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SECULAR TRENDS IN DIETARY INTAKE IN THE UNITED STATES*

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■ **Abstract** This review focuses on dietary intake and dietary supplement use among the U.S. population age 1–74 based on four National Health and Nutrition Examination Surveys conducted in 1971–74, 1976–80, 1988–94, and 1999–2000. Secular trends in intake of energy, macronutrients, cholesterol, sodium, calcium, iron, folate, zinc, vitamins A and C, fruits, vegetables, and grain products are summarized. During the 30-year period, mean energy intake increased among adults, and changed little among children age 1–19, except for an increase among adolescent females. Factors contributing to increases in energy intake include increases in the percentage of the population eating away from home (particularly at fast-food restaurants), larger portion sizes of foods and beverages, increased consumption of sweetened beverages, changes in snacking habits, and improved dietary methodology. Dietary supplement use increased among adult men and women, decreased among children age 1–5, and was stable for children age 6–11 and adolescents.

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INTRODUCTION

Diet is a major contributor to the nutritional status and health of the population, and assessing trends in dietary intake is essential to understanding the role of diet in the public's health (69, 92, 93). Data from cross-sectional national surveys are the primary source of information on the population's food consumption and related behaviors such as the use of dietary supplements (4, 13, 56). National survey data are also used to assess adherence to dietary recommendations and to plan disease prevention and health promotion programs (4, 13, 69, 93).

Diet contributes to obesity and other chronic health problems such as heart disease, diabetes, and several types of cancer (69, 93). The major nutrition issues in the United States have shifted from concern about nutrient adequacy (primarily, nutrient deficiencies) to concern about overconsumption, diet quality, and food choices, although food insecurity is still a concern for some disadvantaged groups (4, 13, 49, 93). At the same time, the concern about health status has focused on the increasing trends in overweight, obesity, and diabetes (23, 39, 68, 94).

All population subgroups have experienced increases in overweight and obesity between the early 1970s and 1999–2000 (36, 37, 39, 68, 72). Figure 1 shows the trends in selected chronic conditions related to diet: overweight, hypertension, and elevated serum cholesterol for adults age 20–74. Overweight (a body mass index, or BMI, of 25 or greater) increased from 48% to 65%, and obesity (a BMI of 30 or greater) increased from 15% to 31% for the time period shown (37, 68).

Decreases in the prevalence of elevated serum cholesterol and hypertension occurred along with some improvements in dietary patterns, such as significant decreases in the mean intake of dietary cholesterol, the mean percentage of calories from fat and saturated fat, and the prevalence of discretionary salt use (66, 93). However, the 1999–2000 data suggest that the downward trend in hypertension may be changing (Figure 1; 68). The relationships between diet and health are usually multifactorial; demonstrating direct or consistent relationships between trends in dietary intake and trends in health conditions is difficult.

We reviewed published literature and government reports and analyzed national survey data in order to summarize the major trends in the U.S. population's dietary intake and supplement use between 1971 and 2000. This review includes sections

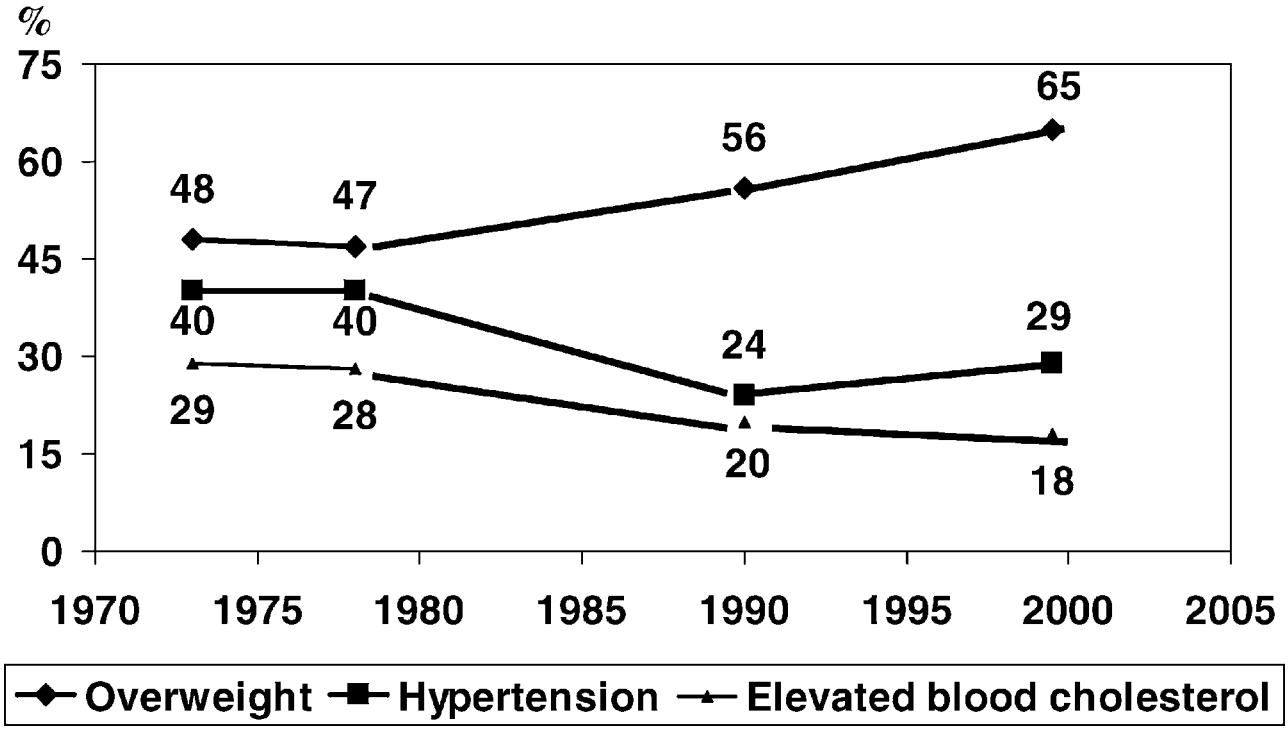

Figure 1 Trends in the age-adjusted prevalence of health conditions among U.S. adults, age 20–74. Data source: National Health and Nutrition Examination Surveys (NHANES); data are plotted at the midpoint of the NHANES survey period. (Reference 68; age-adjusted to 2000 population).

on (*a*) the data sources and methods used in national surveys, (*b*) trends in individuals' intake (energy and nutrients of public health importance) and food group consumption, (*c*) trends in factors that affect dietary intake, and (*d*) a summary.

DATA SOURCES AND METHODOLOGY

The three primary sources of national nutrition data are the National Health and Nutrition Examination Survey (NHANES), the Nationwide Food Consumption Survey (NFCS), and the Continuing Survey of Food Intakes by Individuals (CSFII) (4, 13, 27, 29, 56, 62–65, 67, 86). Table 1 shows the dates of data collection, the population surveyed, the sample sizes, and the methods used to measure food consumption and dietary supplement use. This review focuses on NHANES because it (*a*) includes the most recent dietary data available (1999–2000), (*b*) includes data from four separate cross-sectional surveys during the 1971–2000 period, and (*c*) is the only national nutrition survey (among those listed above) currently in operation and planned for the near future (26–28, 67). This review, however, also draws heavily on published reports from NFCS and CSFII to support conclusions on changes in food sources of nutrients and food consumption patterns.

The U.S. Department of Health and Human Services (DHHS) began conducting national health examination surveys in 1960 and added a nutrition component in 1971. In addition to dietary intake, the NHANES includes anthropometry, blood and urine assessments, and many health status measurements (4, 13). All of the NHANES surveys utilized a stratified, multistage design to provide a representative sample of the U.S. civilian, noninstitutionalized population (29, 62–65, 67). Beginning in 1999, the NHANES became a continuous survey. Thus, unlike in the 1970s, 1980s, and 1990s, when none of the three national nutrition surveys was in the field at all times, dietary intake and other nutrition data (along with health measurements) are now collected on a continuous basis. Beginning in 2002, the CSFII dietary component (What We Eat in America) was integrated into the NHANES, resulting in expanded dietary information that can be linked to various health conditions in one continuous national survey (26–28).

The U.S. Department of Agriculture (USDA) has conducted household food consumption surveys since the 1930s, and began using nationally representative sampling methods in the 1950s. In 1977–78 and 1987–88, the NFCS combined measures of household food use with measures of individuals' food consumption over multiple days (Table 1). The 1987–88 NFCS had a very low response rate, which contributed to USDA's decision to drop the household food-use portion of the survey and focus on the intake of individuals. In the late 1980s and 1990s, USDA periodically conducted the CSFII (4, 13, 86).

Our analysis of NHANES dietary trends is restricted to energy and nutrients from food sources and to the population age 1–74 years, because NHANES I and II did not include detailed supplement information and did not cover the entire age range. [NHANES III included infants age 2 months and older (65). The continuous

TABLE 1 Primary sources of national nutrition data for U.S. individuals, 1971 to 2000

Survey	Dates	Population	Sample size	Dietary intake methodology	Dietary supplements methodology
NHANES I	1971–74	Age 1–74 years; oversampling of women of childbearing age, age 5 and younger, adults age 60–74, and persons with income below poverty	20,749[a]	Single 24-hour dietary recall, no weekend intakes	Type of vitamin and mineral supplements and some other products such as cod liver oil and brewer's yeast; categorized as regular or irregular use (no reference period)
NHANES II	1976–80	Age 6 mo–74 years; oversampling of children age 5 years and younger, adults age 60–74 years, and persons with income below poverty	20,322[a]	Single 24-hour dietary recall, no weekend intakes	Type of vitamin and mineral supplements; categorized as regular or irregular use (no reference period)
NFCS	1977–78	All ages; oversampling of low-income[b] and elderly; 48 states	30,467[c]	Three consecutive days (single 24-hour dietary recall and 2-day food record)	Regular or irregular use of vitamin, mineral, or other supplements; type of supplement
Hispanic HANES	1982–84	Age 6 months–74 years; MA, CA, and PR	MA: 7,462[a] CA: 1,357[a] PR: 2,834[a]	Single 24-hour dietary recall, and 3-month food frequency questionnaire	Type (brand name), frequency, and dose of vitamin and mineral supplements in the past two weeks
CSFII	1985–86	Females age 19–50 years and their children 1–5 years; males age 19–50 years in 1986; oversampling of low-income[b]; 48 states	4,463[c]	Six nonconsecutive 24-hour dietary recalls (first in person, others by telephone)	Regular or irregular use of vitamin and mineral supplements
NFCS	1987–88	All ages; oversampling of low-income[b]; 48 states	10,172[c]	Three consecutive days (single 24-hour dietary recall and 2-day food record)	Regular or irregular use of vitamin and mineral supplements
NHANES III	1988–94	Age 2 months and older; oversampling of MA, African Americans, age 2 months–5 years, and age 60 years and older	31,311[a]	Single 24-hour dietary recall and 3-month food frequency questionnaire; second 24-hour recall on a subsample (~5%)	Type (brand name), frequency, and dose of dietary supplements (vitamins, minerals, and other supplements such as herbs and botanicals) and antacids used in the past month; duration of use; containers observed during the household interview

(*Continued*)

TABLE 1 (*Continued*)

Survey	Dates	Population	Sample size	Dietary intake methodology	Dietary supplements methodology
CSFII	1989–91	All ages; oversampling of low-income[b]; 48 states	15,192[c]	Two nonconsecutive 24-hour dietary recalls	Regular or irregular use of vitamin and mineral supplements
CSFII	1994–96, 1998[d]	All ages; oversampling of low-income[b]; age 0–9 years[d]; 50 states	15,968[c], 5,559[c]	Two nonconsecutive 24-hour dietary recalls	Categorical frequency of any use of vitamin or mineral supplement; type of vitamins, minerals (combination type, single vitamins or minerals)
NHANES 1999–2000[e]	1999–2000	All ages; oversampling of MA, African Americans, age 12–19 years, age 60 years and older, and pregnant women, and low income[b]	8,604[c]	Single 24-hour dietary recall, and second recall on a subsample (~10%)	Type, frequency, and dose of all dietary supplements (vitamins, minerals, and other products such as herbals and botanicals) and antacids used in the past month; containers observed during the household interview

[a]Examined persons.

[b]Low income is defined as a household income at or below 130% of the poverty line, the income cutoff level for eligibility for the Food Stamp Program.

[c]Persons with one-day intakes.

[d]Supplemental sample of children age 0–9 years added to the 1994–96 CSFII.

[e]NHANES has continuous data collection beginning in 1999; most recent data were available for 1999–2000.

Abbreviations: CA, Cuban Americans; MA, Mexican Americans; PR, Puerto Ricans.

NHANES that began in 1999 has no age restrictions (67).] Toddlers who were breastfeeding were excluded from dietary intake calculations.

Changes in daily intake of energy, nutrients, and foods were assessed by calculating mean intake for groups. The primary methodology used in the national surveys—the 24-hour dietary recall—has been modified over time (for example, by automating data collection, standardizing probing, improving visual aids for portion size, and improving methods to assist respondents' recall) (15, 27, 86).While these changes have increased the accuracy of data, interpretation of dietary trends, in general, remains problematic due to these changes and to systematic underreporting of food sources and of energy intake, particularly by overweight persons (15, 45, 47). Changes in dietary recall data collection methods have continued in the integrated NHANES beginning in 2002. Therefore, the issues discussed in this review will be relevant for future analyses of national trends in dietary intake.

Interview methods to collect information on the use of dietary supplements have also undergone improvements, as have changes to the wording and content of questions, making the interpretation of trends difficult (see Table 1). For example, the NHANES changed from asking a few questions on the usage of vitamin and mineral supplements in the 1970s to a detailed accounting of the type, form, and number of dietary supplements (vitamins, minerals, herbals, and botanicals) beginning in the late 1980s (12, 35, 76). Unlike 24-hour dietary recall data, data on dietary supplement use have been collected in other national surveys, including the 1980 Food and Drug Administration's Vitamin and Mineral Supplement Use Survey and the 1986, 1987, and 1992 National Health Interview Surveys (not shown in Table 1) (3, 61, 79, 83). However, the questions on these surveys used different wording and reference periods than those used in the NHANES, the NFCS, and the CSFII.

TRENDS IN DIETARY INTAKE

The U.S. dietary guidelines provide recommendations for intake of fat, saturated fat, cholesterol, calcium, and sodium (89). These nutrients, in addition to energy, alcohol, iron, and folate, are considered public health priorities (56, 66, 93). Iron is an important nutrient because of its relationship to iron-deficiency anemia, and folate because of its relationship to the prevention of neural tube defects (18, 19, 44); both are tracked as national health objectives (66, 93). Fruits, vegetables, and grain products are also included in the dietary guidelines, and are tracked for Healthy People 2010 (89, 93). Findings for these important nutrients and food groups are discussed below.

Energy, Macronutrients, and Cholesterol

Changes in mean energy intake in the population are of great interest because overweight and obesity increased among all age and racial/ethnic groups from

TABLE 2 Mean daily energy intake (in kcal) for the U.S. population, 1971 to 2000[a]

Age/sex (years)	NHANES I 1971–74	NHANES II 1976–80	NHANES III 1988–94	NHANES 1999–2000
Both sexes				
1–2	1350	1287	1289	1511
3–5	1676	1569	1591	1622
6–11	2045	1960	1892	2025
Males				
12–15	2625	2490	2578	2460
16–19	3010	3048	3097	2932
20–39	2784	2753	2965	2828
40–59	2303	2315	2568	2590
60–74	1918	1906	2105	2123
20–74[b]	2450	2439	2666	2618
Females				
12–15	1910	1821	1838	1990
16–19	1735	1687	1958	1996
20–39	1652	1643	1958	2028
40–59	1510	1473	1736	1828
60–74	1325	1322	1522	1596
20–74[b]	1542	1522	1798	1877

[a]One-day intakes.

[b]Age-adjusted to 2000 population.

1971–74 to 1999–2000 (36, 37, 68, 72, 93). Table 2 displays mean daily energy intake by age and gender across this period. Mean energy intake increased among adults between the 1970s and the late 1980s and continued through 1999–2000 for females. The prevalence of overweight increased for adults between NHANES I-II and NHANES III, and between NHANES III and NHANES 1999–2000 (Figure 1; 36, 37, 68).

Mean energy intake for children age 1–19 changed little from the surveys in the 1970s to 1999–2000, except for an increase among adolescent females (Table 2; 87). Figure 2 shows the increase in overweight (defined as at or above the ninety-fifth percentile for BMI cutoffs on the 2000 CDC growth charts (18) among children age 6–11 and adolescents age 12–19. Non-Hispanic black girls age 12–19 had the highest prevalence of overweight (26.6%) in 1999–2000 (72). Between 1988–94 and 1999–2000, overweight also increased from 7.2% to 10.4% among preschoolers age 2–5 (72).

Between 1971–74 and 1999–2000, the relative proportion of calories from macronutrients (protein, fat, and carbohydrate) has changed (see Figure 3 for adults age 20–74). Total fat decreased from 36% to 33% of calories, saturated fat decreased from 13% to 11%, and carbohydrate increased from 44% to 50% of calories (25, 33, 56, 95, 96). Carbohydrate increased from 45% to 52% of calories

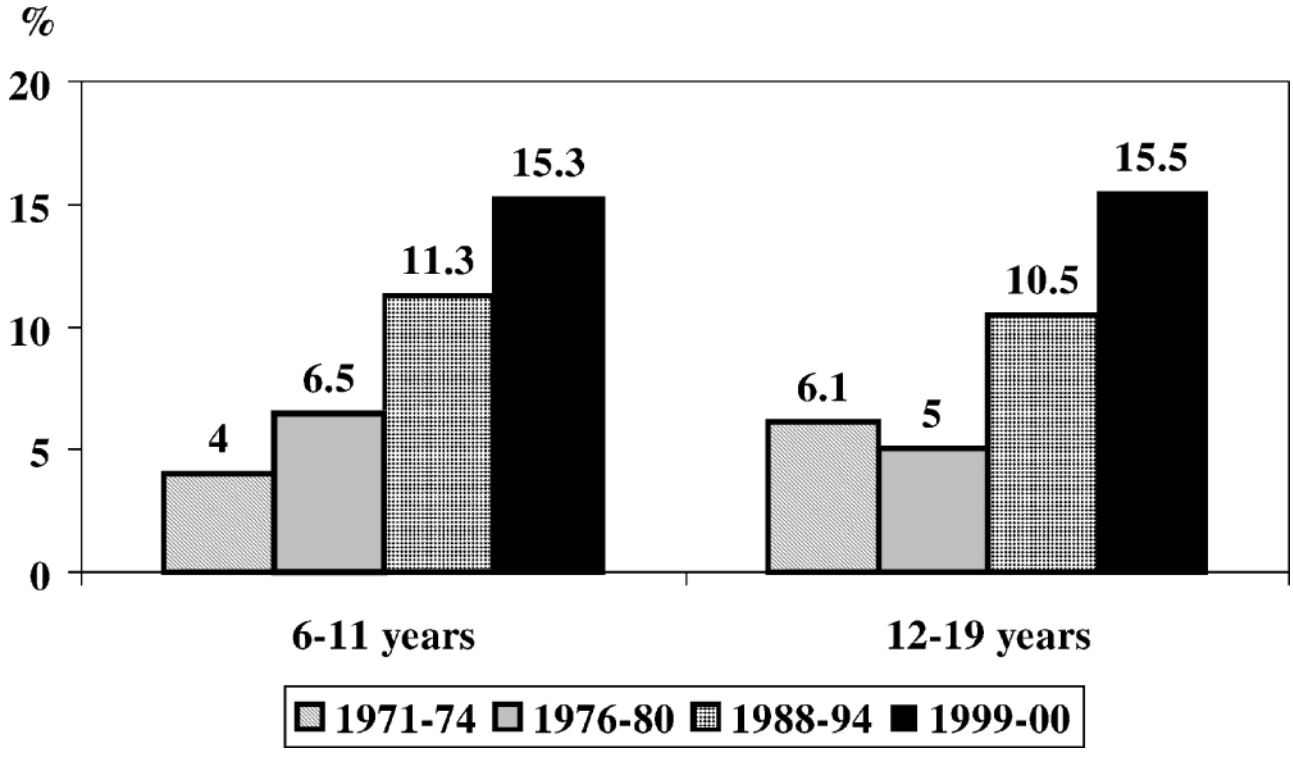

Figure 2 Trends in the prevalence of overweight among U.S. children and adolescents. Data source: National Health and Nutrition Examination Survey; overweight is defined as a BMI at or above the ninety-fifth percentile on the 2000 Centers for Disease Control and Prevention growth charts. Data source: Reference 72.

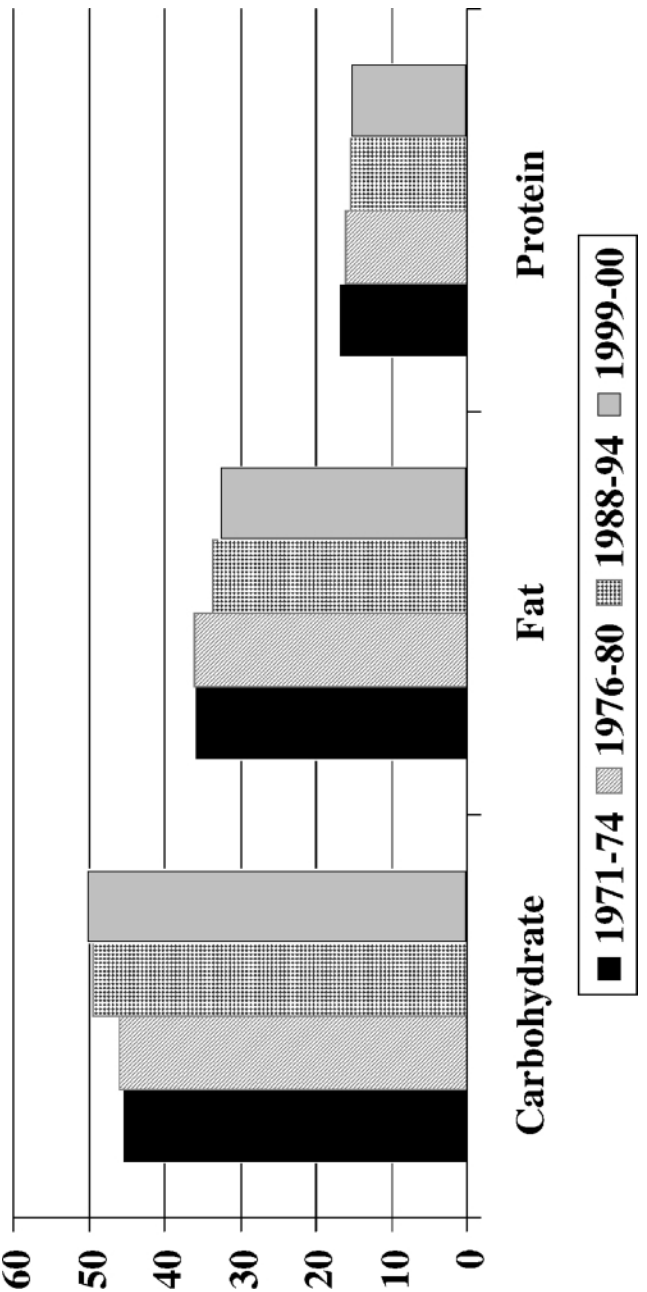

Figure 3 Trends in the percentage of energy from macronutrients, U.S. adults age 20–74. Data source: National Health and Nutrition Examination; age-adjusted to 2000 population.

for adult women, compared to an increase of 42% to 49% for adult men. Protein intake was relatively stable at 14% to 15% of calories. In 1999–2000, the daily mean percentage of calories was 32.7% for total fat, 11.2% for saturated fat, 51.9% for carbohydrate, and 14.7% for protein for all ages of the U.S. population (95). Alcoholic beverages account for 2% to 3% of calories for adult women and 3% to 4% for adult men (5, 56). However, trends in alcohol intake as a percentage of calories are difficult to assess. Underreporting by those who consume alcoholic beverages and the noninclusion of representative intake for weekend consumption by earlier NHANES both contribute to the underestimation of alcohol intake (15, 56).

National surveys indicate a decline in the average percentage of calories from total fat and from saturated fat from 1971–74 to 1999–2000. Despite these improvements, mean levels do not meet the dietary guidelines of 30% or less of calories from total fat and less than 10% of calories from saturated fat; in 1999–2000, only about 38% of the population age 2 and older met the guideline for total fat, and 41% met the guideline for saturated fat (2). Adult women, persons age 60 and older, Hispanics, and persons with higher household income were more likely to meet fat and saturated fat recommendations (2, 93).

Most school-age children consume too much fat and saturated fat (41). Non-Hispanic children were least likely to meet recommendations for total fat and saturated fat. Although 2%-fat, 1%-fat, and skim milk are consumed more frequently than whole milk among youth age 5 or older, there is still room for improvement: 10% to18% of saturated fat and 5% to 10% of total fat comes from whole or 2%-fat milk products for youth age 6–19 (41, 87). In 1988–94, milk products consumed by overweight adolescents were mostly whole or 2%-fat milk, rather than 1%-fat or skim (87).

Mean dietary cholesterol levels declined among all age groups between the 1970s and 1988–94, and have leveled off between 1988–94 and 1999–2000 (25, 96). Age-adjusted mean dietary cholesterol intake for adults age 20–74 declined from 487 mg to 341 mg for men and from 313 mg to 242 mg for women. Factors contributing to the decline are a decrease in the consumption of whole eggs and improved measurement of the cholesterol content of foods (30, 31, 56). New cholesterol composition values for eggs were made available in 1989, but the USDA survey nutrient database does not permit reanalysis of food consumption data collected before 1985 (56). Declines in the proportion of calories from total fat and saturated fat and in dietary cholesterol have been accompanied by decreases in the mean serum cholesterol levels in the United States (see Figure 1; 33). However, national data indicate that average energy intake has increased since the 1970s and that total intake of fat and saturated fat (absolute levels in grams) has been stable or increased (20).

Sodium and Discretionary Salt Use

Sodium intake is of interest because persons who consume less sodium or salt have a lower risk of developing high blood pressure (69, 93). The dietary guidelines

TABLE 3 Mean daily sodium intake (in mg) for the U.S. population, 1971 to 2000[a]

Age/sex (years)	NHANES I 1971–74	NHANES II 1976–80	NHANES III 1988–94	NHANES 1999–2000
Both sexes				
1–2	1631	1828	1983	2148
3–5	1925	2173	2594	2527
6–11	2393	2716	3164	3255
Males				
12–15	2923	3405	4240	3858
16–19	3219	4030	4904	4415
20–39	3043	3760	4680	4334
40–59	2681	3413	4177	4132
60–74	2318	2934	3513	3557
20–74[b]	2780	3486	4288	4127
Females				
12–15	2094	2567	3200	3034
16–19	1812	2336	3160	3048
20–39	1883	2383	3167	3161
40–59	1754	2256	2852	2978
60–74	1529	2053	2543	2633
20–74[b]	1774	2278	2939	3002

[a]Includes food sources and sodium used in food preparation, but not salt added to food at the table; one-day intakes.

[b]Age-adjusted to 2000 population.

recommend moderation in sodium intake (89). About one fifth (21%) of the population met the recommendation to consume less than 2400 mg of sodium per day (93); preschoolers age 2 to 5 were the most likely to meet the recommendation. About one third of all females (32%) met the recommendation, but only 9% of all males (93). In 1999–2000, the mean sodium intake for the population was 3375 mg (95).

Sources of sodium include processed foods, table salt, and salt added in cooking. Table 3 shows the trend in mean sodium intake from food sources and food preparation. In general, mean sodium intake has increased among all age groups between NHANES I and NHANES III, but shows a less consistent pattern or a leveling off between NHANES III and 1999–2000. Trends in sodium intake are difficult to assess due to manufacturers' changes, use of different food composition databases, and difficulties in estimating sodium from all sources, including discretionary salt. Food manufacturers have made some changes to reduce the amount of salt added to foods during processing and now offer lower-sodium options for foods. However, sodium continues to be positively correlated with energy intake, so that increases in energy intake tend to increase sodium intake as well. Increased consumption of processed foods and a greater frequency of eating away from home contribute to increases in mean sodium intake over the 30-year period of study. Other considerations include methodological changes in assessing discretionary salt use and the food composition data.

TABLE 4 Mean daily calcium intake (in mg) for the U.S. population, 1971 to 2000[a]

Age/sex (years)	NHANES I 1971–74	NHANES II 1976–80	NHANES III 1988–94	NHANES 1999–2000
Both sexes				
1–2	885	770	842	930
3–5	921	818	851	838
6–11	1093	1029	965	889
Males				
12–15	1309	1202	1135	1058
16–19	1310	1370	1208	1106
20–39	1034	1008	1065	1026
40–59	837	831	936	969
60–74	747	733	842	773
20–74[b]	908	892	977	962
Females				
12–15	940	854	825	806
16–19	744	725	801	779
20–39	652	634	767	797
40–59	594	582	665	744
60–74	553	550	670	678
20–74[b]	612	599	710	756

[a]Calcium from food sources only; one-day intakes.

[b]Age-adjusted to 2000 population.

Calcium Intake and Milk Consumption

Calcium is an important nutrient for health because of its relationship to growth, formation of teeth and bones, maintenance of bone health (that is, prevention of osteoporosis) in later life, and reduced hypertension risk (43, 69). Table 4 shows trends in mean calcium intake from food sources. Between the 1970s and 1999–2000, mean daily calcium decreased for children age 3–5 and 6–11, adolescent boys, and girls age 12–15. During the same period, mean calcium intake increased for adult women, was stable for men age 20–39, and showed an inconsistent pattern for toddlers age 1–2, girls age 16–19, and older adult men.

The 2010 health objectives track total calcium intake, which has been calculated for NHANES III, but not yet for 1999–2000. Mean total calcium intake (from foods, supplements, and antacids in 1988–94) fell short of recommendations for the population, especially for teenage girls, older women, and older males (43, 93). In 1988–94, nearly half (48%) of persons living in higher-income households met the calcium recommendations, compared to 39% of lower-income persons (and 46% for all age 2 and older) (93). About 80% to 90% of children age 2–8 met the recommended adequate intake for calcium, with food sources providing the majority (52%) of calcium intake. In 1999–2000, only 30% of the population age 2 and older met the recommendations for milk and other dairy food consumption (2).

The major food sources of calcium—milk and other dairy products—have not changed drastically since 1970, although there have been shifts in the proportion consuming milk and in the types of milk and dairy products consumed. Between 1977–78 and 1994–96, milk consumption shifted from whole milk to consumption of reduced-fat and skim milk among children and adults (30, 31). In 1987–88, about 50% of dietary calcium came from milk and milk products, 20% from milk and cheese as ingredients in mixed dishes, and 30% from all other food groups (38). Milk contributes about 60% of calcium for children age 2–5, 54% for age 6–11, and 46% for age 12–18 (85). Among children age five and younger, there is an inverse relationship between household income and whole milk consumption: higher-income children obtain calcium from lower-fat sources of milk (that is, skim and low-fat milk) (51).

Milk consumption begins to decline for females in their teenage years and remains low throughout life, except, perhaps, for periods of pregnancy and lactation. Milk consumption is generally low for adult men and women. Overall milk consumption decreased by 36% among female adolescents from the late 1970s to 1994–96 (10). The observed increases in mean calcium intake among adult women suggest that education messages urging increased calcium intake to prevent osteoporosis are having some influence. In addition, changes in food manufacturing to add calcium to nondairy products such as orange juice have had some effect on intake.

Iron Intake and Iron-Deficiency Anemia

Iron intake is important for the growth and development of infants and children and for the prevention of iron-deficiency anemia among young children and women of childbearing age. Mean iron intake increased between 1971–74 and 1999–2000 for toddlers, preschoolers, children age 6–11, and boys age 12–19, but not for adolescent girls (data not shown; 95). Mean iron intake for all men was 17.8 mg in 1988–94 and 17.2 mg in 1999–2000; the mean for all women was 12.8 mg and 13.4 mg, respectively. For children under 5, mean iron intake is highest for nonnursing infants (5). Iron-fortified formulas and baby cereals are important sources of iron for infants. Grain products supply nearly half of all dietary iron (49%); meat, fish, and poultry provide one fifth (18%) for the population (56).

Between 1976–80 and 1988–94, the prevalence of iron deficiency was fairly stable for the general population, below 5% for most groups (66, 93). Between 1976–80 and 1988–94, the prevalence of iron-deficiency anemia declined from 21% to 13% for low-income children age 1–2, and from 10% to 6% for low-income children age 3–4 (66). However, the prevalence of iron deficiency increased from 8% to 12% for low-income women age 20–44 during the same period. In 1999–2000, iron deficiency remained a problem for 7% of toddlers age 1–2 and 9% to 16% of adolescent and adult females (19). While iron deficiency is relatively uncommon, the targets set for 2010 have not been met, and the prevalence of iron deficiency anemia is highest for minority females age 12–49 (19).

Folate and Grain Products

Folate intake is important because women of childbearing age who are capable of becoming pregnant should consume 400 micrograms of folic acid daily to reduce the risk of having a pregnancy affected with spina bifida or other neural tube defect (18). Folate status is also associated with elevated serum homocysteine levels, a risk factor for atherosclerosis (32).

Folate intake data are only available for NHANES III and NHANES 1999–2000. Folate intake levels increased between 1988–1994 and 1999–2000 in every age/gender group. This finding is expected because in 1998 the Food and Drug Administration required that manufacturers fortify enriched grain products with folic acid (55). Because most of the population consumes these products, the average folate intake in the population would have increased even with no changes in food consumption habits.

Among women of childbearing age, mean intake increased from 230 to 316 *u*g for age 12–15, from 225 to 330 *u*g for age 16–19, and from 238 to 327 *u*g for age 20–39 (data not shown). Increases in mean folate intake between 1988–94 and 1999–2000 ranged from 16% to 19% for boys age 12–15 and adults age 60–74, and from 30% to 45% for other age/gender groups. The percentage increases in mean folate were higher for females than for males. Serum folate and red blood cell folate concentrations increased significantly between 1988–94 and 1999–2000 among women of childbearing age (15–44), which indicates an effective improvement in folate status following the change in food fortification policy and related nutrition education efforts (32).

There is significant interest in monitoring the intake of folate from food sources, as well as from dietary supplements, to gauge the effect of this important public health intervention. Food sources of whole grains include ready-to-eat (RTE) cereals, corn and other chips, and yeast breads (42). Between the 1970s and 1994–96, grain product consumption increased, particularly for RTE cereals (a 60% increase) and snacks such as corn chips, popcorn, pretzels, and crackers (a 200% increase). The grain servings recommendation was more likely to be met by males than by females, by non-Hispanic whites, and by those with higher household income (93). In 1999–2000, only 24% of the population met the recommendation for daily servings of grains, and a smaller percentage met the recommendation for whole grains, a good source of fiber, vitamins, and minerals (2, 93). Persons who consumed whole grains had better nutrient profiles than nonconsumers and were more likely to be male, older, white, nonsmokers, to use dietary supplements, and to have higher household income, education, and physical activity (21).

Vitamins A and C, Fruits, and Vegetables

Mean intake of vitamins A and C fluctuated with no consistent pattern across surveys or subgroups (5, 56). However, mean intake was higher in 1999–2000 compared to 1971–74 across all age/gender groups except for males age

12–15 (data not shown). Between 1988–94 and 1999–2000, mean vitamin A intake increased for children age 1–2, 3–5, and 6–11, males age 16–19, and females age 16–19, 20–39, and 40–59. All other age/gender groups showed little change or a decrease in mean levels. Between 1988–94 and 1999–2000, mean vitamin C intake was constant or decreased for all age/gender groups except children age 1–2 and females age 16–19.

In 2001, the recommended dietary allowances (RDAs) for vitamin A were lowered (44), causing increased concern about potentially high intake of vitamin A among some population groups who consume highly fortified foods and use vitamin supplements (75). Vitamin A intake from 1999–2000 is measured in international units and retinol equivalents and is not comparable to the revised RDA for vitamin A because the food composition database used for the national surveys has not yet been converted to the appropriate units (retinol activity equivalents).

Fruits and vegetables are important sources of vitamins A and C in the diet, in addition to fortified RTE cereals (84, 85). In 1976–80, 45% of adults had no servings of fruit or fruit juice and 22% had no servings of vegetables, and consumption of fruits and vegetables was lower among black adults compared with white adults (74). About half of the population still consumes no fruit on a given day, and fruits are the food group most likely to be omitted in the American diet (2, 74, 90). Based on one day's intake, only 17% of the population age 2 and older met the recommendation for two or more servings of fruit, and 28% met the recommendation for three or more servings of vegetables in 1999–2000 (2). The average number of fruit and vegetable servings for the population age 2 and older increased from 4.1 in 1989–91 to 4.7 in 1994–96 (93). A higher number of servings of fruits and vegetables was associated with education beyond high school and a higher household income (2, 54).

Potatoes account for about one third of all vegetable intake, and starchy vegetables account for about four times as many vegetable servings as dark green and deep yellow/orange vegetables. In 1994–96, only 8% of the population met the recommendation that at least one third of vegetable servings be dark green or deep yellow orange vegetables (93). About 14% of non-Hispanic blacks met this particular recommendation, compared to 8% for non-Hispanic whites and 6% for Hispanics.

Zinc

Data on mean intake of zinc are available only in NHANES III and NHANES 1999–2000 (5, 95). Between these two periods, mean intake of zinc from food sources decreased for all male age groups, increased for preschoolers, children age 6–11, and adult females, and remained constant for female adolescents (data not shown). Based on published data from the 1989–91 and 1994–96 CSFII, the major sources of zinc in the diet were RTE cereals for children age 2–18 (85) and RTE and hot cereals and meats for adults age 60 and older (59, 84).

Data on total zinc intake (foods and supplements) are available only from NHANES III. Dietary supplements contributed an average of 0.7 mg in adolescents and 2.5–3.5 mg in adults (14). Mean total zinc intake was significantly higher in non-Hispanic whites compared with non-Hispanic blacks and Mexican Americans due to higher dietary supplement use (14). In 1988–94, children age 1–3, female adolescents, and adults over age 70 were at greatest risk of inadequate intake (14). Assessments of total zinc intake using 1999–2000 diet and supplement data will be important to determine whether these groups remain at risk of inadequate zinc intake, based on revised RDAs.

Trends in Dietary Quality

The Healthy Eating Index (HEI) was developed as a summary measure of the population's dietary quality and adherence to the Food Guide Pyramid, a food guidance system developed by USDA to meet the Dietary Guidelines for Americans (91); it can be used to track changes over time (11, 50). The HEI includes ten components that assess adherence to the dietary guidelines (servings of grains, fruits, vegetables, milk and dairy products, and meats; the percentage of calories from fat and saturated fat; intake of cholesterol and sodium; and variety of food group selections) (50). Out of a maximum score of 100, an HEI score above 80 reflects a "good diet"; a score between 51 and 80, a "diet that needs improvement"; and a score of 50 or less, a "poor diet."

The overall diets of Americans age 2 and older, as measured by the HEI, improved slightly between the 1989 CSFII (mean of 61.4) and the 1994–96 CSFII (mean of 63.6), but did not improve further in the NHANES 1999–2000 (mean of 63.8) (2, 11, 17). Mean scores improved slightly for grains, saturated fat, total fat, and variety, while mean scores declined for sodium, meat, and milk (Figure 4). The highest mean component scores in 1999–2000 were 7.7 (out of 10) for variety and cholesterol. The lowest mean score was 3.8 for fruit, the food component most in need of improvement in Americans' diets.

HEI scores from NHANES 1999–2000 indicate that 10% of Americans have "good" diets, 74% "need improvement," and 16% have "poor" diets (2). Children age 2–3 had the highest mean HEI score (75.7). Mean HEI scores were higher for Mexican Americans (64.5) and non-Hispanic whites (64.2) than for non-Hispanic blacks (61.1) (2). HEI scores were generally higher for females than for males, for older adults than for younger adults, and for those with higher education levels (2). Figure 5 indicates that improvements are needed in all component areas. Overall, 69% of the population met the recommendation for cholesterol, and 55% met the one for variety. However, less than 50% of the population met the recommendation for any of the other eight components. Only 17% met the recommendation for fruit servings per day and 30% met the recommendation for milk. These findings indicate that most Americans need to substantially improve their food consumption habits in order to meet current dietary recommendations.

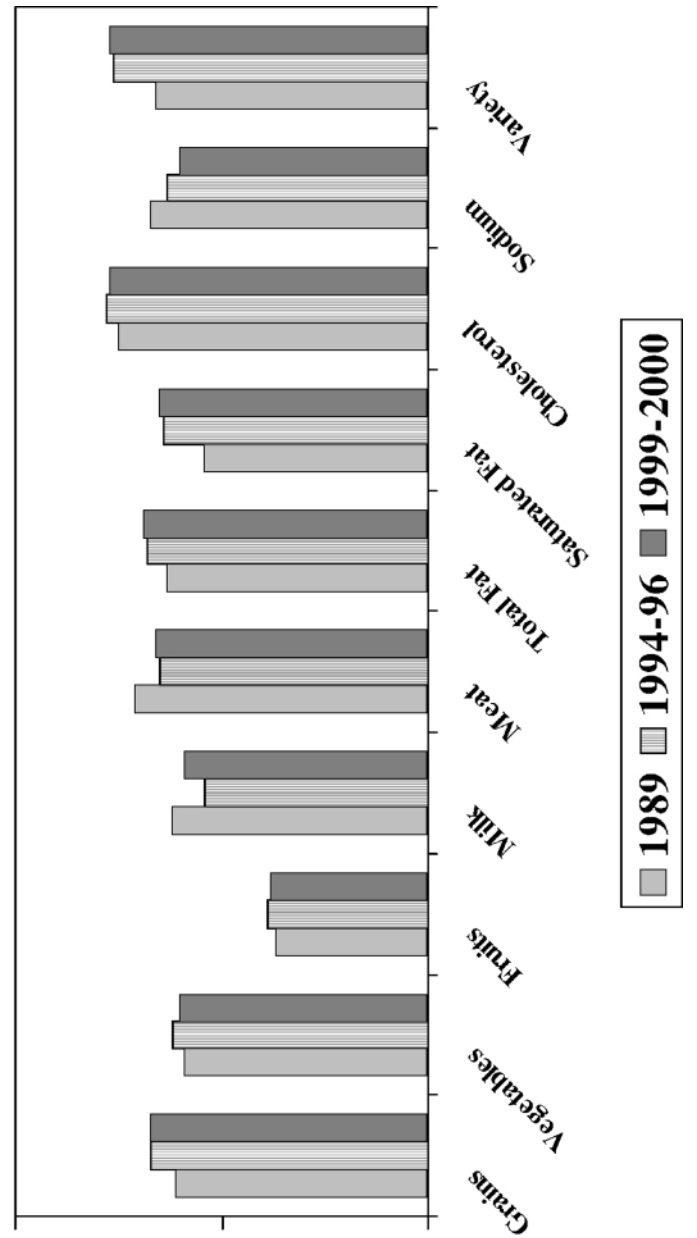

Figure 4 Mean score for the Healthy Eating Index components, age 2 and older. Data sources: Continuing Survey of Food Intakes by Individuals 1989 and 1994–96 and National Health and Nutrition Examination Survey 1999–2000; adapted from References 2, 11, and 17. A score of 10 indicates the dietary guideline was met for that component.

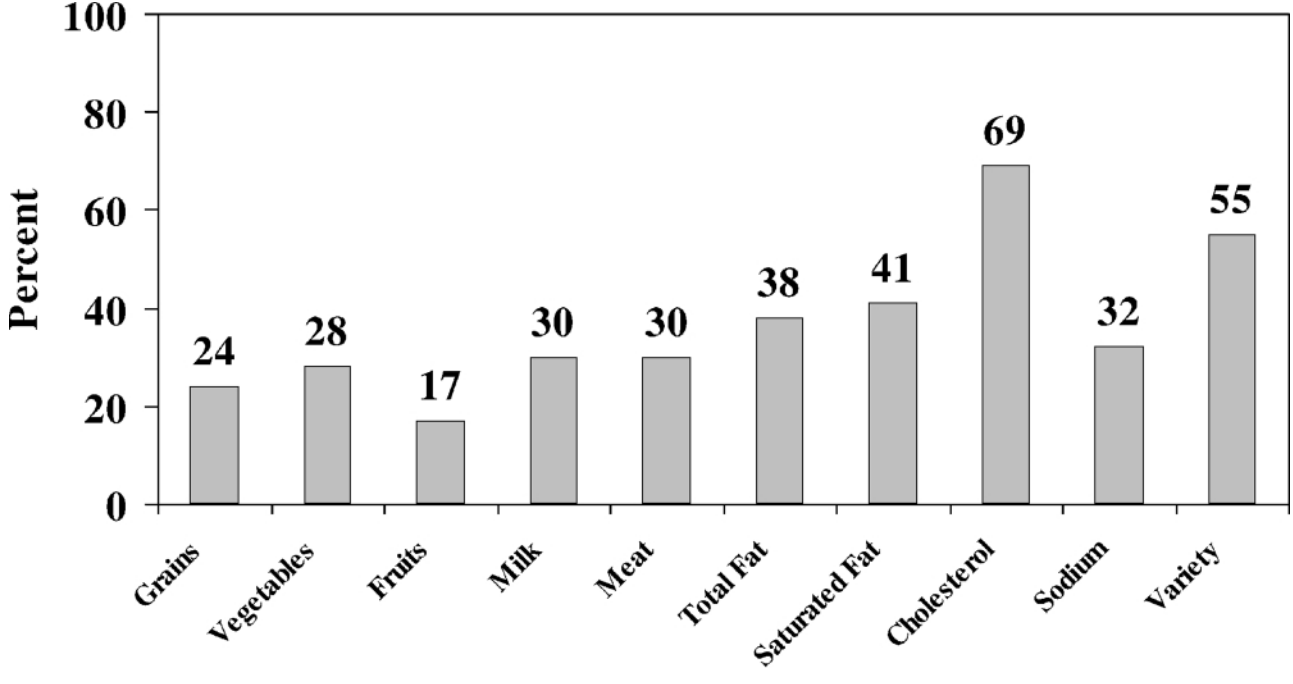

Figure 5 Percent of the population age 2 and older meeting the dietary recommendation for Healthy Eating Index components. Data source: National Health and Nutrition Examination Survey 1999–2000 (from Reference 2).

FACTORS THAT CONTRIBUTE TO TRENDS IN DIETARY INTAKE

Since 1970, food consumption trends have been influenced by factors such as increases in the frequency of eating food away from home and in the average portion sizes of foods commonly consumed. National data suggest that large portions of energy-dense foods and increases in average portion sizes of commonly consumed foods over time are contributing to obesity (60, 70, 78, 81). The frequency of snacking and choice of snacks (food and beverages) have also affected trends in diet. Finally, the frequency of use of dietary supplements has contributed to changes in total nutrient intake among particular population groups.

Eating Away from Home

About 23% of the food dollar was spent away from home in 1977–78 compared to 33% in 1987–88 (58, 86). Blisard et al. projected that total food expenditures will increase by 26% by 2020—28% for away-from-home food and 24% for at-home food (6). Increases in total expenditures on food away from home occurred for all racial/ethnic groups and all income levels, and households with higher income spent more on food away from home than those with lower income (56, 58).

Between the 1970s and the 1990s, consumption of food from fast-food restaurants, prepared food from grocery stores, and ethnic dishes increased. On any given day in 1994–96, about 57% of Americans ate away from home, an increase of one third since 1977–78 (90). Women and young children ate away from home 50% more often in the 1990s than in the late 1970s. Teenage males were most likely to eat away from home; persons age 60 and older, the least likely. Persons with higher incomes were more likely to eat away from home than those with lower incomes (65% compared to 45% percent, respectively).

In 1994–96, fast-food places were more often the venue for foods eaten away from home, whereas in 1977–78 it was restaurants, someone else's home, and fast-food places (90). About 40% of males age 12–59 ate at fast-food restaurants on any given day; only 18% of females age 60 and older did so (90). Restaurants with table service were the top choice of places to eat among persons age 60 and older. Fast-food use, reported by 37% of adults and 42% of children in 1994–96 and 1998, was associated with significantly higher intake of energy, fat, saturated fat, sodium, and carbonated soft drinks, and significantly lower intake of vitamins A and C, fruits, vegetables, and milk (73).

Foods eaten away from home contribute more than 25% of the intake of calories and fat (90). Beverages, particularly carbonated soft drinks, coffee, and milk, are the most popular items consumed away from home. Other popular items include french-fried potatoes, sandwiches (especially burgers), lettuce salads, pizza, and Mexican dishes (90).

Changes in Average Portion Size

Nielsen & Popkin compared the mean portion size of commonly consumed foods reported in USDA's CSFII surveys for three periods: 1977–78, 1989–91, and 1994–96/98 (70). The largest portions were consumed at fast-food restaurants and the smallest at other restaurants (except for pizza). For all categories except pizza, average portion size increased for foods consumed at home and away from home. For example, during the period studied, average portion size increased from 1.0 to 1.6 ounces for salty snacks (a 93-kcal increase), from 13.1 to 19.9 fluid ounces for soft drinks (a 49-kcal increase), from 3.1 to 3.6 ounces for french fries (a 68-kcal increase), from 5.8 to 7.3 ounces for a cheeseburger (a 136-kcal increase), and from 6.3 to 8.0 ounces for Mexican food (a 133-kcal increase) (70).

Between 1977–78 and 1994–96, food portions were stable for most foods consumed by toddlers age 12–18 months, with the exception of meats, which decreased, and milk, bread, cereal, juices, and peanut butter, which increased (60). Between 1989–91 and 1994–96, larger average portion sizes of common food items—including soft drinks (12% to 18% increase), coffee (21%), tea (12%), and RTE cereals (10%)—were consumed by persons age 2 and older (81). The average portion size increased 53% for beer and 22% for wine. The average soft drink consumption per eating occasion increased more than 50% among female adolescents, males and females age 20–39 years, and males 40–59 years. On the other hand, average portion size decreased for some foods: margarine (18%), chicken (11%), pizza (14%), and macaroni and cheese (17%).

Consumption of Energy-Dense, Low-Nutrient-Dense Foods

Using NHANES III data, Kant studied the intake of low-nutrient-dense foods by children age 8–18 and found that items such as soft drinks, candy, table sweeteners, baked and dairy desserts, salty snacks, and discretionary fats accounted for more than 30% of daily calories (48). More frequent consumption of these low-nutrient-dense foods was associated with higher energy intake and with lower intake of nutrient-dense foods, vitamins A and B_6, folate, calcium, magnesium, iron, and zinc. However, consumption of low-nutrient-dense foods was not a significant predictor of body mass index.

Among adults, energy-dense, nutrient-poor foods contributed 27% of calories in 1988–94, not including alcoholic beverages (46). Consumption of foods such as sweetened beverages, desserts, and snacks increased the risk of high energy intake, decreased micronutrient intake, decreased compliance with food group recommendations, and was associated with lower serum levels of vitamins and carotenoids.

Many energy-dense, low-nutrient-dense food items are high in added sugars (defined as sugars added as ingredients to foods in processing or preparation). A high intake of added sugars has a negative effect on the intake of essential micronutrients, especially vitamins A and B_{12}, folate, magnesium, and iron (9). In

addition, in 1994–96, persons in the upper tertile of added sugar intake (more than 18% of calories from added sugars) had low intakes of the major food groups (fruits, vegetables, grains, dairy, and meat) (9). Children and adolescents are the most likely to have a diet high in added sugars. In the 1990s, school-age children consumed nearly 20% of their calories from added sugars, or about 25 teaspoons per day (41). Adolescents have the highest intake of added sugars, and obtain about 40% from carbonated soft drinks, which supply about one third of all added sugars (41, 53).

Trends in Beverage Consumption

Data for 1988–94 show that beverages contributed about 20% to 24% of energy across age and sex groups for youth. For children under 12 years, milk provided one half or more of the energy from beverages. Soft drinks contributed 2.4% of energy among 2–5 year olds and 4.1% among 6–11 year olds; juice drinks contributed another 3.6% and 2.7%, respectively (87). Soft drinks contributed about 8% of the energy in adolescents' intake; but among overweight adolescents, 10.3% for males and 8.6% for females (87).

Analysis of data from the NFCS 1977–78 and the 1994–96 and 1998 CSFII shows that the percentage of children age 6–17 consuming sweetened beverages (including soft drinks, flavored waters, and juice drinks) increased from 37% to 48% (40). Mean daily intake of these beverages doubled from 5 to 12 fluid ounces (40). Among adolescent females, milk consumption decreased and sodas and fruit drinks doubled between 1977–78 and 1994–96, and those who did not consume milk had an inadequate intake of vitamin A, folate, calcium, phosphorus, and magnesium (10).

Consumption of soft drinks, fruit drinks, and fruit ades increased between 1977–78 and 1994–96 and 1998 among adults and children (30, 31). The intake of beer and ale also increased among adults (30). The intake of carbonated soft drinks exceeded that of 100% fruit juice at age 5, and that of milk at age 13 (77). Adolescents drink more carbonated beverages than fruit juices, milk, or fruit ades or drinks. The home was the major source of access to these beverages, but access from fast-food restaurants, vending machines, and school cafeterias increased between the late 1970s and the mid to late 1990s.

Snacking Habits

On average, 75% of Americans report having a snack or beverage break on any given day (8). The prevalence of snacking increases with an increase in household income, although patterns of snack choices change. Mean intake of fried potatoes, potato chips, whole milk, and fruit drinks and ades reported as snacks were higher for persons with income at or below 130% of the poverty line, the cutoff level for the Food Stamp Program, than for those with incomes of 300% of the poverty line or higher. Those with higher income consumed more grain-based salty snacks,

fruits, skim milk, soft drinks, coffee, tea, and alcoholic beverages than those in the lowest income level.

In 1994, snacks provided about one fifth of total calories in the diets of Americans, about one sixth of the nutrients, and one fourth of the total beverages. Most snacking occurred in the late afternoon and later evening; the most popular time was between 8:00 P.M.and 10:00 P.M. (8). Snacks provided 14% to 17% of grain servings, 21% to 24% of milk servings, and 30% to 33% of fruit servings. Trends are difficult to identify because national surveys have not consistently reported on snacking behavior over time.

Trends in Use of Dietary Supplements

Dietary supplements contribute to the total nutrient intake of individuals and are associated with nutritional status and health outcomes (7, 22). Sales of dietary supplements have increased significantly in the past decade; in 2003, they amounted to approximately 18.8 billion dollars (71). So, this paper would not be complete without some discussion of trends in the use of dietary supplements and their contribution to total nutrient intakes.

National estimates of the prevalence of dietary supplement use are available from various surveys conducted between 1971 and 2000 (1, 12, 24, 27, 34, 35, 52, 56, 61, 76, 79, 82, 83, 88, 90). During the 1970s, national survey estimates of vitamin or mineral supplement use (regular or irregular use) ranged from 34% to 37% of the population age 1–74; use was highest among infants (45%) (61). During the 1980s, vitamin or mineral supplement use ranged from 35% to 40%, and about 40% in 1988–94 (35, 56). In 1988–94, children age 1–5 were major users of supplements, primarily multivitamins. About two thirds of supplement users (67%) took only one supplement, typically a combination vitamin/mineral product (35).

Table 5 shows the prevalence of *any* supplement use (regular or irregular), by age, found by the NHANES surveys. The prevalence of supplement use in adult men and women increased with age (76). Dietary supplement use increased over a 30-year period in adult men and women, decreased in children age 1–2 and 3–5, and remained relatively constant in children age 6–11 and adolescents age 12–19. [Note: Although not included in the table owing to the variable age coverage for infants across the NHANES, in general, the data indicate that dietary supplement use declined significantly among infants as it did for preschoolers age 1–5 (12, 35, 90).] In 1999–2000, women age 20–74 had the highest prevalence of supplement use (57%), whereas in the 1970s, children age 1–5 had the highest prevalence (approximately 50%).

The NHANES findings are supported by results from other national surveys. For example, the percentage of adult men and women (age 18 and older) who reported any supplement use in the 1989–91 CSFII was 32.3% and 46.9%, respectively, compared with 41.9% and 55.8% in the 1994–96 CSFII, respectively (76). Slesinski

TABLE 5 Prevalence of any dietary supplement use for the U.S. population, 1971 to 2000 (%)

Age/sex (years)	NHANES I[a] 1971–74	NHANES II[a] 1976–80	NHANES III[b] 1988–94	NHANES[c] 1999–2000
Both sexes				
1–2	54.8	53.7	42.6	30.9
3–5	48.1	49.5	48.4	40.4
6–11	34.2	37.5	34.5	33.1
Males				
12–15	23.9	25.8	21.4	20.5
16–19	22.2	25.0	26.4	27.4
20–39	26.4	31.1	32.0	37.2
40–59	27.1	30.1	37.4	52.5
60–74	31.6	36.9	39.5	60.6
20–74[d]	27.5	31.6	35.7	47.1
Females				
12–15	26.6	28.4	23.1	23.2
16–19	34.7	34.2	32.9	32.4
20–39	37.1	42.1	43.9	49.1
40–59	37.9	42.5	48.9	59.4
60–74	40.2	45.3	52.6	66.4
20–74[d]	37.9	42.8	47.7	56.7

[a]Vitamin or mineral supplements.

[b]Vitamin, mineral, or other supplements used in the past month.

[c]Vitamin, mineral, or other (herbal or botanical) supplements used in the past month.

[d]Age-adjusted to the 2000 population.

et al. reported adults' use of any dietary supplements in the 1987 and 1992 National Health Interview Surveys as 46.2% and 51.1%, respectively (79).

The prevalence of dietary supplement use is significantly lower when the criterion is changed from "any use" to "daily or regular use." For example, in NHANES II "regular" supplement use was 20.3% and 28.2% compared to "any" use (31.6% and 42.8%) for adult men and women, respectively. The prevalence of regular supplement use has increased over time among adult men and women age 20–74 (76). Regular use of dietary supplements is most common among older, white persons; females; individuals with more education and higher income; individuals with higher nutrient intakes from diet and higher levels of self-reported health status; and previous smokers (1, 34, 35, 52, 56, 57, 61, 79, 80, 83). Similar patterns by gender, race, income and education levels, and health status have been observed over the past 30-year period (24, 61, 79, 83).

Diets of supplement users are higher in fruits and vegetables (57), and higher in mean nutrient intake from foods, even after controlling for education and income (52, 57, 79, 82). An NHANES II study found higher mean serum levels of vitamin C among supplement users (24).

SUMMARY

Assessing trends in dietary intake is critical to (*a*) understanding the relationship of diet to overweight, obesity, and other health conditions; (*b*) identifying strategies for nutrition education and weight loss; and (*c*) planning and tracking public health initiatives. Thirty years of data from national nutrition surveys makes this possible; however, changes in data collection and databases for food composition and dietary supplements create some problems of interpretation. The consistency in trends across surveys; the patterns of food consumption, nutrient intake, and supplement use; and the changes in blood measurements of nutritional status support the dietary intake trends reported in this review.

Between 1971–74 and 1999–2000, changes in food consumption patterns were reflected in shifts in macronutrient intake; the mean percentage of calories from fat and saturated fat decreased, and the percentage of calories from carbohydrate increased. Mean dietary sodium intake decreased from the 1970s to the 1980s; the pattern from the 1990s to 2000 is less clear. Mean calcium intake and milk consumption declined among children, and are associated with an increased intake of sweetened beverages, especially carbonated soft drinks. Mean total calcium intake falls short of recommended levels across all groups.

National data indicate higher mean intake of iron and folate, although additional progress is needed for young children, women of childbearing age, and the elderly. Folate intake and blood folate levels dramatically increased following greater fortification of grain products.

Despite improvement in the intake of fruits and vegetables, many Americans still do not meet recommendations for these foods. In 1999–2000, Americans were least likely to meet the recommended servings of fruits. Intake of deep green and deep yellow vegetables and whole grains also fall well below recommended levels. Increasing the consumption of fruits, vegetables, whole grains, and low-fat milk products could improve dietary quality and reduce energy intake, if items from these food groups took the place of higher-calorie, nutrient-poor foods.

Changes in dietary intake methodology, including improved probes, improved visual aids for estimating portion-sizes, and the use of automated data collection, as well as the systematic underreporting of intake, especially among overweight persons, make assessment of changes in energy intake difficult. Because intake is usually correlated with energy, underreporting of energy may also affect estimates of other nutrients and food components. In addition, improvements in food composition databases and actual changes in food composition must be considered in the interpretation of trends in the intake of nutrients and other food components. Higher mean energy intakes in NHANES III than in NHANES I and II may reflect actual changes in consumption patterns or improved data collection. Increases in the average portion size of sweetened beverages and of popular food items, and the consumption of foods away from home, especially at fast-food establishments, are consistent with increases in energy intake and overweight, although changes

in physical activity must also be considered in understanding the increases in overweight and obesity.

Similar methodological issues apply to other dietary information, especially use of dietary supplements. Methodological differences probably account for some variation in the estimates of supplement use by contemporaneous surveys and among surveys at various times. Our analysis—which used definitions of use that reduced survey differences—indicates that the prevalence of dietary supplement use has increased between 1971–74 and 1999–2000 for most population groups except infants and preschoolers. Continued collection of data on supplement use is important to estimate total nutrient intake and nutrient adequacy among groups in the population.

Changes in demographics, such as increases in the number of minorities and persons over age 60, and income and racial-ethnic disparities may produce changes in dietary patterns and health outcomes. Changes in the food supply and dietary behaviors—such as eating away from home, snacking, and beverage choice—will affect food consumption patterns. Increasing levels of overweight and obesity demand attention to these patterns and to levels of physical activity in the population. Data from 1999–2000 show that the dietary quality of most Americans can be improved: Only one in ten has a "good" diet. Tracking the food consumption of population groups will be important to inform food and health policy and may lead to changes in dietary guidance. National nutrition surveys will continue to provide critical information to monitor food consumption, dietary intake, and the related health status of the U.S. population.

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