the sample, 87% consumed water, with an average daily consumption of 51.9 oz (1.53 liters) per consumer. Water consumers drank fewer soft/fruit drinks and consumed 194 fewer calories per day. Water consumers (potentially a self-selected sample) consumed more fruits, vegetables, and low- and medium-fat dairy products. Four distinct unhealthy dietary patterns were found that included little or no water consumption. Older and more educated persons used healthier food patterns. Mexican dietary patterns were much healthier than dietary patterns of blacks.

Discussion: Water consumption potentially is a dietary component to be promoted, but much more must be understood about its role in a healthy diet. Because high water consumption is linked with healthier eating patterns—patterns more likely to be followed by higher-educated, older adults—the target of water promotion and healthy diet options should focus on younger and less educated adults.

Key words: water consumption, energy density, cluster analysis

Introduction

The worldwide pandemic of obesity and the increases in energy intake, particularly from liquid calories, are of great concern. Increased water consumption is used as a key message in many diet control and weight reduction programs; nevertheless, very little research has been undertaken to understand the role of water in diets. For instance, the proportion of energy intake from all beverages has increased rapidly to over 21% for the daily intake of the average American ≥2 years of age (1). Furthermore, adding water to the overall diet is viewed as the major way to reduce energy density (2). Water is clearly important to our health. The Institute of Medicine report provides an excellent review of the benefits of water consumption (3). This panel notes that when dehydration occurs, there is impaired cognition, moodiness, poor thermoregulation, reduced cardiovascular function, impaired physical work capacity, and increased risk of bladder cancer (3).

Water consumption may be important not only for health but also as a way to identify more health conscious consumers. In the context of current dietary trends, in particular related to calorically sweetened beverages, high water consumers may be more health conscious and, therefore, purposefully select water to replace caloric beverages and also select lower calorie, more healthful foods in their eating patterns. If true, low water consumption may be a criterion

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to identify those persons who are not eating a healthful diet, and these persons can be targeted for further education on healthy dietary patterns.

The combination and relative amounts of water, caloric beverages, and food consumption patterns must also be taken into account to understand their relationships and potential effects on each other. There is only limited understanding of how water consumption patterns relate to the consumption of other beverages and foods, how water currently fits into food consumption patterns, and which categories of persons consume more, or less, water as part of their diet. This paper examines 1) the differences between water consumers (those persons who drink any water—tap or bottled—per day) and non-consumers (those persons who do not drink any water) with respect to their consumption of beverages and other selected food groups (as well as the linkage with broader eating patterns), 2) the effects of water consumption on the likelihood of consuming a non-dairy caloric beverage, and 3) the effects of sociodemographic variables on dietary patterns. The analysis is based on results of the National Health and Nutrition Examination Survey 1999 to 2001—the most recent nationally representative study of dietary consumption in the United States.

Research Methods and Procedures

Sampling

The National Center for Health Statistics, part of the Centers for Disease Control and Prevention, has conducted a series of health and nutrition surveys since the early 1960s. Every year, ~7000 individuals of all ages are interviewed in their homes, and ~5000 complete the health examination component of the survey. The National Health and Nutrition Examination Survey design is a stratified, multistage probability sample of the civilian, non-institutionalized U.S. population (4).

This study used data from the dietary interview of the National Health and Nutrition Examination Survey 1999 to 2001 completed by 4755 individuals ≥18 years of age.

Dietary Data

The objective of the National Health and Nutrition Examination Survey dietary interview component was to obtain detailed dietary consumption information. These data were used to estimate total consumption of energy, nutrients, and non-nutrient food components from food and beverages that were consumed during the 24-hour period before the interview (midnight to midnight). A multiple pass 24-hour dietary interview format was used. After the dietary recall, a short post-recall questionnaire was administered, in which, among other things, respondents estimated their water consumption (both tap and bottled) during the past 24-hour period.

The National Health and Nutrition Examination Survey computer-assisted dietary interview system, developed by PowerBuilder (Sybase, Dublin, CA) and RoboHelp (Macromedia, Inc., San Francisco, CA), is a standardized, automated data collection format to collect dietary interview data; several databases are linked to this system. Food probes [i.e., brand names, food preparation methods, use of fat and salt in preparation, cooking methods, type of liquid added in recipe foods (selected food groups), and food group–specific guidelines] were listed for the interviewers (so they would know how to probe for food amounts and record information used in previous National Health and Nutrition Examination Survey and U.S. Department of Agriculture surveys) and became part of the built-in features of the system.

The water data came both from the dietary intake survey and also from some separate questions. We have been unable to find any calibration studies undertaken by National Health and Nutrition Examination Survey. Essentially, these data were obtained in a two-part manner. The information about bottled water was obtained by including this as one of the consumed beverages in the dietary intake survey. The information about tap and spring (well) water was obtained in a question at the end asking for the quantity of drinking water consumed with a follow-up reminder to the respondent that stated: "Include only plain tap or spring water."

Food Group Descriptions

To examine the thousands of foods contributing to energy consumption, the University of North Carolina-Chapel Hill food grouping system was used (5). This system aggregates all of the foods in the U.S. Department of Agriculture nutrient composition tables into 74 descriptive and nutrient-based subgroups. Of these 74 subgroups, 11 were used; within 2 of these, a full set of beverages was included—milk, fruit juices, soft drinks, fruit drinks, coffee and tea, and alcohol (beer, wine, and liquor). To undertake cluster analysis, it is necessary to limit the number of food groupings. The food groups selected allowed us to differentiate the potential healthfulness of the dietary pattern selected. The following 11 nutrient-based subgroups were examined: 1) salty snacks, including low- and high-fat salty snacks (i.e., potato chips, pretzels, and popcorn); 2) desserts, including low- and high-fat desserts (i.e., gelatin, cake, cookies, and pies); 3) a combined low- and medium-fat dairy food group, including skim milk, 2% milk, whole milk, low-fat yogurt items, and low-fat cheese; 4) a high-fat dairy food group, including malted shakes, cream items, and high-fat cheeses; 5) all non-dairy caloric beverages, including coffee and tea with caloric additions, alcohol, regular (non-diet) soda, fruit juices, and fruit drinks; 6) all non-caloric beverages, including no-calorie coffee, no-calorie tea, no-calorie juice drinks, and diet soda; 7) a set of fast

foods, including French fries, hamburgers, cheeseburgers, pizza, and Mexican food (i.e., burritos, enchiladas, tacos, tamales, and nachos); 8) high-fat meats, including high-fat beef, pork, veal, lamb, game, poultry, luncheon meats/hot dogs, fish, and bacon; 9) fruit, excluding dried fruits and fruit juices from this category; 10) vegetables, excluding French fries from this vegetable category; 11) candy, includes the full array of packaged and ethnic group items.

Statistical Analysis

The sample survey results were analyzed regarding the amount of water consumption, differences in the number of sampled persons consuming water, quantity of certain food groups consumed (calories as well as grams), and the type of water consumed. Guided by the descriptive statistics, a cluster analysis was performed using Z scores of specific food and beverages consumed, and simulations of socioeconomic status or demographic characteristics were conducted.

Cluster analysis was used to examine water consumption. The purpose of cluster analysis is to place objects into groups or clusters suggested by the data, not defined a priori, such that objects in a given cluster tend to be similar to each other in some sense, and objects in different clusters tend to be dissimilar. Water consumption was treated as a continuous variable, similar to the foods consumed from other food groups. Although descriptive statistics were weighted for survey sample design, the cluster analysis was performed on an unweighted sample. Cluster analysis was performed for diets delineated by different numbers of food groups. We examined these for between 3 and 15 clusters. The patterns of cluster analysis that proved most insightful in terms of delineating water-related food consumption patterns, as well as providing other interpretable distinguishable patterns of diet, were used.

The PROC FASTCLUS tool (SAS statistical software version 8.12; SAS Institute, Cary, NC) was used to group people into clusters based on their dietary behaviors. The FASTCLUS procedure performs a disjoint cluster analysis on the basis of distances computed from one or more quantitative variables. The observations were divided into clusters such that every observation belonged to one, and only one, cluster. By default, the FASTCLUS procedure uses Euclidean distances, so the cluster centers were based on least squares estimation. PROC FASTCLUS produced brief summaries of the resultant clusters.

Based on the cluster results, simulations were conducted using mlogit in STATA 8 (Stata Corp., College Station, TX) to determine how sociodemographic characteristics affected dietary patterns: mlogit fits maximum likelihood, multinomial logit models. Predicted probabilities were calculated from these models simulating a specific level of socioeconomic status or demographic characteristics (e.g., low education).

Additional weighted analyses, based on the effects of water consumption on the likelihood of consuming a non-dairy caloric beverage, were undertaken using mlogit in STATA 8. Furthermore, among non-dairy caloric beverage consumers, water consumption was used to determine the calorie differential consumption between water consumers and non-consumers, using a linear regression. These analyses controlled for sociodemographic characteristics.

Results

Results related to the consumption of regular (non-diet) soda, milk, and fruit juices are the only ones presented because these were the only food groups that had a significant difference between water consumers and non-consumers.

Prevalence of Water Consumption

After weighting for survey sampling design, we found that 88% of the U.S. population sample consumed water as a beverage. The average quantity of water consumed by this sample of water consumers was 51.9 oz (1.53 liters) per day—about 6.5 8-oz glasses of water.

Water and Other Beverage Daily Consumption

There were unique differences in the daily beverage consumption patterns for water and non-water consumers. Table 1 presents the proportion of the overall sample, the water consumers, and the non-water consumers who consumed each of the food groups listed. We provide all non-dairy caloric beverages in combination and separately. Soft drinks were consumed by 45% of water consumers, with an average daily consumption level of 139 kcal, whereas 63% of non-water consumers consumed an average daily total of 276 kcal from soft drinks. In contrast, 49% of water consumers also consumed milk, whereas only 38% of water non-consumers consumed milk. The average daily calories from milk was 66 kcal for consumers and 75 kcal for non-consumers, showing that water consumers were consuming either less milk or lower-fat dairy items. In addition, 29% of water consumers consumed fruit juices, but only 17% of water non-consumers consumed fruit juices. What is interesting is that so few water consumers and non-consumers consumed fruit juice. In results not presented in Table 1, we found that considering juice drinkers only, on average, the water consumers among them consumed less energy from fruit juices than did the water non-consumers (139 vs. 163 kcal).

We found that the total daily caloric consumption of water consumers was much smaller and significantly less than non-consumers of water—2188 vs. 2382 kcal, respectively. This 194-kcal difference is not only statistically significant but very large (~9%).

Table 1. Descriptive characteristics of water consumers, non-consumers, and total sample among U.S. adults ≥18 years of age*

	Total sample (n = 4755)		Water consumers (n = 4186)		Water non-consumers (n = 569)	
Food groups	Daily consumption (%)	Average daily consumption (kcal)	Daily consumption (%)	Average daily consumption (kcal)	Daily consumption (%)	Average daily consumption (kcal)
Salty snacks	41.1	84	40.5	83	45.3	94
Desserts	52.5	196	52.9	195	50.3	205
Low-and medium-fat dairy	55.3	117	57	118	43.8	108
High-fat dairy	50	67	50	66	49.8	75
Non-dairy caloric beverages						
Coffee and tea	13	17	12.3	14†	17.8	36†
Regular soda	47.3	157	45	139†	63.1	276†
Fruit juices	27.5	39	29.2	41†	16.5	27†
Fruit drinks	16.6	41	16.2	39	19.6	54
Total	74.9	253	73.8	233†	82.5	394†
Non-caloric beverages	60.4	8	62.2	8	47.9	7
Fast food	31.2	168	30.3	160†	37.5	222†
Higher-fat meat products	29.9	82	29.7	80	31.3	92
Fruits	6.6	3	6.8	3	5.3	2
Vegetables	22.3	11	23.8	12†	11.6	6†
Candy	23.1	39	22.9	38	24.4	47
Any other foods	100	931	100	959	100	737
Total	100	2213	100	2188†	100	2382†

* Weighted to be nationally representative.
† $p < 0.05$.

We also explored the odds of consuming a combination of sugared, non-dairy beverages (e.g., combined fruit drinks and soft drinks). In logit results, controlling for sociodemographic factors, water consumers were 25 times less likely to consume a combination of these beverages.

The quantity of non-dairy caloric beverage consumption increased as water consumption decreased. Furthermore, a water consumer consumed 161 kcal fewer of these beverages than a water non-consumer.

What Are the Dietary Patterns of Water Consumers?

Six clusters (Table 2) of dietary patterns were found in this sample from the cluster analysis: 1) a nondescript (normal) cluster of 2668 people who ate about the norm for all foods and consumed small amounts of water; 2) a cluster of 407 people who consumed desserts; 3) a cluster of 509 people who consumed non-caloric beverages and high-fat meats; 4) a cluster of 91 people who consumed high-fat dairy products and salty snacks; 5) a cluster of 790 people who consumed water, fruit, vegetables, and low- and medium-fat dairy products; and 6) a cluster of 290 people who consumed salty snacks, candy, non-dairy caloric beverages, fast food, and high-fat meats. Water non-consumers consumed twice the amount of vegetables as water consumers (24% vs. 12%, but only 50 vs. 55 kcal). There were fewer water consumers than non-consumers who consumed salty snacks, non-dairy caloric beverages (specifically regular soda), fast food, high-fat meats, and candy.

Who Consumes the Various Food Patterns?

The multinomial logit results were used to understand the proportion of individuals with various backgrounds whose consumption fit specific food patterns (Table 3). The multinominal logit results that were used provided all combinations of the likelihood of selecting a single outcome as contrasted with other outcomes. Simulation of the final models provides some sense of how changes

Table 2. Food group clusters represented in each eating pattern derived from cluster analysis (means of Z scores) for adults ≥18 of age

Food group clusters (eating patterns)	Frequency (no. of people)	Salty snacks	Desserts	Low- and medium-fat dairy	High-fat dairy	Nondairy caloric beverage	Noncal beverage	Fast food	High-fat meat	Fruit	Vegetables	Candy	Water
1*	2668	−0.214	−0.292	−0.242	−0.170	0.067	−0.323	0.043	−0.062	−0.172	−0.233	−0.145	−0.253
2†	407	−0.170	2.370	−0.033	−0.008	0.183	−0.098	−0.083	0.073	−0.183	−0.116	−0.023	−0.069
3‡	509	0.043	−0.028	−0.172	0.136	−0.546	2.004	0.033	0.259	−0.103	−0.094	0.006	0.042
4§	91	0.500	0.042	0.124	4.717	0.197	0.057	0.016	0.120	0.180	−0.046	−0.091	−0.058
5¶	790	−0.182	−0.207	0.910	−0.077	−0.215	−0.153	−0.225	−0.137	0.749	0.953	−0.092	0.889
6‖	290	2.475	−0.037	−0.037	0.069	0.606	−0.012	0.267	0.350	−0.081	−0.111	1.639	−0.054

Values are Z scores.
* Norm.
† High: desserts.
‡ High-fat meats, non-caloric beverages.
§ High-fat dairy foods, salty snacks.
¶ Water, fruits, vegetables; low-fat dairy.
‖ Fast foods, snacks, soda.

in each socioeconomic and demographic factor affected food patterns. Results showed that 6% of the population consumed the least healthy "fast food/snack/soft drink" dietary pattern; 17% were healthier eaters, consuming the "water/fruit and vegetable/low fat milk" pattern with higher water consumption; and 55% consumed the norm food pattern, 9% consumed the high desserts food pattern, 11% consumed the high-fat meats and non-caloric beverages food pattern, and only 2% consumed the high-fat dairy foods and salty snacks food pattern.

Age, education, and race were the variables that seemed to be more significant than income or sex in terms of actual impact on dietary patterning (Figure 1). Simulations showed that young adults (age 18 to 35 years) had a tendency to consume less healthy diets; 9% consumed the least healthy "fast food/snack/soft drink" dietary pattern, and 14% consumed the healthy "water/fruit and vegetables/low-fat milk" pattern. In contrast, among older adults (>60 years), only 3% consumed the least healthy diets, whereas 20% consumed the healthy diets. Simulations showed that 21% of the highly educated (more than high school education) had healthy dietary patterns, whereas only 13% of the less educated (less than high school education) consumed the healthy "water/fruit and vegetables/low-fat milk" dietary pattern. Dietary patterns also differed by races and nationalities, with Mexicans having 20% healthy eaters and blacks having only 13% healthy eaters. Simulations showed that the higher-educated, older adults were more likely to have a healthy dietary pattern, including high water consumption.

Discussion

This paper provides useful insights into consumption patterns and overall dietary differences between water consumers and non-consumers. For instance, the descriptive research showed that, among a representative sample of U.S. adults ≥18 years of age, water consumers consumed many fewer calorically sweetened non-dairy beverages as well as 194 fewer daily calories than water non-consumers. These relationships might reflect an effect of water on overall energy intake; however, there is the possibility that these correlations are misleading. That is, water consumers are potentially a self-selected sample because they seem to follow different, more healthful eating patterns (i.e., fruits, vegetables, low- and medium-fat dairy products: nutrient-based subgroups 3, 9, and 10). Aside from the healthy food patterns that accompany water consumption, there were four distinct unhealthy dietary clusters found that included little or no water consumption: 1) high consumption of desserts (nutrient-based subgroup 2); 2) high consumption of high-fat meats and non-caloric beverages (nutrient-based subgroups 6 and 8); 3) high consumption of high-fat dairy and salty snacks (nutrient-based subgroups 1 and 4); 4) increased levels of salty snacks, candy, caloric

Table 3. Multinominal logit results: likelihood of consuming the high water food pattern* compared with the norm and the high fast food pattern†‡

	Likelihood of consuming water pattern compared with the norm food pattern			Likelihood of consuming water pattern compared with the fast food pattern		
SES variables	**Coefficient**	**Z**	***P* > z**	**Coefficient**	**Z**	***P* > z**
Constant	−1.70	−11.83	0.00	−0.46	−2.07	0.04
Black	−0.64	−5.27	0.00	−0.06	−0.31	0.75
Mexican	−0.13	−1.24	0.21	0.96	4.83	0.00
Other races and nationalities	−0.51	−3.23	0.00	0.44	1.59	0.11
Middle income	0.07	0.70	0.48	0.25	1.39	0.17
High income	0.19	1.75	0.08	0.31	1.73	0.08
Age 36 to 59	0.30	2.91	0.00	0.56	3.46	0.00
Age 60 and older	0.44	4.28	0.00	1.62	8.26	0.00
Female	0.07	0.82	0.41	0.69	4.83	0.00
High school degree only	0.32	2.74	0.01	−0.09	−0.46	0.64
More than a high school education	0.70	6.44	0.00	0.26	1.42	0.16

* The food pattern characterized by higher water, fruits, vegetables, and low-fat dairy.
† The food pattern characterized by higher fast foods, snacks, and calorically sweetened soft drinks.
‡ Results are weighted to be nationally representative.

beverages, fast food, and high-fat meats (least healthy; nutrient-based subgroups 1, 5, 7, 8, and 11).

It is interesting to note that most of the unhealthy dietary patterns with their average (close to zero), or below, levels of water consumption consist of at least one food group that is very high in salt; this may indicate that these people need to consume more water and be more hydrated.

Our analysis showed a large inverse relationship between consumption of water and the likelihood of consuming non-dairy caloric beverages. As noted above, our descriptive analysis revealed that water consumers are less likely than non-consumers to consume each caloric beverage category (except the fruit juice category). Our multivariate analysis found that water consumers are 25 times less likely to consume the combination of any non-dairy caloric beverages (combined fruit drinks and soft drinks). The fact that the water consumers do not seem to be consuming sugared beverages (i.e., fruit drinks and soft drinks) bolsters the idea that water non-consumers should be encouraged to consume water as a replacement for caloric beverages, because caloric beverages are linked with increased caloric consumption and greater weight gain (6,7). Furthermore, drinking of caloric beverages may not satisfy their thirst/hunger and may lead to greater energy consumption.

There are several limitations to this research. One of our goals is to understand the relationship between water consumption and overall diet patterning. Causality of water consumption and other components of a healthy eating pattern cannot be ascertained from this cross-sectional analysis. Both might be selected by the same underlying factors. The second relates to the quality of the water data. The questions used to obtain the bottled water measures were part of the standard 24-hour multipass recall questionnaire. The tap and spring water data were collected in separate questions. There has been no validation study of the quality of these questions.

Clearly this paper is just a small step forward in our efforts to understand more about water intake patterns and their relationship with overall diet. There are so many questions linked to the relationship and impact of water use on consumption not only of other beverages, particularly the caloric beverages, but also of overall diets. Longitudinal research is the major need from an epidemiological perspective. At the same time, it is clear that many questions that relate water use to the overall selection of foods and beverages require clinical trials.

Our results show that higher-educated, older adults will more likely be water consumers. This lends some credence to the fact that the target of a public health message should be younger, less-educated adults. In fact, anyone not consuming water/eating a healthy diet should be encouraged to do so because this may alleviate some of the additional energy consumed daily.

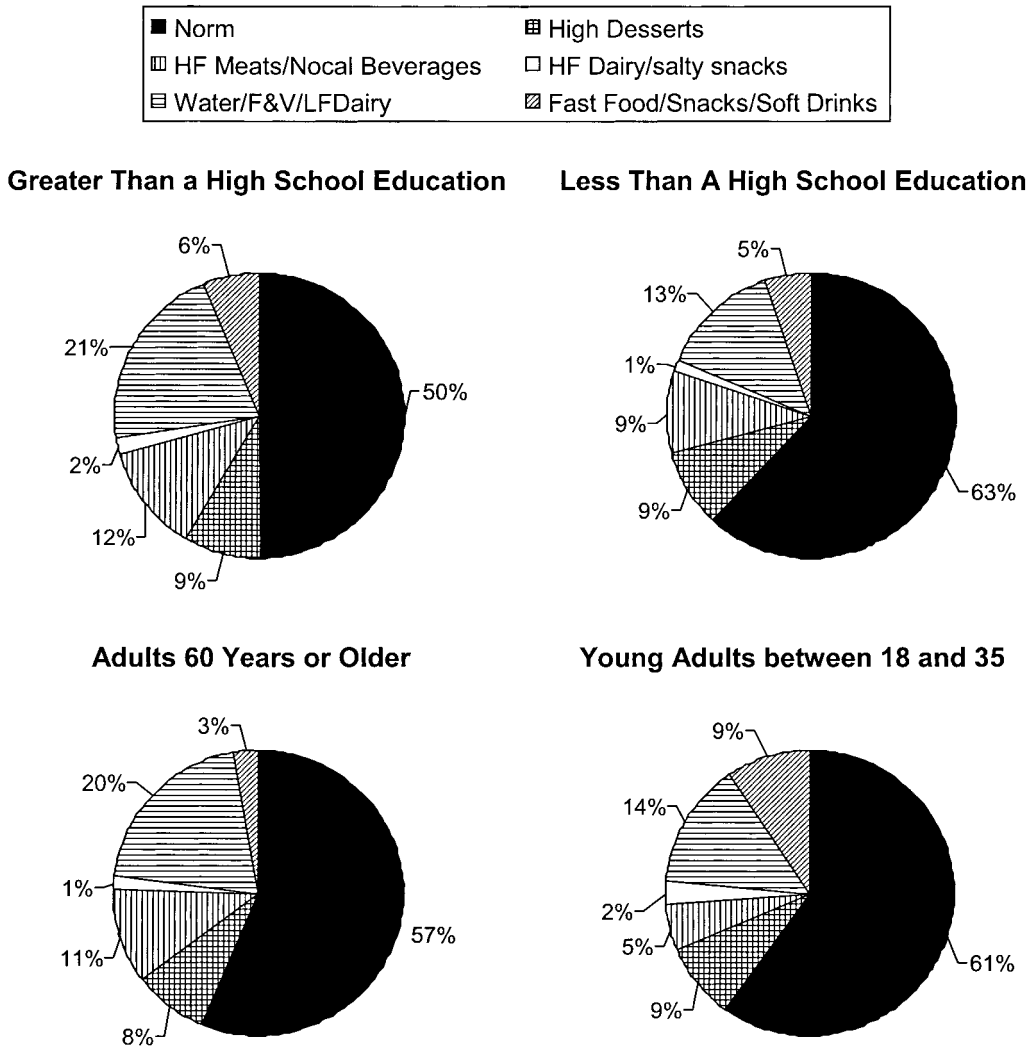

Figure 1: The impact of age and education on dietary patterns. HF, high fat; F&V/LF, fruits & vegetables/low fat.

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