Part D. Section 2: Nutrient Adequacy

Introduction

Numerous nutrients and food components are needed for normal growth, development, and body functioning. Essential nutrients—those that the body cannot produce itself in adequate amounts—must be obtained from foods. Nutrients function in many ways to build, maintain, and protect body structures and systems and to promote health. For example, some nutrients provide substrates or structure for various body tissues. Others serve as antioxidants, counteracting oxidative damage to biomolecules. Many nutrients are necessary for the production and functioning of compounds necessary for health, such as hormones, enzymes, or coenzymes and for homeostasis of physiological systems. Some nutrients can be used as an energy source, and others are necessary in various stages of energy production. In addition to preventing classic nutrient deficiency diseases, prospective epidemiologic studies suggest that a healthy dietary pattern—one that provides recommended intakes of essential nutrients within recommended energy levels—reduces the risk of some common chronic diseases, including obesity, cardiovascular disease, and some cancers (see ***Part D. Section 1: Energy Balance and Weight Management***; ***Part D. Section 3: Fatty Acids and Cholesterol***; ***Part D. Section 4: Protein***; ***Part D. Section 5: Carbohydrates***; and ***Part D. Section 6: Sodium, Potassium, and Water***).

A fundamental premise of the DGAC is that nutrient intake should come primarily from foods. Many people understand the importance of good nutrition but believe that a daily multivitamin/mineral pill will substitute for actually eating the foods that they know are good for them. However, the more scientists learn about nutrition and the human body, the more they realize the importance of eating foods in their most intact forms without added solid fats, sugars, starches, or sodium. For example, some studies have shown that people who eat a diet rich in beta-carotene have a lower rate of several kinds of cancer. In contrast, studies have shown that taking beta-carotene in pill form does not decrease the risk of cancer in healthy individuals, and that, indeed, supplemental nutrients may be harmful in some cases (Bjelakovic, 2007) (see Question 7 on Vitamin, Mineral, and Nutrient Supplements). It is possible that beta-carotene and other nutrients are most beneficial to health when they are consumed in their natural form and in combination with each other, such as in vegetables (including cooked dry beans and peas), fruits, and whole grains. These foods contain not only the essential vitamins and minerals that are often targeted in nutrient supplement pills, but also hundreds of naturally-occurring phytonutrients and other substances, including carotenoids, flavonoids, isoflavones, and protease inhibitors that may protect against cancer, heart disease, osteoporosis, and other chronic health conditions. The Institute of Medicine (IOM) report *Dietary Reference Intakes: Applications in Dietary Planning* (FNB, 2003) notes instances when fortification of certain foods may be advantageous, including provision of additional sources of key nutrients that might otherwise be present only in low amounts in some food sources, and providing nutrients in highly bioavailable forms. Fortification can provide a food-based means for increasing intakes of particular nutrients, for example, folic acid fortification of grains to reduce the incidence of neural tube defects (NTDs) (see Questions 4, 5, and 6 within Nutrient Issues for Selected Population Subgroups).

The DGAC advocates the consumption of nutrient-dense forms of foods by all Americans to provide the maximum nutrition intake within calorie needs. Nutrient-dense foods were defined in the 2005 *Dietary Guidelines for Americans* as those "that provide substantial amounts of vitamins and minerals (micronutrients) and relatively few calories" (HHS and USDA, 2005a, p. 7). The DGAC accepts this definition, with the following clarification. Nutrient-dense foods are forms of foods that are lean or low in solid fats and without added solid fats, sugars, starches, or sodium and that retain naturally-occurring components such as fiber. For example, all vegetables, fruits, whole grains, fish, eggs, and nuts prepared without added solid fats or sugars are considered nutrient-dense, as are lean or low-fat forms of fluid milk, meat, and poultry prepared without added solid fats or sugars. While a variety of equations are available with which to calculate the nutrient density of specific foods (Drewnowski, 2005; Drewnowski, 2008; Kennedy, 2008), the DGAC does not advocate the use of any particular equation over the others because all foods in nutrient-dense forms within a total dietary pattern are more likely to confer health benefits compared to non-nutrient-dense forms of foods. Non-nutrient-dense foods supply relatively few micronutrients and/or more calories than their nutrient-dense counterparts because nutrient-bearing components have been removed or calories from solid fats or added sugars have been added. If non-nutrient-dense foods displace nutrient-dense foods, an individual's ability to achieve recommended nutrient intakes is lessened despite often excessive calorie intakes. This can leave a person overweight but undernourished and thus, at higher risk of disease. Nutrient-dense foods are found in a variety of forms (e.g., intact, minimally processed, sliced, diced, frozen, canned, cooked), and a range of nutrient-dense forms of food can be included in a healthful, energy balanced, total diet.

As defined in ***Part D. Section 1: Energy Balance and Weight Management***, "energy density is the amount of energy per unit of weight, usually expressed as calories per 100 grams of food." To achieve food and nutrient recommendations without exceeding recommended energy intake levels, Americans are encouraged to consume a variety and balance of nutrient-dense forms of foods within and among the basic food groups, while keeping the energy density of the total diet relatively low. Some nutrient-dense foods also are naturally energy-dense (e.g., nuts, olive oil), and these foods can be incorporated into a total diet that is relatively low in energy density.

Another basic premise of the DGAC is that *Dietary Guidelines for Americans* should provide guidance in obtaining all the nutrients needed for growth and health. To this end, the DGAC recommends that food guidance aim to achieve the most recent Dietary Reference Intakes (DRIs), including Acceptable Macronutrient Distribution Ranges (AMDRs), Recommended Dietary Allowances (RDAs), and Adequate Intakes (AIs) that consider the individual's life stage, sex, and activity level (FNB, 2006), as well as Tolerable Upper Intake Levels (ULs) for nutrients (FNB, 2006). These DRIs are to be considered in diet planning for individuals. Table D2.1, lists nutritional goals for age-sex groups, based on DRI and *Dietary Guidelines for Americans* recommendations, and USDA Food Patterns using these goals as targets (see ***Part B. Section 2: Total Diet*** for a related discussion of dietary patterns).

The AMDRs for dietary carbohydrate, fat, and protein are relative to total energy intake. Each AMDR "is the range of intakes of an energy source that is associated with a reduced risk of chronic disease, yet can provide adequate amounts of essential nutrients" (FNB, 2006, p. 11). Macronutrients are discussed in ***Part D. Section 3: Fatty Acids and Cholesterol***, ***Part D. Section 4: Protein***, and ***Part D. Section 5: Carbohydrates***.

The RDA is "the average daily dietary nutrient intake level that is sufficient to meet the nutrient requirements of nearly all (97 to 98 %) healthy individuals in a particular life stage and gender group" (FNB, 2006, p. 8). RDAs are established from Estimated Average Requirements (EARs) which are the "average daily nutrient intake level that is estimated to meet the requirements of half of the healthy individuals in a particular life stage and gender group" (FNB, 2006, p. 8). AIs are used when scientific evidence is insufficient to determine EARs, and thus RDAs, for nutrients. AIs are "based on observed or experimentally determined approximations or estimates of nutrient intake by a group (or groups) of apparently healthy people that are assumed to be adequate" (FNB, 2006, p. 8). EARs should be used to plan intakes for groups, while the IOM recommends that RDAs or AIs be used to plan diets for individuals (FNB, 2006). The planning of food intake patterns, which was introduced in ***Part C: Methodology***, is an example of this application. Both the RDAs and AIs are intended to serve as goals for individual intakes by apparently healthy people. In general, these values are intended to cover the needs of nearly all persons in a life-stage group. Meeting the DRIs provides assurance that the probability of inadequate dietary intake of a nutrient will not exceed 2 percent to 3 percent of the population (FNB, 2003).

The UL is "the highest average daily nutrient intake level that is likely to pose no risk of adverse health effects to almost all individuals in the general population" (FNB, 2006, p. 8). Because consuming intakes below the UL minimizes risk to the individual, dietary guidance for individuals should avoid exceeding the UL (FNB, 2003).

List of Questions

This section addresses eight major questions related to achieving nutrient adequacy in an overall food intake pattern that is within defined energy levels. Special considerations for meeting recommended intakes of nutrients also are considered.

DIETARY COMPONENTS OVERCONSUMED

1. What nutrients and dietary components are overconsumed by the general public?

FOOD GROUPS AND SELECTED DIETARY COMPONENTS UNDERCONSUMED

2. What food groups and selected dietary components are underconsumed by the general public?

NUTRIENTS OF CONCERN

3. What nutrients are underconsumed by the general public and present a substantial public health concern?

4. What is the relationship between folate intake and health outcomes in the United States (US) and Canada following mandatory folic acid fortification?

5. Is iron a nutrient of special concern for women of reproductive capacity?

6. Are older adults consuming sufficient vitamin B_{12}?

VITAMIN, MINERAL, AND NUTRIENT SUPPLEMENTS

7. Can a daily multivitamin/mineral supplement prevent chronic disease?

NUTRIENT INTAKE AND SELECTED BEHAVIORS

8. What is the relationship between nutrient intake and breakfast consumption, snacking, and eating frequency?

Methodology

The DGAC promotes achievement of recommended nutrient intake by consuming foods. In order to recognize nutrient shortfalls and nutrients that present a public health concern, the DGAC began its review with an examination of nutrients and dietary components consumed in amounts high enough or low enough to be of concern. Questions 1 and 2 are new to the 2010 DGAC report and provide a foundation for understanding the food-based gaps in nutrient intakes of Americans. Nutrient and selected dietary component intakes by Americans are drawn from analyses conducted by the National Cancer Institute (NCI) (NCI, 2009), USDA's Food and Nutrition Service (FNS) (FNS, Report No. FSP-08-NH, 2008; FNS, Report No. CN-08-NH, 2008; FNS, Report No. WIC-

08-NH, 2008), USDA's Agricultural Research Service (ARS) (ARS, 2008), and the IOM (FNB, 2009), using standard methodologies and data from the National Health and Nutrition Examination Survey (NHANES).

The 2005 *Dietary Guidelines for Americans* was the reference point for comparing recommended intake levels to usual intakes of food groups and dietary components. Food pattern modeling was used to determine recommended amounts from each food group—that is the amount that should be consumed in order to meet nutrient needs. The process and detailed results are described in the USDA Food Patterns modeling report (see online Appendix E3.1 at www.dietaryguidelines.gov) and are also summarized in ***Part B. Section 2: Total Diet: Combining Nutrients, Consuming Food***. These food group recommendations were compared to typical intakes to identify food groups of concern. Recommendations for dietary components (e.g., oils and refined grains) also were included in USDA Food Patterns modeling, and usual intakes were compared to limits for these items to identify dietary components of concern. The modeling process also was used to determine the maximum amounts of additional calories from non-essential nutrient sources (primarily solid fats and added sugars) that individuals could consume, while at the same time staying within energy needs and consuming recommended amounts of food from all food groups in nutrient-dense forms. These maximum limits were compared to usual intake levels to identify components that are overconsumed. The maximum limit for calories from solid fats and added sugars replaces the "discretionary calorie allowance" used by the 2005 DGAC. The concept of discretionary calories is considered scientifically relevant and theoretically valid. However, it has been difficult to translate into meaningful consumer education. Also, the inclusion of a discretionary calorie allowance may place too much emphasis on a portion of the diet that for most Americans should be a very small contribution (an average of about 150 to 200 kcal per day) and is not needed for nutrient adequacy.

Food sources of energy, food groups, nutrients, and other dietary components were identified through analyses that grouped specific foods reported in dietary surveys into 96 mutually exclusive food categories. These categories were described and used by Bachman (2008), and also used by Bosire et al. (2009), and additional analyses conducted for the DGAC by the Risk Factor Monitoring and Methods Branch of the NCI (available at http://riskfactor.cancer.gov/diet/foodsources/).

Nutrients of concern (Question 3) were identified using a two-step approach. First, dietary intake data were compared to DRIs to identify shortfall nutrients. Second, biochemical indices of nutrient or functional status, when available, and/or disease prevalence data were further considered to identify nutrients underconsumed and of substantial public health significance. This chapter also addresses special nutrient recommendations for certain population subgroups. A complete systematic review was conducted for folate (Question 4), due to the documented importance of folate in preventing NTDs and emerging evidence of health risks with increased folic acid intakes in the post-fortification era. Conclusions for iron in women of reproductive capacity (Question 5) and vitamin B_{12} in older adults (Question 6) are based on the 2005 DGAC report and relevant new literature from updated searches. Vitamin, mineral, and nutrient supplements (Question 7) are new to the 2010 report. More than half of all Americans report using nutrient supplements. Their use in primary prevention of chronic disease warrants evaluation. Conclusions are based on evidence compiled for use by the 2006 National Institutes of Health (NIH) "State-of-the-Science Conference on Multivitamin/Mineral Supplements for Chronic Disease Prevention" (NIH, 2006), NIH panel conclusions, and subsequent evidence reviewed by the 2010 DGAC. The DGAC also was interested in identifying behaviors that help individuals achieve nutrient intake recommendations. Hence, the chapter ends with a question new to this report, involving a discussion of nutrient intake based on selected behaviors (Question 8)— derived from a full systematic review.

USDA Food Pattern modeling analyses were conducted to provide additional contextual information for two questions (Questions 3 and 4) related to nutrient adequacy and food group intakes. These analyses include nutrient adequacy if fluid milk and milk products intake is eliminated, modified, or replaced with alternative sources of calcium (within Question 3) and the adequacy of folate and other nutrient intakes if all grains are consumed as whole grains (within Question 4). The process and detailed results for both modeling analyses are described in the full Milk Group and Alternates and Replacing all Non-Whole Grains with Whole Grains reports (see online appendices E3.6 and E3.7 at www.dietaryguidelines.gov).

The search strategies used to identify relevant literature and update scientific evidence appear in ***Part C: Methodology***. Additional information about the search strategies and criteria used to review specific questions can be found online in the Nutrition Evidence Library at www.nutritionevidencelibrary.com.

DIETARY COMPONENTS OVERCONSUMED

Americans eat certain nutrients and dietary components in excess compared to dietary targets. Americans are strongly encouraged to modify their dietary patterns to lower intakes of non-nutrient-dense items that are overconsumed and may contribute to overweight and obesity.

Question 1: What Nutrients and Dietary Components are Overconsumed by the General Public?

Conclusion

Estimated intakes of the following nutrients and dietary components are high enough to be of concern:

- For adults: total energy intake, particularly energy intake from solid fats and added sugars; sodium; percentage of total energy from saturated fats; total cholesterol (in men); and refined grains.
- For children: energy intake from solid fats and added sugars; sodium; percentage of total energy from saturated fats; total cholesterol (only in boys, aged 12 to 19 years); and refined grains.

Implications

To lower overall energy intakes (see ***Part D. Section 1: Energy Balance and Weight Management***) without compromising nutrient intakes, Americans should reduce consumption of calories from solid fats and added sugars (SoFAS). SoFAS generally provide few, if any, micronutrients. Intakes of SoFAS should be kept as low as possible across all age-sex groups, to less than the maximum limits calculated for the USDA Food Patterns. Concentrated efforts are needed to lower total sodium intakes by all Americans (see ***Part D. Section 6: Sodium, Potassium, and Water***). Likewise deliberate public health efforts are warranted to reduce intakes of saturated fats to meet dietary guidelines for optimal health. Males older than age 12 years also are encouraged to consume less total dietary cholesterol (see ***Part D. Section 3: Fatty Acids and Cholesterol***). Intakes of refined grain are too high and at least half of all refined grains should be replaced with high-fiber whole grains (see ***Part D. Section 5: Carbohydrates***).

Review of the Evidence

To reach this conclusion, the DGAC examined usual intake distributions from 2001-2004 NHANES data (NCI, 2009) and usual mean intakes from 2005-2006 NHANES data (ARS, 2008). In all cases, the most current NHANES data available for a specific nutrient or food component was used. In addition, the Committee reviewed FNS reports on quality of American diets and the IOM report on school meals.

Methods to Identify Components Overconsumed

When a population group has dietary intakes that exceed recommended maximum levels for a food group, dietary component, or nutrient, that dietary constituent is considered a component consumed in an amount high enough to be of "concern" (i.e., the component is overconsumed). Such components are consumed in amounts higher than levels recommended in the USDA Food Patterns or by the IOM to promote optimal health. When basic food groups, energy intake, proportions of energy intake, or specific nutrients are consumed in amounts higher than recommended levels, such intakes are of concern because their contributions to overall nutrient intakes, overall dietary components, and the balance of macro- and micronutrients in the total dietary pattern may be unsuitable to confer potential health benefits

Findings Regarding Components Overconsumed

Energy

Appropriate intake levels for total energy vary based on a person's age, sex, size and level of physical activity. Overconsumption of total energy in comparison to individual need on an ongoing basis results in weight gain. Although mean intakes of energy may be within recommended ranges, the increase over time in the number of adults and children classified as overweight or obese indicates that for some, usual energy intakes exceed needs. The mean energy intakes of men and women older than age 19 years are 2638 calories and 1785 calories per day, respectively (ARS, 2008), while recommended total energy intakes range from 2000 to 3000 calories per day for men and 1600 to 2400 calories per day for women, depending on age and physical activity level. Many men and women appear to balance their energy intakes based on energy needs, but there are clearly many more whose usual energy intakes exceed their daily needs, thereby contributing to the massive obesity epidemic currently affecting Americans.

Data document that adult men and women who are classified as overweight (body mass index [BMI] of 25.0 to 29.9 kg/m^2) or obese (BMI of greater than or equal to 30.0 kg/m^2) often systematically under-report their dietary intakes (Karelis, 2010). For example, Moshfegh et al. (2008) compared self-reported energy intake, estimated using the automated multiple-pass dietary intake method used in NHANES, to total energy expenditure measured by doubly labeled water in 221 normal weight, 193 overweight, and 110 obese men and women. Overweight and obese men underestimated energy intake by 14 percent and 20 percent, respectively. Overweight and obese women underestimated energy intake by 15 percent and 21 percent, respectively, while normal weight men and women underestimated energy intake by 1 percent and 6 percent, respectively (Moshfegh, 2008). Hence, actual average energy intakes are likely greater than estimated by NHANES from self-reported intakes, particularly in individuals who are overweight or obese, suggesting that total energy is overconsumed.

Children, aged 2 to 18 years, on average, consume calories within the recommended ranges for their ages and physical activity levels (ARS, 2008). Yet, as with adults, subgroups of children may be consuming calories in amounts too high for their daily energy needs, and as with adults, there is significant under-reporting of energy intake among overweight and obese children compared with normal weight children. Calories, energy needs, energy balance, and relationships to BMI and health outcomes are thoroughly discussed in ***Part D. Section 1: Energy Balance and Weight Management***.

Five categories of foods contribute nearly 30 percent of the total calories consumed in the American diet (Bosire, 2009). These five categories—grain-based desserts (e.g., cakes, cookies, donuts, pies, crisps, cobblers, granola bars); yeast breads; chicken and chicken-mixed dishes; sodas, energy, and sports drinks; and pizza—are often consumed in forms high in SoFAS and should be replaced with other foods that are more nutrient-dense or prepared in a way that reduces the content of SoFAS. Replacing foods containing higher amounts of SoFAS with foods from each of the basic food groups in nutrient-dense forms, to achieve appropriate dietary patterns within individual calorie needs, can help promote health (see the online resource for ***Part D. Section 1: Energy Balance and Weight Management*** at www.dietaryguidelines.gov for information on the primary energy sources in the diets of children).

Energy from Solid Fats and Added Sugars

Solid fats are fats that are solid at room temperature. Solid fats come from many animal foods and can be made from vegetable oils through hydrogenation. Some common solid fats are butter, beef tallow (tallow, suet), chicken fat, pork fat (lard), stick margarine, and shortening. Foods high in solid fats include many cheeses, creams, ice cream, well-marbled cuts of meats, regular ground beef, bacon, sausages, poultry skin, and many baked goods (such as cookies, crackers, donuts, pastries, and croissants). Most solid fats are high in saturated fats and/or *trans* fats and have less monounsaturated or polyunsaturated fats. Animal products containing solid fats also contain cholesterol.

Added sugars are sugars and syrups that are added to foods or beverages during processing or preparation. They do not include naturally occurring sugars such as those in milk and fruits. Names for added sugars include brown sugar, corn sweeteners, corn syrup, dextrose, fructose, fruit juice concentrates, glucose, high-fructose corn syrup, honey, invert sugar, lactose, maltose, malt syrup, molasses, raw sugar, and sucrose.

Together, solid fats and added sugars (SoFAS) contribute greatly to overall energy intake without contributing importantly to nutrient intakes (i.e., they are non-nutrient-dense). Intakes of SoFAS come from foods that are high in solid fats (naturally present or added) and added sugars and from the SoFAS that are added to foods during preparation, service, and intake. The major food sources of SoFAS in American diets for those ages 2 and older were identified by Bachman et al. (2008), using NHANES 2001-2002 intake data. Top sources of solid fats included grain-based desserts (10.9% of total energy from solid fats); regular-fat cheese (7.7%); sausage, franks, ribs, and bacon (7.1%); pizza (5.9%); fried white potatoes (mainly French fries [5.5%]); and dairy-based desserts (5.1%). The top sources of added sugars included sodas (36.6% of total energy from added sugars); grain-based desserts (11.7%); sugar-sweetened fruit drinks (11.5%); dairy-based desserts (6.4%); candy (6.2%); ready-to-eat cereals (4.0%); sugars/honey (3.9%); tea (3.2%); syrups and toppings (2.7%), and yeast breads (2.0%). For children, aged 2 to 18 years, the major sources of SoFAS were very similar to those for the overall population, with the exception that whole milk was the top source of solid fats for children aged 2 to 8 years. Very similar results for the top sources of added sugars were reported by Marriott et al. (2010) in an analysis of added sugars intake for individuals 4 years and older, using NHANES 2003-2006 intake data. These included sodas (30.7%); sugars/sweets (which included candy, sugars, syrups and toppings, and jams and jellies [13.7%]); sweetened grains (which included cakes, cookies, pies, pastries, crackers, and snacks, [12.6%]); and fruitades/fruit drinks (10.3%).

Neither a recommendation for intake of SoFAS, nor a reasonable proportion of total energy intake as SoFAS has been determined. Nutrient recommendations may be met on a daily basis without consuming SoFAS; thus, SoFAS are not an essential component of the diet. If consumed at all, intake of SoFAS should be infrequent and in quantities as small as possible. The USDA Food Patterns offer guidance on the maximum amount of SoFAS that can be accommodated within an individual's energy allotment *only after* nutrient requirements have been met (Table B2.3 in ***Part B. Section 2: Total Diet***). SoFAS should not be misconstrued as a goal or daily allowance, but rather, are a maximum daily amount that most Americans routinely exceed and do not need to meet nutrient requirements. These SoFAS substitute for discretionary calories that were included in the 2005 *Dietary Guidelines for Americans* dietary patterns. In this report, SoFAS do not include calories from alcohol because alcohol makes a very minor contribution to overall energy intake in the diets of most Americans and does not apply to children.

Slightly more than one-third of all calories currently consumed in the average American diet come from SoFAS (Figure D2.1[1]). On a caloric basis, the individual components of SoFAS (i.e. solid fats and added sugars) are consumed in roughly equal amounts (Figure D2.2). SoFAS contribute little or nothing to overall nutrient adequacy of the diet but add from 500 calories to 1050 calories to total energy intake each day for many Americans. This is excessive. Most Americans overconsume SoFAS. More than 95 percent of children, aged 2 to 13 years, adolescent girls and women, aged 14 to 50 years, and men, aged 19 to 30 years; more than 90 percent of adolescent boys, aged 14 to 18 years, and men, aged 31 to 50 years; more than 75 percent of men and women older than 50 years of age consume more than the maximum caloric limit for SoFAS intake identified in the USDA Food Patterns (Figure D2.3). Median intakes of energy as SoFAS in the typical American diet are 536 calories and 701 calories per day for children, aged 2 to 3 years and 4 to 8 years, respectively; 730 calories to 1028 calories per day for children, aged 9 to 18 years; and 603 calories and 852 calories per day for women and men older than 19 years of age, respectively (NCI, 2009). This means the majority of Americans eat too many calories from non-nutritious sources. The DGAC is concerned that Americans are overweight and under-nourished. In support of this conclusion, Marriott et al. (2010) reported lower intakes of micronutrients in Americans with higher intakes of added sugars beyond 5 percent to 10 percent of total calories. .

[1] Note: All Figures and Tables for this chapter are found at the end of the chapter.

Other Evidence Considered for Energy from SoFAS

The Committee on Nutrition Standards for National School Lunch and Breakfast Programs examined 1999-2002 NHANES data and found that average caloric intakes from SoFAS for school-aged children, aged 5 to 8 years, 9 to 13 years, and 14 to 18 years, were 719, 810, and 946 calories per day (FNB, 2009). The contrast with discretionary calorie allowances, which accommodate intakes of SoFAS, for these same ages was striking. The allowances in typical energy intake patterns for children were 132 (for 1600 calorie pattern), 267 (for 2000 calorie pattern) and 362 (for 2400 calorie pattern) calories per day.

The Food and Nutrition Service (FNS) evaluated diet quality of several groups of Americans using the HEI-2005, which examined components of the overall diet compared to compliance with 2005 Dietary Guidelines for Americans. Using 1999-2004 NHANES data, the FNS reported that 41 percent of total energy consumed came from SoFAS and alcohol (SoFAAS) in the typical diet of all Americans (FNS, Report No. FSP-08-NH, 2008), 39 percent among all school-aged children (SoFAS only, assuming no alcohol intake) (FNS, Report No. CN-08-NH, 2008), and 37 percent among all preschool-aged children (SoFAS only, assuming no alcohol intake) (FNS, Report No. WIC-08-NH, 2008). In contrast, calories from SoFAS should theoretically comprise only up to 20 percent of total energy intake in boys, aged 14 to 18 years who exercise at recommended levels (the age-sex group that also has a high energy need for growth and development). Even in the average school-aged child, SoFAS should contribute only up to 13 percent of calories or with added physical activity up to 17 percent of calories.

In summary, SoFAS contribute to excessive intakes of non-nutrient-dense foods and extra calories in a substantial proportion of boys and girls, aged 2 to 18 years, as well as in women and men older than age 19 years. Food sources of SoFAS include sodas, sugar-sweetened fruit drinks, sugars, syrups, sweets, puddings, grain-based dessert products, pasta, rice-based dishes, pizza, tacos, ice cream, whole milk, and whole cream (Bachman, 2008).

Sodium

Based on evidence of the relationship of sodium intake to health outcomes, which places the majority of Americans at risk of developing hypertension, intake of less than the UL of 2300 mg per day for sodium by all individuals is recommended with an eventual goal of less than the AI for sodium of 1500 mg per day (see ***Part D. Section 6: Sodium, Potassium, and Water*** for a detailed discussion of sodium intakes and implication of excessive sodium intake). Usual intakes of sodium exceed the AI for more than 97 percent of all age-sex groups. Usual intakes also exceed the UL for more than 90 percent of boys older than 9 years and adult men up to age 70 years, as well as for 50 percent to 75 percent of girls older than 9 years and women of all ages (Figure D2.4) (ARS, 2010a).

Saturated Fats

Based on evidence of the relationship of saturated fat intake to health outcomes and the absence of any biologic requirement for saturated fat, an immediate reduction to less than 10 percent of energy from saturated fats is recommended, as a step toward an eventual goal of less than 7 percent of energy from saturated fats. (see ***Part D. Section 3: Fatty Acids and Cholesterol*** for an extensive discussion of this relationship). Current usual intakes of saturated fats are in excess of this recommendation for more than half of the total American population. More than 75 percent of children, aged 1 to 13 years, and 50 percent of older children and adults consume more than 10 percent of calories as saturated fats (Figure D2.5) (NCI, 2010). Median usual intakes of saturated fats (ARS, 2008) in the typical American diet are:

- 12.6 percent and 11.4 percent of calories for children, aged 1 to 3 years and 4 to 8 years, respectively;
- 11.1 percent to 11.7 percent of calories for children, aged 9 to 18 years; and
- 10.6 percent to 11.1 percent of calories for women and men older than 19 years, respectively.

Cholesterol

Based on evidence of the relationship of cholesterol intake to health outcomes, intake of less than 300 mg of cholesterol per day by all individuals is recommended (see ***Part D. Section 3: Fatty Acids and Cholesterol*** for additional information on the health implications of overconsuming dietary cholesterol). Current usual intakes of cholesterol exceed this amount for more than 50 percent of boys, aged 14 to 18 years, and adult men, aged 19 to 70 years, while only 25 percent of men older than 70 years and 5 percent to 10 percent of children, aged 2 to 13 years, girls, aged 14 to 18 years, and adult women consume more than the recommended limit for cholesterol (Figure D2.6) (ARS, 2010b). Median usual intakes of cholesterol (ARS, 2010b) in the typical American diet are:

- 164 mg and 190 mg per day for children, aged 1 to 3 years and 4 to 8 years, respectively;
- 200 mg to 230 mg for children, aged 9 to 13 years;
- 190 mg to 226 mg for girls and women older than 14 years;
- 206 mg to 363 mg for boys and men, aged 14 to 70 years; and
- 269 mg for men older than 70 years.

Refined Grains

Although intakes of whole grains are far below recommended levels for all age-sex groups (see Question 2 on Food Groups and Selected Dietary Components Underconsumed), intakes of refined grains are higher than recommended. Refined grains are "a grain product that is missing the bran, germ, and/or endosperm (a grain product that is not a whole grain)." Many refined grains are enriched with thiamin, riboflavin, niacin, and iron, and fortified with folic acid (USDHHS and USDA, 2005b) but also are high in SoFAS and calories.

Usual intakes of refined grains exceed recommendations for 90 to 95 percent of all age-sex groups, (Figure D2.7) (NCI, 2009). Recommended intakes of refined grains are defined as up to one-half or less of the total grain intake recommendation, which translates to 3 ounce equivalents in the reference 2000 calorie food pattern, and no more than 5 ounce equivalents in the highest calorie patterns. Median usual intakes of refined grains (NCI, 2009) in the typical American diet are:

- 3.8 ounce equivalents for children, aged 1 to 3 years;
- 6.0 ounce equivalents for children, aged 4 to 8 years;
- 7.5 ounce equivalents for boys, aged 9 to 13 years;
- 6.3 ounce equivalents for girls, aged 9 to 13 years;
- 8.3 ounce equivalents for boys, aged 14 to 18 years;
- 5.9 ounce equivalents for girls, aged 14 to 18 years;
- 7.0 ounce equivalents for men older than 19 years; and
- 5.2 ounce equivalents for women older than 19 years.

Usual intakes of refined grains alone are very close to or are above total grain recommendations for all age-sex groups, reflecting the extremely low intakes of whole grains. Overconsumption of refined grains is a major source of extra calories in the diet. When refined grains are consumed, these grains should be enriched and fortified.

Lowering intakes of total energy, calories from SoFAS, sodium, saturated fats, total cholesterol (in adolescent boys and men), and refined grains is important for meeting essential nutrient requirements and promoting health. Nutrient-dense forms of foods should be consumed within a total diet that has relatively low energy-density.

FOOD GROUPS AND SELECTED DIETARY COMPONENTS UNDERCONSUMED

Nutrient recommendations should be met by consuming nutrient-dense forms of foods and from the basic food groups. Paralleling the overconsumption of some dietary components that are not essential for health, many Americans are not consuming enough of certain foods and dietary components that are essential for health. Estimated usual intakes of food groups and dietary components by Americans are evaluated against recommendations for intakes.

Question 2: What Food Groups and Selected Dietary Components are Underconsumed by the General Public?

Conclusion

Currently reported dietary intakes of the following food groups and selected dietary components are low enough to be of concern:

- For both adults and children: vegetables, fruits, whole grains, fluid milk and milk products, and oils.

Implications

Despite the evidence that health-promoting dietary patterns are those that include a variety of foods and combinations of foods from each of the basic food groups, many Americans make food choices that do not meet the characteristics of healthy dietary patterns (Bachman, 2008). A fundamental premise of the DGAC is that nutrients should come from foods. Often, nutrient intake shortfalls are an indicator of low intakes of certain food groups that provide specific nutrients. Hence, efforts are warranted to promote increased intakes of vegetables (especially dark-green vegetables, red-orange vegetables, and cooked dry beans and peas), fruits, whole grains, and fat-free or low-fat fluid milk and milk products (including calcium and vitamin D fortified soymilk) among all ages; substitution of oils for solid fats, regardless of age; and increased intakes of lean, heme-iron-rich meat, poultry, and fish by adult women and adolescent girls. Intake of nutrient-dense foods—that is, foods in their leanest or lowest fat forms and without added fats, sugars, starches, or sodium—should replace foods in the current American diet that contribute to high intakes of SoFAS and refined grains (see Question 1 on Nutrients and Dietary Components Overconsumed). Oils should only be substituted for solid fats rather than added to the diet. Substitutions and selection of nutrient-dense forms of vegetables, fruits, whole grains, and fluid milk and milk products to replace non-nutrient-dense forms of foods should be done in a manner such that total caloric intake falls within or below daily energy needs.

Review of the Evidence

To reach this conclusion, the DGAC examined data published by the NCI (NCI, 2009). The NCI reported findings from 2001-2004 NHANES data of usual (i.e., long-term daily average) food intakes. In addition, the Committee considered the FNS reports on diet quality as well as findings from the IOM report on the state of school meals.

Methods to Identify Components Underconsumed

If a population group has a high prevalence of intakes of a basic food group that are below recommended levels, that food group is called a shortfall food group. Such food groups are consumed in amounts lower than the minimum levels recommended in the USDA Food Patterns to meet IOM nutrient intake recommendations for each age-sex group. (Some food group recommendations in the USDA Food Patterns are higher for those within an age-sex group who have higher energy needs.) When basic food groups are consumed in low amounts, such intakes are of concern because their contributions to overall nutrient intakes and other beneficial dietary components would be inadequate to confer potential health benefits.

Findings Regarding Components Underconsumed

Vegetables

Most Americans of all ages have usual intakes of vegetables that fall below minimum recommended intakes (Figure D2.8). For 75 percent to 95 percent of almost all age-sex groups, usual intakes of all vegetable subgroups, including dark-green vegetables, red-orange vegetables, cooked dry beans and peas, starchy vegetables, and other vegetables fall below amounts recommended. For example, more than 95 percent of all age-sex groups, except for men and women older than age 50 years, consume less than the recommended amounts of dark-green vegetables. Men and women older than age 50 years do only slightly better, with 75 percent to 90 percent not meeting the recommended intake. Similarly, 95 percent of all females, adolescent boys and older men consume less cooked dry beans than are recommended, while 75 percent to 90 percent of men aged 19 to 50 years fail to meet intake recommendations. Recommended intake of total vegetables for individuals with the lowest energy needs in their age-sex group is 2.5 to 3 cup equivalents per day (in adult men and adolescent boys, aged 14 to 18 years), and 2 to 2.5 cup equivalents per day (in adult women, adolescent girls, aged 9 to 18 years, and boys, aged 9 to 13 years).

Median intakes, which fall below these minimum recommendations, are:

- 1.8 cup equivalents per day for adult men;

- 1.5 cup equivalents for adult women;
- 1.4 cup equivalents for adolescent boys, aged 14 to 18 years;
- 1.1 cup equivalents for girls, aged 9 to 13 and 14 to 18 years; and
- 1.2 cup equivalents per day for boys, aged 9 to 13 years.

Children, aged 1 to 8 years, also have low intakes of total vegetables, with 75 percent consuming less than recommended levels and median intakes less than 1 cup equivalent per day.

Fruits

Most children and adolescents aged 4 to 18 years, and most adult men and women have usual intakes of total fruits—including whole, sliced, diced, and processed fruits and 100 percent fruit juices—that fall below minimum recommended levels (Figure D2.9). More than 75 percent of adult men and women as well as boys and girls, aged 9 to 18 years, consume less than their minimum recommended level of fruit per day. The recommended intake for individuals with the lowest energy needs by age-sex group is 2 cup equivalents per day (in adult men and adolescent boys, aged 14 to 18 years), and 1.5 cup equivalents per day (in women, adolescent girls, aged 9 to 18 years, and boys, aged 9 to 13 years).

Median intakes fall far below these minimum recommendations. They are:

- 0.9 cup equivalents per day for adult men;
- 0.8 cup equivalents for adult women;
- 0.8 cup equivalents for adolescent boys, aged 14 to 18 years;
- 0.6 cup equivalents for adolescent girls, aged 14 to 18 years;
- 0.8 cup equivalents for boys, aged 9 to 13 years; and
- 0.8 cup equivalents for girls, aged 9 to 13 years.

Children, aged 1 to 3 and 4 to 8 years, are more likely to consume recommended amounts of fruits, with about 25 percent and 50 percent, respectively, not consuming the minimum of approximately 1 cup equivalent per day. However, children, aged 2 to 18 years, consume more than half of their fruit intake as juice. While 100 percent fruit juice can be part of a healthful diet in childhood, consumption of excessive amounts has been associated with adverse health effects (AAP, 2001). Health-related organizations recommend limits on juice intake to 4 or 4 to 6 ounces per day for young children (AAP, 2001; AHA, 2010).

Collectively, vegetables and fruits are major contributors of vitamins A, C, and K, and magnesium, potassium, and dietary fiber—all shortfall nutrients (see Question 3 on Nutrients of Concern). Vegetables and fruits also contain dietary folate, a nutrient of special concern for women of reproductive capacity or those who do not eat fortified refined grains. In addition, many vegetables contain calcium, another nutrient of concern; although the bioavailability of calcium in these foods is limited (see Question 3 on Nutrients of Concern). Fruits contribute to vitamin C intake which may help to enhance iron absorption, a nutrient of particular concern for women of reproductive capacity.

Whole Grains

Americans of all ages consume fewer whole grains than recommended (Figure D2.10). Whole grains are those "foods made from the entire grain seed, usually called the kernel, which consists of the bran, germ, and endosperm. If the kernel has been cracked, crushed, or flaked, it must retain nearly the same relative proportions of bran, germ, and endosperm as the original grain in order to be called whole grain" (USDHHS and USDA, 2005b).

More than 95 percent of all age-sex groups fail to consume the minimum recommended amounts of whole grains. Median intakes for adult men and women are 0.50 and 0.47 ounce equivalents per day, respectively, compared to the recommended minimum of 3 ounce equivalents per day (one-half of total grains).

Median intakes are:

- 0.26 and 0.33 ounce equivalents per day, respectively, for adolescent boys and girls, aged 14 to 18 years, compared to the recommended level of 3.5 and 3 ounce equivalents per day, respectively; and
- 0.48 and 0.34 ounce equivalents per day for boys and girls, aged 9 to 13 years, respectively, compared to recommended levels of 3 and 2.5 ounce equivalents per day, respectively.

Children, aged 1 to 3 years and 4 to 8 years, also have low intakes of whole grains, with median intakes of 0.37 and 0.41 ounce equivalents per day, respectively, less than the recommended 1.5 or 2 ounce equivalents per day, respectively. Inadequate intakes of whole grains contribute to the lack of adequate intakes of magnesium and fiber across all age groups (see Question 3 on Nutrients of Concern). Most Americans consume more than the recommended amount of total grains per day (6 ounce equivalents for 2000 calories) but deliberate efforts are required to replace refined grains with whole grains, especially fiber-rich whole grains, such that at least one-half of all grains consumed are whole grains. Individuals with perceived allergies to grains should be evaluated before unnecessarily avoiding whole grains.

Fluid Milk and Milk Products

Intakes of fluid milk and milk products, including fortified soymilk, are less than the recommended 3 cup equivalents per day for most adult men and women and children and adolescents, aged 9 to 18 years, and less than the recommended 2 cup equivalents per day for many children, aged 4 to 8 years (Figure D2.11). In general, intakes are lower for females than males and decline with age. More than 50 percent of boys, aged 9 to 18 years, consume less than the recommended amount of fluid milk and milk products, while more than 75 percent to 90 percent of adult men consume less that the recommended amount. For all but 9- to 13-year-old girls, more than 90 percent to 95 percent of all women and girls consume less than the recommended amount of fluid milk and milk products.

Median intakes are:

- 1.6 cup equivalents per day for adult men;
- 1.2 cup equivalents for adult women;
- 2.3 cup equivalents for adolescent boys, aged 14 to 18 years;
- 1.5 cup equivalents for adolescent girls, aged 14 to 18 years;
- 2.4 cup equivalents for boys, aged 9 to 13 years; and
- 1.9 cup equivalents for girls, aged 9 to 13 years.

For boys and girls, aged 1 to 3 and 4 to 8 years, median intakes are 2.35 and 2.18 cup equivalents, respectively, in comparison to the recommendation of 2 cup equivalents per day. However, at least 25 percent of children, aged 1 to 8 years, do not consume this recommended amount of fluid milk and milk products. Fluid milk and milk products contribute vitamin D, calcium, and potassium—targeted nutrients of concern—to the diet (see Question 3 on Nutrients of Concern). The majority of current fluid milk intake comes from 2 percent milk or whole milk, with smaller amounts of low-fat (i.e., 1 percent milk fat) or fat-free milk consumed. Choosing these fat-free, nutrient-dense forms of fluid milk and milk products provides essentially the same micronutrients with less solid fat (a source of saturated fat) and fewer calories.

Meat, Poultry, Fish, Eggs, Soy Products, Nuts, and Seeds

Usual intakes of meat, poultry, fish, eggs, soy products, nuts, and seeds are below recommended amounts for most adolescent girls and many adult women (Figure D2.12). For men, boys, aged 9 to 18 years, and children, aged 1 to 8 years, low intakes of foods from this food group are less prevalent. About 75 percent of girls, aged 9 to 18 years, and about 50 percent of adult women consume less than the amounts recommended for those with lower energy needs.

Median intakes are:

- 4.5 ounce equivalents per day for adult women, in comparison to a recommendation of 5 to 5.5 ounce equivalents per day; and
- 3.7 and 3.6 ounce equivalents per day for adolescent girls, aged 14 to 18 years, and girls, aged 9 to 13 years, respectively, in comparison to a recommendation of 5 ounce equivalents per day.

Foods from this group contribute to heme-iron intake—a nutrient of concern for the special population of women of reproductive capacity (see Question 5 within Nutrient Issues for Selected Population Subgroups).

Oils

Oils are fats that are liquid at room temperature. Oils come from many different plants and from fish. Some common oils include canola, corn, olive, peanut, safflower, soybean, and sunflower oils. A number of foods are naturally high in oils, such as nuts, olives, some fish, and avocados. Foods that are mainly oil include mayonnaise, certain salad dressings, and soft (tub or squeeze) margarine with no *trans* fats. Most oils are high in monounsaturated or polyunsaturated fats, and low in saturated fats. A few plant oils, including coconut oil and palm kernel oil, are high in saturated fats and for nutritional purposes should be considered solid fats. Hydrogenated oils that contain *trans* fats should also be considered solid fats for nutritional purposes.

Americans of all ages do not achieve recommended intakes of oils (Figure D2.13). While solid fats and saturated fatty acids are consumed in excess (see Question 1 on Nutrients and Dietary Components Overconsumed), oils fall short of dietary targets. These oils provide essential fatty acids and vitamin E, a shortfall nutrient (see Question 3 on Nutrients of Concern). Intakes of oils would be sufficient, if these oils were to be substituted for a portion of the excessive current intake of solid fats, which contributes to the intake of saturated and *trans* fats (see ***Part D. Section 3: Fatty Acids and Cholesterol*** for discussions of health-related issues regarding dietary fats).

Other Evidence Considered for Components Underconsumed

The IOM Committee on Nutrition Standards for National School Lunch and Breakfast Programs examined estimates from 1999-2002 NHANES data and also found that school-aged children consumed inadequate amounts of vegetables, specifically dark-green and orange vegetables, and legumes, fruits, whole grains, fluid milk and milk products, meats and beans, and oils (FNB, 2009). Efforts should be made to ensure that school meals promote intake of these underconsumed food groups and selected dietary components.

Using 1999-2004 NHANES data, the FNS reported that many areas of concern for food group intakes, based on HEI-2005 analysis, existed for adults, aged 19 years and older, and for school-age children, aged 5 to 8 years and 9 to 18 years (FNS, Report No. FSP-08-NH, 2008; FNS, Report No. CN-08-NH, 2008). For adults, shortfalls in intakes of vegetables, notably dark-green and orange vegetables, and cooked dry beans, fruits, particularly whole fruits (among adults, aged 19 to 59 years only), whole grains, fluid milk and milk products, and oils were reported, regardless of participation status in the Supplemental Nutrition Assistance Programs, formerly known as the Food Stamp Program.

For children, shortfalls in intakes of vegetables, notably dark-green and orange vegetables, and legumes, fruits, particularly whole fruits, whole grains, fluid milk and milk products, meat and beans, and oils were identified, regardless of participation status in the School Lunch Program. Preschool children, aged 2 to 4 years, had shortfalls in intakes of vegetables, notably dark-green and orange vegetables, and legumes, whole fruits (but not total fruits due to consumption of 100% fruit juice), whole grains, meat and beans, and oils, regardless of participation in the Special Supplemental Nutrition Program for Women, Infants and Children (FNS, Report No. WIC-08-NH, 2008).

Relevant Contextual Issues

Barriers to Achieving Dietary Guidelines for Americans

As evidenced by analyses of NHANES data, a substantial portion of the population fails to meet intakes of food groups recommended in the 2005 *Dietary Guidelines for Americans*. Among selected subgroups of Americans, primarily those with low incomes, five key barriers to adopting dietary guidance have been identified—accessibility, expense, knowledge/ understanding, cultural issues and other factors (physical limitations, psychosocial issues, and stage of change) (Marriott, 2008). At present, the food environment—from individual or personal factors to social networks to the physical settings of communities to macro-level sectors of human ecosystems—does not fully support the ability of Americans to achieve dietary targets for food group intakes and may be compromising the health of Americans (see ***Part D. Section 1: Energy Balance and Weight Management*** and ***Part B. Section 3: Translating and Integrating the Evidence: A Call to Action***).

Using the HEI-2005 as a benchmark, current data demonstrate that dietary quality is inadequate. This is true at the individual level (HEI-2005 score = 57.5 out of 100), community level (represented by the dollar menu at a typical fast-food restaurant [HEI-2005 score = 43.4]), and macro-level (represented by the US food supply in 2005 [HEI-2005 score = 54.9]) (Reedy, 2010). Americans' choices and consumption patterns of the basic food groups and dietary components as shown in their total diets are limited by the degree to which the food environment offers higher nutrient-dense forms of foods. Specifically, while the quality of the food supply in the US has improved somewhat from 1970 (HEI-2005 score = 47.5) to 2007 (HEI-2005 score = 57.5) (Krebs-Smith, 2010), the macro-level food environment fails to achieve an acceptable level of dietary quality, notably because vegetables, fruits, whole grains, fat-free and low-fat fluid milk and milk products, and fish are in short supply.

Food Production

To meet intake targets by Americans for the basic food groups, an additional 7.4 million acres of cropland per year must be harvested (ERS, ERR-31, 2006). Specifically, 8.9 and 4.1 million more acres of cropland would be needed to support vegetable and fruit production, respectively. At the same time, sufficient cropland is currently devoted to wheat production and could, in fact, be reduced by 5.6 million acres. Emphasis could be placed on increased production of vegetables and fruit and a shift in manufacturing toward more whole grains (specifically high-fiber, whole wheat products) and fewer refined grain products. Farm milk production must increase by 107.7 billion pounds for Americans to have full availability to fluid milk and milk products to meet recommendations for this food group, according to estimates from the Economic Research Service (ERS, ERR-31, 2006).

NUTRIENTS OF CONCERN

In this segment, shortfall nutrients and nutrients of concern are addressed. Public health implications are identified.

Question 3: What Nutrients are Underconsumed by the General Public and Present a Substantial Public Health Concern?

Conclusion

Reported dietary intakes and associated indices of nutrient status for the following nutrients are of public health concern:

- For both adults and children: vitamin D, calcium, potassium, and dietary fiber.

Implications

Efforts are warranted to promote increased dietary intakes of foods higher in vitamin D, calcium, potassium, and dietary fiber for all Americans regardless of age. Recommended intakes of these nutrients of concern, in particular, and of all essential nutrients, in general, should be achieved within the context of flexible dietary intake patterns that balance energy intake with energy expenditure.

Review of the Evidence

To reach this conclusion, the DGAC examined dietary intake data from reports that used methods recommended by the IOM for assessing the prevalence of inadequate nutrient intakes in a population (FNB, 2001), supplemented by data from the ARS and FNS. In addition, the Committee considered data on biochemical indices of nutrient status from the Centers for Disease Control and Prevention (CDC) and current peer-reviewed published research, as well as disease prevalence data.

Methods to Identify Shortfall Nutrients

A high prevalence of inadequate dietary intake of a nutrient among any segment of the population constitutes a *shortfall* nutrient. Although RDAs are intended to be used in planning diets, they are not to be used for identifying the proportion of a group whose usual intake of a nutrient is less than the requirement for that nutrient (FNB, 2003). When available, the EAR is the appropriate value to be used for assessing adequacy of intake—that is, for determining the proportion of individuals whose *usual* intake is less than the EAR (FNB, 2006).

The usual intake is the long-run average intake. If intake data are available for at least two days, statistical methods can be used to estimate usual intake (Guenther, 1997; Nusser, 1996). Because the requirement distribution for iron is skewed, the probability approach (FNB, 2006) is the recommended method for determining the adequacy of iron intake. For nutrients for which there are AIs rather than EARs, usual intake distributions are examined, if available, and mean intakes are compared with the corresponding AI (FNB, 2001). If mean intake is above the AI, a low prevalence of inadequate intake for that nutrient is likely.

Analyses that use the nutrient assessment methods recommended by the IOM (FNB, 2003) were available from several published sources to examine nutrient intakes in comparison to nutrient recommendations. Data on the distribution of usual nutrient intakes from food sources for the US population ages 1 year and older, 2001-2002, were available for vitamins A, C, E, K, $B_{6,}$ and B_{12}, thiamin, riboflavin, niacin, folate, phosphorus, magnesium, iron, zinc, copper, selenium, carbohydrate, protein, calcium, potassium, sodium, dietary fiber, linoleic acid, and linolenic acid (Moshfegh, 2005) and from 2005-2006 for vitamin D, calcium, phosphorus, and magnesium

(Moshfegh, 2009). In addition, data on usual intakes from both food sources and supplements were available for vitamin D and calcium (Bailey, 2010a). Data for specific population subgroups also were available for vitamins A, C, and E, thiamin, riboflavin, niacin, folate, vitamins B_6 and B_{12}, phosphorus, magnesium, iron, zinc, calcium, potassium, sodium, and dietary fiber (FNS, Report No. FSP-08-NH, 2008; FNS, Report No. CN-08-NH, 2008; FNS, Report No. WIC-08-NH, 2008). The DGAC also examined mean one-day intakes from 2005-2006 NHANES data for 25 nutrients, including energy, total fat, carbohydrate, protein, vitamins A, C, E, and K, thiamin, riboflavin, niacin, folate, vitamins B_6 and B_{12}, choline, phosphorus, magnesium, iron, zinc, copper, selenium, calcium, potassium, sodium, and dietary fiber (ARS, 2008). Overlap among nutrients across these reports existed. The DGAC considered all of these reports because findings were presented as means, medians, and percentiles, depending on the availability and analyses of dietary intake data.

Overall Findings Regarding Shortfall Nutrients

As shown in Figures D2.14 and D2.15, the probability of adequate dietary intake of 10 nutrients is tenuous for adult men and women. These nutrients include vitamins A, C, D, E, and K, and choline, calcium, magnesium, potassium, and dietary fiber. Results of an analysis of food intake from 1999-2004 NHANES data for school-aged children (FNS, Report No. CN-08-NH, 2008) showed that shortfall nutrients for children (most notably adolescents) include vitamins A, C, D, and E, and phosphorus and magnesium. Calcium is a shortfall nutrient for boys and girls, aged 9 to 18 years, and more recent intake data suggest that calcium is a shortfall nutrient for boys and girls, aged 4 to 8 years (Bailey, 2010a). Intakes of potassium and dietary fiber are inadequate among nearly all school-aged children.

Biochemical Indices and Disease Prevalence Data

Biochemical indices, when available, were considered for shortfall nutrients.

Vitamins A, C, K, and E: NHANES data from 1999-2002 (USDHHS, 2008) show that less than 5 percent of the population in the US has an inadequate serum retinol concentration, defined as less than or equal to 20 μg/dL. Based on 2003-2004 NHANES data, age-adjusted serum vitamin C deficiency, defined as less than 11.4 μmol/L, is found in 7.1 percent of the population in the US (Schleicher, 2009). Current data are not available for vitamin K status in a large representative sample of individuals in the US. In addition, less than 5 percent of the population in the US has an inadequate serum alpha-tocopherol concentration, defined as less than or equal to 500 μg/dL (USDHHS, 2008). Thus, it is unlikely that vitamins A, C, K, and E, respectively, are of major public health significance for the vast majority of healthy individuals in the US.

Intakes of vitamins A, C, and K tend to reflect low intakes of vegetables and fruits (see Question 2 on Food Groups and Selected Dietary Components Underconsumed), and food pattern modeling shows that these nutrient requirements can easily be met by increasing dietary intakes of these foods. Tables D2.2, D2.3, and D2.4 list the best food sources of vitamins A, C, and K per standard amount, respectively, from the ARS nutrient database, along with the number of calories for each standard amount. Most Americans do not typically consume foods that are especially rich in vitamin E on a daily basis. Table D2.5 lists the best food sources of vitamin E per standard amount from the ARS nutrient database, along with the number of calories for each standard amount. Although salad dressings, mayonnaise, and oils provide the greatest amount of vitamin E in American diets overall, the oil most commonly used in these products—soybean oil—is not an especially rich source of vitamin E. Oils containing higher amounts of vitamin E—sunflower, cottonseed, and safflower oils—are less commonly consumed. The same is true for nuts—almonds and hazelnuts are relatively rich in vitamin E, but peanuts and peanut butter, with lower levels of vitamin E, represent the majority of all nut consumption in the US. Food composites used in modeling food patterns are relatively low in vitamin E content, reflecting Americans' limited use of foods rich in vitamin E. As the energy level of the food pattern increases, the pattern comes closer to providing the recommended intake of vitamin E. To come closer to achieving the recommended intake, vitamin E-rich oils can be substituted for some other oils in the diet, and vitamin E-rich nuts can replace some other nuts. Americans should not increase total energy intake to achieve a higher intake of vitamin E, in light of adequate serum alpha-tocopherol concentrations.

Choline: Choline is required for cell structure and function, neurotransmission, lipid transport from the liver, and as a dietary methyl group source (Zeisel, 2006). Deficiency states that can arise from inadequate choline intake include fatty liver and muscle dysfunction in postmenopausal women and men across all ages, as well as elevated plasma homocysteine level after methionine loading. Risk of NTDs in infants of choline-deficient mothers have been reported in some epidemiologic studies, but very little evidence of overt choline deficiency symptoms exists in the American population (Sanders, 2007). Americans could meet recommendations for choline by consuming modest amounts of eggs and by replacing other meat, poultry, and starchy vegetables with cooked dry beans and peas, within fixed energy intakes. Table D2.6 lists the best food sources of choline per standard amount, from the ARS nutrient database, along with the number of calories for each standard amount.

Magnesium and phosphorus: Intakes of magnesium tend to reflect low intakes of vegetables, nuts, seeds, and cooked dry beans and peas. Phosphorus intake among adolescent girls reflects a low intake of fluid milk and milk products (see Question 2 on Food Groups and Selected Dietary Components Underconsumed). Magnesium and phosphorus requirements may be met by increasing dietary intakes of vegetables, nuts, seeds, cooked dry beans and peas, and fluid milk and milk products. Tables D2.7 and D2.8 list the best food sources of magnesium and phosphorus per standard amount, respectively, from the ARS nutrient database, along with the number of calories for each standard amount.

Vitamin D: A substantial number of Americans have lower serum 25-hydroxyvitamin D [25(OH)D] concentrations during the wintertime (USDHHS, 2008; Looker, 2002). Combined with evidence of widespread inadequacy of vitamin D intake, this nutrient presents a public health concern (discussed below).

Calcium: NHANES data from 2005-2006 indicate that 10 percent of women and 2 percent of men older than 50 years have osteoporosis of the femoral neck; moreover, 49 percent of women and 30 percent of men older than 50 years have osteopenia at this same skeletal site (Looker, 2010). Nearly 40 million men and women in the US have low bone mass (Looker, 2010), with bone mineral density or content change serving as a criterion for adequacy of calcium status (FNB, 1997). Calcium is discussed below as a nutrient of public health significance.

Potassium: Increased potassium consumption modifies systolic and diastolic blood pressure (see ***Part D. Section 6: Sodium, Potassium, and Water***). Approximately 57 percent of adults living in the US have prehypertension or hypertension (Ostchega, 2008) and many more have inadequate dietary intake of potassium. Thus, potassium is a nutrient of public health significance.

Dietary fiber: Adequacy of dietary fiber intake cannot be determined by biochemical or clinical indices (FNB, 2006). Rather, dietary fiber is considered in light of risk reduction of coronary heart disease (CHD) (FNB, 2006), which is the leading cause of death in the US. The widespread inadequate intake of dietary fiber among adults and children coupled with the prevalence of CHD and fiber's possible role in contributing to satiety (important for weight control) constitute a major public health concern for this nutrient (see ***Part D. Section 5: Carbohydrates***).

Specific Underconsumed Nutrients of Public Health Concern

The DGAC gives special attention to four underconsumed nutrients of public health concern: vitamin D, calcium, potassium, and dietary fiber. These four shortfall nutrients are clearly linked to indicators of nutrient inadequacy or disease prevalence and require special consideration in developing dietary guidance to meet recommended food intakes, as explained later in this section.

Table D2.9 identifies the functions of the nutrients of concern—vitamin D, calcium, potassium, and dietary fiber. Americans should increase intakes of these nutrients to achieve recommended levels, within limited energy intakes, for health promotion.

Vitamin D

Strong evidence indicates that many children and a majority of adults do not meet the AI for vitamin D. Furthermore, a significant portion of the population has deficient or inadequate blood levels of vitamin D to promote health and prevent chronic diseases, such as poor bone health and possibly certain types of cancers, cardiovascular disease, and immune-related disorders. This is especially apparent in people living in northern latitudes, in persons with dark skin, and in overweight and obese adults.

All children, adults, and the elderly are encouraged to meet the AI for vitamin D by consuming vitamin D-rich foods in both naturally occurring and fortified forms. Children, adults, and the elderly with deficient or inadequate blood levels of vitamin D should consume more vitamin D-rich foods. If necessary, individuals may consider vitamin D supplementation if they are having difficulty meeting the AI through vitamin D-rich foods.

The DGAC chose not to conduct an independent systematic review of vitamin D due to the fact that the IOM concurrently empanelled an expert committee to review the DRI for vitamin D. The previous DRI for vitamin D was established in 1997. The IOM empanelled the committee because significant new and relevant research had become available to review the existing DRI for vitamin D (Yetley, 2009). Recommendations from the IOM committee are expected to be available in Fall 2010.

For this review of vitamin D and health, the DGAC primarily relied upon three different sources of information: 1) vitamin D intake data from the NHANES (Bailey, 2010a); 2) an *American Journal of Clinical Nutrition* (AJCN) supplement (Brannon et al, 2008a) that presented findings from two sources, including proceedings from the National Institutes of Health (NIH) conference "Vitamin D and Health in the 21st Century: An Update" held in September 2007 and an NIH roundtable discussion with expert scientists held after the conference (Brannon et al, 2008b); and 3) an Agency for Healthcare Research and Quality (AHRQ) evidence report, *Vitamin D and Calcium: A Systematic Review of Health Outcomes* (Chung, 2009) prepared for use by the 2009-2010 IOM committee. The results of the DGAC's review are presented below.

Vitamin D and health: Adequate vitamin D status, which depends upon dietary intake and cutaneous synthesis, is important for health (Brannon et al, 2008a). Well-established research demonstrates the importance of vitamin D for bone health. Vitamin D deficiency results in rickets in children and osteomalacia in adults (Brannon et al, 2008a). In adults and older adults, adequate vitamin D reduces risk of fractures (Looker, 2010). Recent evidence suggests that vitamin D is important for other body systems (Brannon et al, 2008a; *Nutrition Reviews*, 2007). Emerging research has shown a reduced risk for type 1 diabetes, some cancers, autoimmune diseases, and infectious diseases (Brannon, 2008b; Chung, 2009). Further well-designed, dose-response research is needed to fully establish the relationship between vitamin D and many of these outcomes (Chung, 2009).

Vitamin D intake: Results from 2003-2006 NHANES data indicate that the majority of the population does not meet the AI for vitamin D (Bailey, 2010a). With diet alone, less than 10 percent of men and women older than 50 years meet the AI, and less than 2 percent of adults older than 70 years meet the AI (10 μg/day for 51 to 70 years of age; 15 μg /day for 71 years of age and older) (Figure D2.16). Approximately 47 percent and 53 percent, respectively, of adolescent girls and boys older than 9 years meet the AI. About 53 percent and 67 percent of girls and boys, respectively, aged 4 to 8 years, meet the AI (5 μg /day). The only population subgroup that comes close to meeting the AI with diet alone, due to fluid milk consumption, is children, with 70 percent and 72 percent of girls and boys, respectively, aged 1 to 3 years, meeting the AI of 5 μg per day.

When supplements are added to dietary intake, the percentage of children and adults who meet the AI improves. Thirty-seven percent of the population consumes supplements that contain vitamin D. However, even with combined dietary intakes and supplementation, a majority of adults still do not meet the AI:

- less than 50 percent of men and women, aged 19 to 30 years;
- less than 60 percent of men and women, aged 31 to 50 years;
- less than 45 percent of adults older than 50 years; and
- less than 25 percent of adults older than 70 years.

Less than 1 percent of the population exceeds the UL for vitamin D intake (Bailey, 2010a). These vitamin D intakes are compared against the 1997 AI for vitamin D. Should the IOM determine new AIs for vitamin D, comparisons of intakes to AI standards should be adjusted accordingly.

Vitamin D status: The criterion used by the IOM for setting the AI in 1997 was the normal level of serum 25(OH)D concentration, an indicator of vitamin D status. The 1997 25(OH)D criterion of greater than or equal to 27.5 nmol/L for children up to age 18 years and greater than or equal to 30 nmol/L for adults aged 19 years and older set by the IOM was based upon associations with bone growth in children and normal parathyroid concentrations in adults. This criterion has been brought into question based on new information on the relationship of serum 25(OH)D to health, the relationship of vitamin D intake to serum 25(OH)D concentration, vitamin D status of the US population, and safety of vitamin D status, as summarized in the September 2008 supplement of the *American Journal of Clinical Nutrition* and elsewhere (Dawson-Hughes, 2005; Norman, 2007). The DGAC expects that the IOM empanelled committee will carefully evaluate the criteria for determining deficient, marginal or insufficient, and adequate serum vitamin D concentrations. Until a determination is made by the IOM panel, the DGAC must independently consider published evidence of potential thresholds for adequacy regarding health outcomes and implications related to food guidance.

Contributing scientists to the 2007 NIH roundtable discussion used the following cutoff points to evaluate vitamin D adequacy: less than 27.5 nmol/L, less than 50 nmol/L, and less than 75 nmol/L when analyzing blood samples from the 2002-2004 NHANES (Yetley, 2008). Approximately 30 percent of people aged 12 years and older had serum 25(OH)D levels lower than 50 nmol/L. For children, aged 1 to 11 years, approximately 15 percent had serum 25(OH)D levels lower than 50 nmol/L. Slightly more women than men had serum 25(OH)D concentrations lower than 50 nmol/L. Yetley (2008) further reported an inverse association of body fatness and BMI on serum 25(OH)D concentrations. Leaner women, regardless of the method used to assess body fatness, had higher concentrations of serum 25(OH)D. A more recent evaluation in children, aged 1 to 11 years, using 2001-2006 NHANES findings reported that 18 percent of children in this age range had serum 25(OH)D concentrations below 50 nmol/L (Mansbach, 2009). An even higher percentage of non-Hispanic black and Hispanic children had serum 25(OH)D concentrations below 50 nmol/L.

These data should be interpreted with caution because of lingering questions related to measurement drift from assay method changes and completeness of data (Looker, 2008; Yetley, 2008). However, using the NHANES values, after adjusting for an apparent measurement drift, serum 25(OH)D concentrations for the US population were lower in the years 2000 to 2004 than in 1988 to 1994 (Looker, 2008). In adults, increases in BMI, reductions in fluid milk intakes, and increases in sun protection appeared to contribute to this decline (Looker, 2008).

Sources of vitamin D: Vitamin D can be obtained through dietary sources, cutaneous synthesis, and supplementation. Fatty fish, such as salmon and herring, is the primary natural food source of vitamin D. Based on 2005-2006 NHANES data, fish and shellfish provide 8.6 percent of the vitamin D intake in the US. All fluid milk must be fortified with vitamin D, and other foods (e.g., cereals, margarine, and yogurt) and beverages (e.g., orange juice) are also commonly fortified. The best sources of vitamin D include fortified fluid milk, fatty fish such as salmon and trout, portabella mushrooms, and fortified orange juice (Table D2.10). Slightly more than 52 percent of the total intake comes from vitamin D-fortified fluid milk, milk drinks and desserts, and yogurt (Table D2.11). Fortified cereals account for an additional 6.5 percent of intake, and meat, poultry, and eggs together account for 11.2 percent. Various vitamin D-fortified foods differ in the amounts of vitamin D that they contain.

The USDA Food Patterns include vitamin D from fortified fluid milk, fortified ready-to-eat cereals, fortified butter and margarine, and the naturally occurring vitamin D in meat, poultry, fish, and eggs. The food patterns that contain 3 cup equivalents from the fluid milk and milk products food group provide sufficient vitamin D to meet the current AI for all children and adults, aged 19 to 50 years (i.e., 5 μg/day). However, the patterns do not provide sufficient vitamin D for adults over 50 years (i.e., 10 μg/day). The food patterns at 1000 to 1400 calories that contain only 2 cup equivalents from the fluid milk and milk products group do not provide adequate vitamin D to meet the AI of 5 μg/day for children, aged 2 to 8 years. Additional vitamin D could be obtained by selecting more natural food sources of vitamin D, such as certain fish, and fortified sources of vitamin D, such as fortified orange juice. In addition, choosing fortified fluid milk or yogurt rather than including cheese or non-fortified yogurt when making selections from the fluid milk and milk products food group would increase vitamin D intakes to adequate amounts for all age-sex groups, except those over 70 years of age. When necessary, individuals may consider vitamin D supplementation along with dietary intake, especially in older individuals because endogenous production of vitamin D from sun exposure is reduced by more than 50 percent in elderly populations.

Calcium

Strong evidence shows that many children and a majority of adults do not meet the AI for calcium. Furthermore, a significant number of Americans have low bone mass, placing them at risk of bone fractures and falls. Fluid milk and milk products contribute substantially to calcium intakes by Americans. Removing fluid milk and milk products from the diet requires careful replacement with other calcium-rich or calcium-fortified foods.

All children, adults, and the elderly are encouraged to meet the AI for calcium. Nutrient recommendations for calcium may be achieved by meeting recommended levels of fluid milk and milk products or consuming alternative calcium sources (see Table D2.12).

The DGAC chose to not conduct an independent systematic review of calcium due to the fact that the IOM concurrently empanelled an expert committee to review the DRI for calcium. As with vitamin D, the previous DRI for calcium was established in 1997. Recommendations from the IOM committee are expected to be available in Fall 2010.

For this review of calcium and health, the DGAC primarily relied upon three sources of information: 1) calcium intake data from the NHANES (Bailey, 2010a); 2) an AHRQ evidence report, *Vitamin D and Calcium: A Systematic Review of Health Outcomes* (Chung, 2009); and 3) the 1997 IOM report on *Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D and Fluoride* (FNB, 1997). The results of the Committee's review are presented below.

Calcium and health: Adequate calcium status is important for optimal health of the skeleton, in addition to having vital roles in nerve transmission, vasoconstriction, vasodilation, and muscle contraction (FNB, 1997). Emerging evidence suggests a role for calcium intake in cardiovascular health and lowering risk for breast cancer (Chung, 2009). Evidence on other health-related outcomes, such as growth in infants and children, body weight (see ***Part D. Section 1: Energy Balance and Weight Management*** and ***Part D. Section 4: Protein***), colorectal (CRC), prostate and pancreatic cancer, preeclampsia, pregnancy-induced hypertension, and preterm birth, is too insufficient or inconsistent to permit strong conclusions (Chung, 2009).

Calcium intake: NHANES data from 2003-2006 indicate that the majority of the population does not meet the AI for calcium, except for boys and girls, aged 1 to 3 years, due to fluid milk consumption (Bailey, 2010a). With diet alone, 96 percent and 94 percent of girls and boys, aged 1 to 3 years, respectively, and 67 percent and 80 percent of girls and boys, aged 4 to 8 years, respectively, meet the AI (500 mg/day and 800 mg/day for 1- to 3-year-olds and 4- to 8-year-olds, respectively). However, only 15 percent and 22 percent of girls and boys, aged 9 to 13 years, respectively, are above the AI of 1300 mg per day for calcium, and only 10 percent and 42 percent of adolescent girls and boys, respectively, aged 14 to 18 years, are above the AI of 1300 mg per day for calcium. Between 70 percent to 75 percent of women and 37 percent to 44 percent of men, aged 19 to 50 years, fail to meet the AI for calcium (1000 mg/day) (Figure D2.17). Less than 10 percent of women and less than 22 percent of men older than 51 years meet the AI for calcium (1200 mg/day). Forty-three percent of the population consumes supplements that contain calcium. When supplements are added to dietary intake, the percentage of children and adults up to age 30 years who meet their AIs improve very little. However, total calcium intakes increase substantially in women and men, aged 31 to 50 years, 51 to 70 years, and those older than 71 years when calcium supplements are used (Bailey, 2010a). Less than 2 percent of the population exceeds the UL for calcium (Bailey, 2010a). These calcium intakes are compared against the 1997 AI for calcium. Should the IOM determine new AIs for calcium, comparisons of intakes to AI standards should be adjusted accordingly.

Sources of calcium: Fluid milk and milk products are the most bioavailable sources of calcium (Table D2.12) and are also the major sources of calcium in typical American diets (Table D2.13). The USDA Food Patterns specify 2 (for those 8 years and under) or 3 (for those 9 years and older) cup equivalents per day from the fluid milk and milk products food group and meets the goals for calcium intake.

The DGAC conducted a food pattern modeling analysis to assess nutrient adequacy with various changes in intake from the fluid milk and milk products group because: 1) many Americans fall short of the recommended intake levels for fluid milk and milk products (see Question 2 on Food Groups and Selected Dietary Components Underconsumed); 2) relative proportions of fluid milk and cheese consumption have changed over time and they differ in some important ways in nutrient content (Figure D2.18); and 3) some individuals desire non-dairy calcium sources for a variety of physiological, psychosocial, and personal reasons (see Appendix E3.6 at www.dietaryguidelines.gov for the full report). When fluid milk and milk products are removed from the USDA Food Patterns, calcium drops substantially below the AI across all energy levels. In addition, vitamins D and A, and choline, magnesium, phosphorus, and potassium also fall below 100 percent of DRI levels in some or all patterns. When fat-free fluid milk is substituted for some or all of the low-fat cheese in the USDA Food Patterns: 1) energy, protein and calcium levels remain similar; 2) vitamin A, and choline, magnesium, and potassium increase slightly; 3) sodium, cholesterol, and saturated fatty acids decrease slightly; and 4) vitamin D content is substantially improved across energy levels. Of the non-dairy alternatives evaluated as a substitute for fluid milk, yogurt, and cheese in the USDA Food Patterns, soymilk fortified with calcium and vitamins A and D is the alternative with the most similar nutrient profile to fluid milk (compared to calcium-fortified rice drink or orange juice; tofu prepared with calcium sulfate; green vegetables; green soybeans; white beans; almonds; and canned sardines and salmon with bone).

Both calcium content and bioavailability should be considered when selecting dietary sources of calcium. The fluid milk and milk products food group provides more than 70 percent of the calcium consumed by Americans. Some plant foods contribute calcium that is well absorbed, but the large quantity of these plant foods that would be needed to provide the equivalent amount of calcium found in 8 ounces of fluid milk may be unachievable for many. Individuals who perceive that they are lactose intolerant or allergic to dairy products should be evaluated for such before unnecessarily limiting or eliminating dairy-based foods from their dietary patterns (NIH, 2010). Lactose-reduced or low-lactose dairy-based products may assist in obtaining nutrients provided by the fluid milk and milk products food group for those who are lactose intolerant.

Potassium

Conclusions and implications of inadequate dietary intakes of potassium related to health outcomes are presented in ***Part D. Section 6: Sodium, Potassium, and Water***. Based on 2001-2002 NHANES data, usual intakes for less than 3 percent of Americans, older than 1 year, meet the AI for potassium (Moshfegh, 2005). Approximately 6 percent and less than 3 percent of adult men and women, respectively, consume potassium at intake levels that reach the AI. For boys and girls, aged 9 to 13 years and 14 to 18 years, and for children, aged 4 to 8 years, less than 3 percent of these age-sex groups meet AIs for potassium intakes. Approximately 6 percent of children, aged 1 to 3 years, reach the AI for potassium intake. Analysis of 2005-2006 NHANES data also indicates that potassium intakes fall short of the AIs for all age-sex groups, with approximately 97 percent of Americans not meeting recommended intake levels (Figure D2.19) (ARS, 2008).

Dietary sources of potassium are found in all food groups, notably in vegetables and fruits (see Question 2 on Food Groups and Selected Dietary Components Underconsumed). Table D2.14 lists the best food sources of potassium per standard amount, from the ARS nutrient database, along with the number of calories for each standard amount. Table D2.15 lists the major sources of potassium from American food consumption data. Americans typically consume potassium-rich foods in relatively low amounts. Americans should select foods from all food groups that are higher in potassium content to better meet recommendations for intake.

Dietary Fiber

Conclusions and implications regarding inadequate intakes of dietary fiber related to health outcomes are presented in ***Part D. Section 5: Carbohydrates***. Based on 2003-2006 NHANES data, less than 3 percent of Americans, older than 1 year, have a usual intake of dietary fiber that exceeds the AI (ARS, 2010c). Less than 3 percent of adult men and approximately 6 percent and of adult women consume dietary fiber at intake levels that reach the AI. For boys and girls, aged 9 to 13 years and 14 to 18 years, and children, aged 1 to 3 years and 4 to 8 years, less than 3 percent of these age-sex groups meet their AIs for dietary fiber intakes (Figure D2.20).

Mean intakes of dietary fiber in 2005-2006, based on one-day data, were well below AI levels. For men, mean intake was 17.8 grams, in comparison to AIs of 38 grams (ages 19 to 50 years) or 30 grams (older than age 50 years). Mean intakes were similarly low in women, with a mean of 14.1 grams, in comparison to AIs of 25 grams (ages 19 to 50 years) or 21 grams (older than age 50 years) (ARS, 2008). For all Americans, older than 1 year, mean intakes of dietary fiber fall short of the AIs, with less than 3 percent meeting recommended intake levels (ARS, 2010c). Inadequate intake of dietary fiber is widespread.

Dietary sources of fiber are found in vegetables and fruits, whole grains, cooked dry beans and peas, and nuts—all foods that are lacking in the typical American diet (see Question 2 on Food Groups and Selected Dietary Components Underconsumed). Table D2.16 lists the best food sources of dietary fiber per standard amount, from the ARS nutrient database, along with the number of calories for each standard amount. Table D2.17 lists the major sources of dietary fiber from American food consumption data. Refined breads, rolls, buns, and pizza crust are not among the best sources of dietary fiber, but contribute substantially to what little dietary fiber is consumed because they are so ubiquitous in current dietary patterns of Americans. Refined grains are overconsumed in the American diet (see Question 1 on Nutrients and Dietary Components Overconsumed) and provide less dietary fiber per portion than vegetables, fruits, whole grains, cooked dry beans and peas, and nuts. Americans should replace such foods with foods that are higher in dietary fiber while not increasing total energy intakes.

NUTRIENT ISSUES FOR SELECTED POPULATION SUBGROUPS

The 2010 DGAC agrees with the 2005 DGAC report, noting that special nutrient recommendations are warranted for the following subgroups and nutrients:

- Adolescent females and women of reproductive capacity—folic acid.
- Adolescent females and women of reproductive capacity—iron.
- Persons over age 50 years—vitamin B_{12}.

Question 4: What is the Relationship between Folate Intake and Health Outcomes in the US and Canada Following Mandatory Folic Acid Fortification?

Conclusion

Strong and consistent evidence demonstrates a large reduction in the incidence of neural tube defects (NTDs) in the US and Canada following mandatory folic acid fortification. A limited body of evidence suggests stroke mortality has declined in the US and Canadian populations following mandatory folic acid fortification. A limited body of evidence suggests that mandatory folic acid fortification has increased the incidence of colorectal cancer (CRC) in the US and Canada.

Implications

Folic acid fortification in the US and Canada appears to be successful in the primary health objective of reducing the incidence of NTDs. Although some negative consequences appear to have occurred (i.e., possible increase in CRC), the evidence supports the continuation of folic acid fortification of flour and uncooked cereals at current levels (140 μg/100 g). Despite the increases in folic acid through fortification, about 22 percent of women of reproductive capacity still do not meet the EAR. Women of reproductive capacity should continue to be counseled to select foods high in folate, and when necessary, take a folic acid supplement to meet their folate requirements. As a result of the increase in folic acid in food from fortification and because many adults take a supplement containing folic acid, approximately 5 percent of adults older than age 50 years now exceed the UL (1000 μg/day) for folic acid intake. To avoid exceeding the UL, adults over age 50 years should not supplement with folic acid in excess of 400 μg/day. Because whole grain foods are not always fortified with folic acid, individuals who consume mainly whole grains in their dietary patterns should ensure that some of these whole grains are fortified to achieve dietary folate recommendations.

Review of the Evidence

Background

In 1992, the US Public Health Service recommended that all women of reproductive capacity consume 400 μg of folic acid daily to reduce the risk of NTDs. To help the public better meet this nutritional need, the Food and Drug Administration (FDA) authorized the addition of synthetic folic acid to all flour and uncooked cereal grains in March 1996, with mandatory compliance by January 1998. Similar mandates were authorized in Canada, with full compliance by November 1998.

As a result of mandated folic acid fortification, blood concentrations of folate increased in the US and Canada. Five nationally representative studies (all using NHANES data) demonstrated that serum folate more than doubled between the pre- and post-fortification periods and that red blood cell (RBC) folate, a marker of long-term folate status, increased approximately 57 percent (Dietrich, 2005; Dowd, 2008; Ganji, 2006; Pfeiffer, 2007; Quinlivan, 2007). Prevalence of low serum folate (less than 3 ng/mL) and low RBC folate (less than 140 ng/mL) was significantly lower in the post-fortification periods. However, some women of reproductive capacity are still at risk for low folate concentrations (1% and 5%, respectively, for serum and RBC folate concentrations) (Pfeiffer, 2007). The prevalence of high serum folate (greater than 20 ng/mL) concentrations in children and adults older than age 60 years increased (from 5% to 42% and from 7% to 38%, respectively), but have decreased somewhat, especially in children, since fortification was first mandated and food companies have adjusted fortification levels to accurately meet the mandate (Pfeiffer, 2007).

Current dietary folate and supplemental folic acid intakes in the US indicate that the majority of the population is achieving adequate folate intakes. A recent study by Bailey et al. (2010b) used NHANES data to estimate total folate and folic acid intakes in the US between the years 2003 and 2006. Because the bioavailability of dietary folate is much lower than that of folic acid added to fortified foods and dietary supplements, researchers used a dietary folate equivalent (DFE) conversion (1 DFE = 1 μg food folate = 0.6 μg folic acid from supplements and fortified food) to reflect the differential bioavailability. Results of this study demonstrated that approximately 22 percent of all women were below the EAR for folate from diet only, though 28 percent of non-Hispanic black women were below the EAR. For all men, only 5 percent to 10 percent across the different age categories were below the EAR, though 13 percent of non-Hispanic black men were below the EAR. In all age-sex categories, slightly fewer people were below the EAR when folic acid from supplements was included. In the Bailey et al. (2010b) study, 53 percent of the population took dietary supplements, 34 percent of which contained folic acid. Total folate and folic acid intakes were the highest in people older than age 50 years, with 5 percent of this population exceeding the UL. Another study, using the same NHANES data, reported that 34 percent of adults who consumed folic acid supplements in excess of 400 μg/day exceeded the UL (Yang, 2010). Exceeding the UL for folate intake is a concern as it may intensify or worsen neurological damage caused by vitamin B_{12} deficiency, as outlined by the IOM (FNB, 1998). In addition, some recent evidence indicates that folic acid at high exposure may have harmful effects even without vitamin B_{12} deficiency (Morris, 2005). Table D2.18 lists the best food sources of folate per standard amount, from the ARS nutrient database, along with the number of calories for each standard amount.

Folic Acid Fortification and Neural Tube Defects

Strong and consistent evidence demonstrates that the incidence of children being born with NTDs has been reduced following mandatory folic acid grain fortification in the US and Canada. This conclusion is based on the review of 13 studies (Besser, 2007; Canfield, 2005; CDC, 2004; Chen, 2008; de Wals, 2007; de Wals, 2008; Forrester, 2005; Godwin, 2008; Honein, 2001; Mosley, 2007; Persad, 2002; Williams, 2002; Williams, 2005). Of these 13 studies, nine were conducted in the US and four were conducted in Canada. Given the ecologic nature of mandatory fortification, it was impossible to conduct a controlled trial during this time. The range of NTD reduction varied depending upon the study size and study design. The large, nationally representative trials conducted in the US reported reductions of 23 percent to 54 percent in spina bifida and 11 percent to 16 percent in anencephaly. In Canada, one national trial demonstrated a 53 percent reduction in spina bifida and a 31 percent reduction in anencephaly.

Folic Acid Fortification and Stroke

A limited body of evidence suggests that stroke mortality has declined in the US and Canada following mandatory folic acid fortification. This evidence is based upon one population cohort study conducted in the US, Canada, England and Wales (Yang, 2006). This study evaluated trends in stroke-related mortality before and after folic acid fortification in the US and Canada and, as a comparison, during the same period in England and Wales, where fortification is not mandated. The ongoing decline in stroke mortality observed in the US and Canada between 1990 and 1997, accelerated in the years 1998 to 2002, in nearly all population strata. In contrast, the decline in stroke mortality in England and Wales did not change significantly between 1990 and 2002.

Folic Acid Fortification and Colorectal Cancer

A limited body of evidence suggests that mandatory folic acid fortification has increased the incidence of CRC in the US and Canada. This evidence is based on two trend studies in the US and Canada (Mason, 2007) and one in Chile, which instituted mandatory folic acid fortification in 2000 (Hirsch, 2009). In these studies, the increase in incidence of CRC coincided with mandatory folic acid fortification in each country. Mason et al. (2007) used US and Canadian data collected between 1986 and 2002, by the Surveillance, Epidemiology and End Results Program to address the question. In the US, the absolute rates of CRC began to increase in 1996 and peaked in 1998. In Canada, the absolute rates of CRC began to increase in 1997 and peaked in 2000. The sudden increase in CRC incidence represents a significant deviation from the time period just before folic acid fortification in the US by 4 to 6 additional cases per 100,000 individuals. It does not appear that changes in colorectal endoscopic procedures accounted for the increase in CRC incidence. Hirsch et al. (2009) compared rates of hospital discharges due to CRC in Chile before (1992-1996) and after (2001-2004) mandatory folic acid fortification (220 μg/100 g wheat flour). Results were described in two groups: 1) adults, aged 45 to 64 years, and 2) adults aged 65 to 70 years. In age group 1, the rate ratio of hospital discharges due to CRC was 2.6 for an overall increase of 162 percent. In age group 2, the rate ratio was 2.9. Hirsh et al. (2009) concluded that mandatory folic acid fortification may be associated with an increased risk of CRC.

Folic Acid Supplements and Other Health Outcomes

The DGAC also evaluated the health impact of folic acid supplementation in people with pre-existing cardiovascular disease (CVD). A systematic review was conducted to evaluate the effect of folic acid supplementation with or without additional B-vitamin supplementation on CVD. Strong evidence demonstrates that folic acid supplementation with or without additional B-vitamins in adult men and women with pre-existing vascular disease does not appear to reduce risk of CVD, and may even increase risk slightly. This conclusion is based on results from four well-designed randomized double-blind placebo controlled trials (Albert, 2008; Bonaa, 2006; Ebbing, 2008; Ray, 2007) and one meta-analysis (Bazzano, 2007) that analyzed 12 relevant randomized controlled trials. All of the reviewed studies were in consistent agreement that folic acid supplementation conferred no benefit, and two studies reported an increased CVD risk Evidence that folic acid supplementation might prevent stroke is inconsistent (Bazzano, 2007; Wang 2007; Sapsonik, 2009), with the most recent meta-analysis documenting no benefit (Miller, 2010).

Relevant Contextual Issues

Impact on Intake of Folate and Other Nutrients of Selecting All Grains as Whole Grains Rather than Half Whole and Half Enriched Refined Grains

The USDA Food Patterns are designed to meet *Dietary Guidelines for Americans* and IOM recommendations. To achieve this, the 2005 *Dietary Guidelines for Americans* recommended that at least half of all grain intake come from whole grain sources. For the standard 2000 calorie dietary pattern, 6 ounce equivalents of grains are recommended, with 3 or more of these consumed as whole grains and preferably fiber-rich whole grains. This is interpreted in the USDA Food Patterns to be half of the recommended ounce equivalents of grains as whole grains, and half as enriched refined grains. For example, in the 2000 calorie pattern, 3 ounce equivalents of whole grains and 3 of enriched refined grains are included. The most commonly consumed refined grains are enriched with iron and other B-vitamins and fortified with folic acid. Whole grain products are typically not fortified with folic acid or enriched because many enrichment nutrients are naturally present in the whole grain. Ready-to-eat (RTE) whole grain cereals are the exception—many are fortified with a range of nutrients, including folic acid and enrichment nutrients. The DGAC chose to use modeling (see ***Part C: Methodology***) to determine the impact on intake of folate and other nutrients if all recommended grains were selected as whole grains rather than half whole and half enriched refined grains (see online Appendix E3.7 at www.dietaryguidelines.gov for the full report). The whole grains selected to replace enriched refined grains for the purpose of this analysis were not enriched or fortified with folic acid, except for RTE cereals. To replace enriched-grain RTE cereals, two replacement foods were identified: 1) a non-fortified whole grain RTE cereal (scenario 1); and 2) a fortified whole grain RTE cereal (scenario 2).

The base USDA Food Patterns that include foods from all of the basic food groups provide adequate amounts of folate and other enrichment nutrients for all age-sex groups, with 625 μg of folate (155% of the RDA for women, aged 19 to 30 years) in the reference 2000 calorie pattern. The modified food patterns without any fortified whole grains (scenario 1) did not provide sufficient folate for girls, aged 14 to 18 years, women of all ages with low to moderate energy needs, and men older than age 50 years with relatively low energy needs. For example, in the 2000 calorie pattern, dietary folate levels fell to 332 μg (83% of the RDA for adults). In addition, the all-whole grains dietary patterns were low in iron for boys and girls, aged 2 to 8 years, and adolescent girls and women, aged 14 to 50 years. Inclusion of some fortified whole grain RTE cereals (scenario 2) in the all-whole grains dietary patterns improved nutrient levels to adequate amounts for dietary folate (392 μg or 98% of RDA) and also increased amounts of iron in the patterns somewhat.

As shown by food pattern modeling, consumption of all grains as whole grains, without including any fortified whole grain products, would lower dietary folate and iron intake levels to less than adequate amounts for individuals in population groups who may be at high risk for inadequate intakes of these nutrients. Individuals are encouraged to consume most of their grains as fiber-rich whole grains, and when doing so, should select some of these fiber-rich whole grains as products that have been fortified with folic acid and possibly other nutrients.

Question 5: Is Iron a Nutrient of Special Concern for Women of Reproductive Capacity?

Conclusion

Substantial numbers of adolescent girls and women of reproductive capacity have laboratory evidence of iron deficiency.

Implications

Efforts are warranted to increase dietary intake of heme-iron-rich foods and of enhancers of iron absorption by these special populations.

Review of the Evidence

A full systematic review was not conducted, because although the DGAC believes that the issue is still pertinent, little new data have been published since 2005. Laboratory values from 1999-2002 NHANES blood samples indicate that more than 5 percent of individuals, aged 1 to 59 years, have inadequate serum ferritin concentrations of less than 12 ng/mL or less than 15 ng/mL for children less than 5 years or greater than or equal to 5 years of age, respectively, and that more than 10 percent of individuals of all ages have low levels of transferrin saturation (less than 16%), suggestive of iron deficiency (USDHHS, 2008). More recent data indicate that from 3.7 percent to 14.4 percent of children, aged 1 to 5 years, and about 9 percent of women, aged 12 to 49 years, have inadequate stores of body iron (Cogswell, 2009).

From 15 percent to 17 percent of adolescent girls and women younger than 51 years, have usual iron intakes below their EARs (Moshfegh, 2005). In contrast, less than 3 percent of any other age-sex group has a usual intake below their EAR (Moshfegh, 2005). Adolescent girls consume a usual average daily intake of 13.3 mg per day, while adult women, aged 20 to 49 years, consume between 13.9 to 14.9 mg of iron per day (ARS, 2008). Moreover, women older than age 19 years fall short of meeting the recommended number of servings from the meat, poultry, fish, eggs, soy, nuts, and seeds food group, and a substantial number of adolescent girls also do not meet the recommended servings for this food group (see Question 2 on Food Groups and Selected Dietary Components Underconsumed) (NCI, 2009). Approximately 6.5 million adolescent girls and women of childbearing age are iron deficient. These findings support the need to encourage these special populations to increase dietary intake of foods that are sources of heme-iron, such as meat, poultry, and fish, and sources of nonheme-iron, such as fortified cereals and whole grains, while also achieving energy balance. Foods containing nonheme-iron should be consumed along with enhancers of iron absorption, such as vitamin C-rich foods and foods containing heme-iron. Table

D2.19 lists the best food sources of iron per standard amount, from the ARS nutrient database, along with the number of calories for each standard amount.

Question 6: Are Older Adults Consuming Sufficient Vitamin B_{12}?

Conclusion

Recent evaluation of NHANES data shows that individuals older than age 50 years are consuming adequate intakes of vitamin B_{12}, including B_{12} found naturally in foods and crystalline B_{12} consumed in fortified foods. Nonetheless, a substantial proportion of individuals older than age 50 years may have reduced ability to absorb naturally occurring vitamin B_{12} but not the crystalline form.

Implications

Although individuals older than age 50 years appear to be meeting their need for vitamin B_{12}, they should be encouraged to consume foods fortified with B_{12}, such as fortified cereals, or the crystalline form of B_{12} supplements, when necessary. Practitioners should assess vitamin B_{12} status in those older than age 65 years, using a low serum vitamin B_{12} value of less than 300 pg/mL, high serum methylmalonic acid value of greater than 0.4 μmol/L, and serum total homocysteine level of greater than 15.0 μmol/L as evidence of vitamin B_{12} deficiency.

Review of the Evidence

A full systematic review was not conducted, because although the DGAC believes that the issue is still pertinent, little new data have been published since 2005. However, the conclusion was supported by evidence from a published systematic review conducted for the IOM (FNB, 1998) and updated to 2009, by laboratory studies designed to screen for functional vitamin B_{12} status, as summarized below, and by dietary intake findings from the NHANES.

Based on a systematic, extensive review of published literature, the IOM (FNB, 1998) set the RDA for vitamin B_{12} at 2.4 μg per day for individuals aged 14 years and above and for both sexes. Because 10 percent to 30 percent of the older population may be unable to absorb naturally-occurring vitamin B_{12}, the IOM advised that people age 50 years and older should meet their RDA mainly by consuming foods fortified with vitamin B_{12} or by taking vitamin B_{12}-containing supplements. This RDA was based on the amount needed to maintain the hematological status, as well as the normal serum vitamin B_{12} level. Vitamin B_{12} deficiency, as determined by serum B_{12} of less than 148 pmol/L in combination with serum homocysteine of greater than 10 μmol/L, was found in approximately 2.5 percent of adults older than age 50 years. Supplement use reduced the prevalence of B_{12} deficiency to less than 0.5 percent of adults older than age 50 years (Evatt, 2010). The incidence of vitamin B_{12} deficiency increases with age, and marginal B_{12} status occurs in as many as 20 percent of individuals older than 60 years (Allen, 2009). Neurological manifestation of vitamin B_{12} deficiency was not used to establish vitamin B_{12} status because it occurs at a later depletion stage than does the hematological status. Furthermore, the progression of neurological manifestation is variable, generally gradual, and currently not amenable for easy quantification. A Cochrane review (Malouf, 2008) with a 2009 update concluded that the major effect of folate with or without vitamin B_{12} on cognitive function occurred in those individuals with high homocysteine concentrations. Three additional randomized controlled trials (Aisen, 2008; Ford, 2008; Gariballa, 2007), examining the effects of vitamin B_{12} supplementation in combination with folate and or vitamin B_6 on dementia, cognition, and depression, did not find beneficial effects in the groups studied despite an increase in B_{12} status (Aisen, 2008). Therefore, individuals older than age 50 years should achieve a total intake of vitamin B_{12} consistent with IOM recommendations by eating fortified foods or by taking the crystalline form of vitamin B_{12} supplements and in balance with folate and vitamin B_6.

Studies using serum radioimmunoassay of vitamin B_{12}—combined with serum homocysteine and methylmalonic acid values—to screen for functional vitamin B_{12} status further support this conclusion. A low serum vitamin B_{12} value (less than 300 pg/mL), high serum methylmalonic acid value (greater than 0.4 μmol/L) and homocysteine greater than 15.0 μmol/L would suggest vitamin B_{12} deficiency. Using results from these three laboratory tests, Clarke et al. (2004) reported the prevalence rate of vitamin B_{12} deficiency to be 1 in 20 among people aged 65 to 74 years, and 1 in 10 among people aged 75 years and older. In addition, various clinical trials (McKay, 2000), either among free-living or institutionalized elderly, demonstrated that either oral vitamin B_{12} supplements alone or as multivitamin/mineral supplements could improve vitamin B_{12} status. A systematic review of oral versus intramuscular vitamin B_{12} in the treatment of vitamin B_{12} deficiency found that oral doses may be as effective as intramuscular administration in inducing short-term hematological and neurological responses (Butler, 2006). All individuals older than age 65 years should be screened for deficiency with simple tests of serum vitamin B_{12} status (Goringe, 2006).

According to 2005-2006 NHANES data, the estimated mean daily vitamin B_{12} intakes from foods ranged from 3.96 (girls, aged 12 to 19 years) to 7.91 μg (men, aged 40 to 49 years) (ARS, 2008). For men and women, means and standard errors of vitamin B_{12} intakes were 6.62±0.763 μg/day (men aged 60 to 69 years), 6.092±0.477 μg/day (men aged 70+ years), 4.69±0.403 μg/day (women aged 60 to 69 years) and 4.38±0.171 μg/day (women aged 70+ years). These mean intakes were similar to or somewhat greater than mean intakes reported for 2001-2002, as estimates of usual intake distributions showed that more than 95 percent of men and 90 percent of women, aged 50 years and older, had usual total vitamin B_{12} intakes above the EAR (Moshfegh, 2005). These NHANES estimates included the B_{12} naturally occurring in foods and added to foods as fortificants. However, the IOM recommends that adults older than age 50 years meet much of their vitamin B_{12}

requirement by consuming foods fortified with vitamin B_{12} or a supplement containing it (FNB, 1998). In 2005-2006, mean daily amounts of crystalline vitamin B_{12}, found in fortified foods, for older adults were 1.22 μg/day (men aged 60 to 69 years), 1.28 μg/day (men aged 70+ years), 0.84 μg/day (women aged 60 to 69 years) and 1.14 μg/day (women aged 70+ years) (ARS, 2008). Thus, 18 percent to 26 percent of the vitamin B_{12} in foods consumed by older adults is in crystalline form. Table D2.20 lists the best food sources of vitamin B_{12} per standard amount, from the ARS nutrient database, along with the number of calories for each standard amount.

VITAMIN, MINERAL, AND NUTRIENT SUPPLEMENTS

The DGAC encourages Americans to achieve nutrient adequacy through a total diet in which they select and consume nutrient-dense forms of foods from the basic food groups. However, 53 percent of the American population uses vitamin, mineral, and nutrient supplements (Bailey, 2010a). Therefore, the DGAC examined the literature regarding potential health effects of such supplementation in healthy Americans.

Question 7: Can a Daily Multivitamin/Mineral Supplement Prevent Chronic Disease?

Conclusion

For the general, healthy population, there is no evidence to support a recommendation for the use of multivitamin/mineral supplements in the primary prevention of chronic disease. Limited evidence suggests that supplements containing combinations of certain nutrients are beneficial in reversing chronic disease when used by special populations; in contrast, certain nutrient supplements appear to be harmful in other subgroups.

Implications

Although intake of a variety of multivitamin/mineral supplements increase blood levels of many nutrients, notably in individuals with suboptimal nutrient status before supplementation (Maraini, 2009), long-term effects on primary prevention of several chronic diseases has not been demonstrated. In this context, obtaining essential micronutrients from foods when possible is the optimal approach and reliance on multivitamin/mineral supplements is discouraged. At present, Americans are encouraged to meet overall nutrient requirements within energy levels that balance daily energy intake with expenditure. This can be accomplished through a variety of food intake patterns that include nutrient-dense forms of foods.

Review of the Evidence

The DGAC evaluated three primary sources of evidence to reach this conclusion: 1) an AHRQ-commissioned systematic review on nutrient supplements and chronic disease prevention (Huang, 2006); 2) the 2006 NIH "State-of-the-Science Conference on Multivitamin/Mineral Supplements for Chronic Disease Prevention" (Coates, 2007a); and 3) the *American Journal of Clinical Nutrition* supplement, "n-3 Fatty Acids: Recommendations for Therapeutics and Prevention" (Akabas, 2006a). This review was limited to vitamins, minerals, and EPA and DHA. Other dietary supplements, such as botanicals, hormones, peptides, and amino acids were not evaluated.

Huang et al. (2006) established four key questions to guide the examination of published literature regarding health outcomes of multivitamin/mineral supplements in the primary prevention of 10 chronic disease categories, including cancer, vascular, endocrine, neurological, sensory, liver, renal, musculoskeletal, infectious, and pulmonary diseases. These investigators also evaluated published data on the effects of 14 single-nutrient supplements and four functionally related paired-nutrient supplements on these chronic diseases as well as the safety of eight single-nutrient supplements on health-related outcomes. Their conclusions were based on findings reported in 63 published papers. NIH conference panelists used this AHRQ report (Huang, 2006) as a foundational piece of evidence for their independent review, along with further scientific evidence provided by scientific experts who addressed six key questions posed by the NIH panel. The DGAC used the three key sources of evidence, as previously indicated, along with three meta-analyses, three systematic reviews, and 11 randomized controlled nutrient supplementation trials that were published after the 2006 AHRQ report and 2006 NIH conference to group and summarize overall evidence by outcome or body system.

Cancer

In healthy adults, no effects of beta-carotene supplementation or a combined vitamin A plus zinc supplement or vitamin A plus beta-carotene supplement on cancer prevention were reported. There was an observed beneficial effect of a combined beta-carotene, vitamin E, and selenium supplement on lowering gastric cancer incidence and gastric and overall cancer mortality in inadequately nourished men and women in China. A reduced overall cancer risk in men, but not women, in France, was noted with a beta-carotene, vitamins E and C, selenium, and zinc combination. Lowering of prostate cancer incidence and mortality in men and CRC in adult smokers with vitamin E supplementation was reported. An observed adverse effect of beta-carotene supplementation or a combined beta-carotene plus vitamin A supplement on lung cancer and mortality in adult smokers and in individuals exposed to asbestos was noted. Data presented by program participants of the NIH conference (NIH, 2006) were congruent with the AHRQ report

(Huang, 2006) regarding beneficial effects of a combined beta-carotene, vitamin E, and selenium supplement on lowering gastric cancer in nutritionally deficient adults in China (Greenwald, 2007) and harmful effects of beta-carotene supplementation or a combined beta-carotene plus vitamin A supplement on increasing lung cancer in adult smokers and individuals exposed to asbestos (Greenwald, 2007).

A meta-analysis (Tanvetyanon 2008) confirmed that lung cancer incidence increased with beta-carotene supplementation in former smokers and individuals exposed to asbestos. Conversely, lung cancer incidence was not significantly increased in the overall population of male physicians (Hennekens, 1996) or women in health professions who were not former smokers (Lee, 1999) and who consumed beta-carotene supplements on alternate days. Among all current smokers, the risk of lung cancer incidence significantly increased by 24 percent in individuals receiving any beta-carotene supplement. A more recent study by Liu et al. (2009) examined a panel of cancer markers in stored lung tissue from participants of the Physician's Health Study who developed lung cancer. Neither smoking status nor beta-carotene supplementation status was significantly different for the 39 men from whom samples of lung tissue were provided. Significant differences in selected markers of lung cancer were not found between adult men supplemented with beta-carotene versus placebo, suggesting that factors other than the beta-carotene supplement lead to lung cancer development.

Among healthy postmenopausal women living in rural Nebraska, combined calcium plus vitamin D supplementation lowered all-cancer risk over a 4-year intervention compared to placebo or calcium alone (Lappe, 2007). Recent findings from the Selenium and Vitamin E Cancer Prevention Trial (SELECT) demonstrated that supplementation of selenium alone, vitamin E alone, or combined selenium plus vitamin E had no effect on prostate cancer compared to placebo in adult men in the US, Puerto Rico and Canada (Lippman, 2009).

Cardiovascular Disease

In adults, no effect of beta-carotene supplementation on CVD was noted, and no effect of a combined beta-carotene, vitamins E and C, selenium, and zinc supplement on ischemic CVD incidence was reported. Among adults, a combined vitamin A plus zinc supplement or vitamin A plus beta-carotene supplement had no impact on cerebrovascular disease or CVD (Huang, 2006; NIH, 2006). The effect of vitamin E supplementation on CVD prevention, particularly among older women, had incomplete evidence on which to base a positive recommendation for supplementation (Traber, 2007). Additional vitamin K, beyond that consumed in a multivitamin supplement, reduced the progression of coronary artery calcification in individuals with greater than or equal to 85 percent supplementation compliance and in individuals with preexisting coronary artery calcification (Shea, 2009).

EPA and DHA supplementation as a treatment strategy lowered blood concentration of triacylglycerol as a marker of CVD, lowered overall mortality in persons with CVD, and lowered arrhythmias and sudden death (Akabas, 2006b). The American Heart Association recommends a total of 1 g per day of EPA plus DHA from a combination of higher omega-3 fatty acid-containing fish and supplements, if needed, in individuals with coronary heart disease (Kris-Etherton, 2002) (see ***Part D. Section 3: Fatty Acids and Cholesterol*** for a discussion on fish intake).

Sensory Disease

In adults, no effects of beta-carotene supplementation on sensory diseases were reported. Lessening of age-related macular degeneration and total mortality, only in adults with intermediate or advanced disease, with supplementation of zinc or zinc plus antioxidant nutrients was noted. However, no effect of multivitamin/mineral supplements on preventing cataracts in healthy Americans was found (Huang, 2006; NIH, 2006).

A combined zinc plus antioxidant nutrients supplement that also included copper reversed age-related macular degeneration in individuals with diagnosed disease (Seddon, 2007). A common over-the-counter multivitamin/mineral supplement reduced total (by 18%) and nuclear (by 34%) lens events but doubled the number of posterior subcapsular cataracts in men and women, aged 55 to 75 years (CTNS, 2008). Findings from the Women's Health Study demonstrated that vitamin E supplementation on alternate days, versus placebo, had no effect on overall cataract incidence or nuclear, cortical or posterior subcapsular cataract incidence, even when controlling for cataract progression risk factors (Christen, 2008). Fish intake, but not EPA or DHA supplements, was related to lower risk of macular degeneration (Johnson, 2006).

Some evidence supports DHA supplementation by pregnant women and lactating mothers at 200 to 300 mg per day to promote cognitive development and possibly visual acuity in their offspring (Eilander, 2007; Koletzko, 2008). Consumption of 6 to 10 ounce equivalents of seafood per week would achieve the DHA intake goal (Brenna, 2009) for this population (see ***Part D. Section 3: Fatty Acids and Cholesterol***).

Musculoskeletal Disease

Retention of bone mineral density in postmenopausal women is well-documented with calcium supplementation and a reduction in hip and non-vertebral fractures and falls with combined calcium and vitamin D supplements in older women, particularly those with low levels of these nutrients before supplementation (Huang, 2006; NIH, 2006). Modest positive effects of a combined calcium plus vitamin D supplement on bone health and fall prevention in older individuals has been confirmed in recent studies (Heaney, 2007). Vitamin K supplementation does not appear to provide significant benefit to bone mineral density in older adults (Booth, 2008), although vitamin K is an important nutrient for bone health.

Neurological and Central Nervous System Disease

A study in community-living older adults in Scotland found that daily supplementation with combined vitamins A, C, D, E, B_6 and B_{12}, thiamin, riboflavin, niacin, folic acid, pantothenic acid, iron, zinc, copper, manganese, and iodine did not prevent cognitive decline, although supplementation was associated with positive changes in verbal fluency among participants older than age 75 years and in those at risk of nutritional deficiency (McNeill, 2007). Pitkin (2007) noted that supplementation of women of reproductive capacity with folic acid, along with adequate intake of folic acid-fortified foods and usual intakes of dietary folate, was beneficial in preventing NTDs in offspring (see Question 4 within Nutrient Issues for Selected Population Subgroups). An additional topic addressed by the NIH panel included the effect of vitamin B_6 and of folic acid, with or without vitamin B_{12}, supplementation on cognitive decline; no effects were reported in older adults (NIH, 2006) (see Question 6 within Nutrient Issues for Selected Population Subgroups).

DHA may lower risk of cognitive decline and Alzheimer's disease (Akabas, 2006b), although a more recent 2-year randomized controlled trial of EPA plus DHA supplementation in older individuals showed no change in cognitive function compared to an olive oil control (Dangour, 2010). DHA supplementation modulated functional brain activity in healthy boys, aged 8 to 10 years (McNamara, 2010), although this evidence was exploratory and requires further investigation. EPA plus DHA supplementation did not impact self-rated depression in a group of non-depressed older individuals compared to a placebo group (van de Rest, 2008). One meta-analysis concluded that EPA plus DHA supplementation improved mood only in individuals already diagnosed with mood disorders (Appleton, 2010).

Other Systems

In adults, no effects of beta-carotene supplementation on endocrine diseases were reported (Huang, 2006). EPA and DHA may improve insulin sensitivity (Akabas, 2006b). Effects of a daily multivitamin/mineral supplement on liver, renal, infectious, and pulmonary diseases have not been documented (NIH, 2006).

Other Factors

An increased risk of kidney stone formation with calcium supplementation and discoloration of the skin with beta-carotene supplement use was noted (Huang, 2006). However, few, if any, randomized placebo-controlled clinical trials have tested the safety of nutrient supplements used as single or combinations of nutrients by the healthy population of Americans. A meta-analysis that examined effects of beta-carotene, vitamins A, C, and E, and selenium as single nutrients or as combinations of antioxidants on various outcome measures reported increased risk of death across a variety of low-bias clinical trials with beta-carotene and vitamins A and E supplementation (Bjelakovic, 2007).

Relevant Contextual Issues

One distinct limitation to studies on the effects of multivitamin/mineral supplement use on chronic disease endpoints is insufficient standardization of preparation compositions and characteristics (Yetley, 2007). Some discrepancies exist between the actual content of nutrients in supplements and the amounts reported on product labels, along with differences in chemical formulations and dosing regimens that affect bioavailability, bioequivalency, and, ultimately, biological effects. Although randomized placebo-controlled trials reduce confounding effects on primary outcomes of interest in rigorous studies, the fact that 53 percent of adults in the US use multivitamin/mineral supplements on a somewhat regular basis (Bailey, 2010a), with supplements contributing substantially to overall adequacy of nutrient intakes among adults (Murphy, 2007), limits the generalizability of nutrient supplement effects within a healthy and adequately nourished population. Nutritional status at baseline may modify long-term health effects of nutritional supplements as may the age at which nutritional supplements are initiated and the duration of their use (Fairfield, 2007). Moreover, typical users of multivitamin/mineral supplements are older, non-Hispanic white women and individuals with higher education and physical activity levels, lower BMI, and greater nutrient adequacy from dietary intake (Rock, 2007). These demographic and physical characteristics are also positively correlated to an overall healthy lifestyle, including health care screening and self-efficacy in primary prevention of chronic disease. Distinguishing the contribution of a single-nutrient or combined-nutrient supplement to long-term health outcomes is difficult in a healthy population (Coates, 2007b).

NUTRIENT INTAKE AND SELECTED BEHAVIORS

Meeting food and nutrient intake recommendations is challenging for many Americans. The DGAC evaluated selected individual behaviors to explore factors that may be associated with nutrient intakes.

Question 8: What is the Relationship between Nutrient Intake and Breakfast Consumption, Snacking, and Eating Frequency?

Conclusion

Moderate evidence supports a positive relationship between breakfast consumption and intakes of certain nutrients in children, adolescents, and adults. A limited body of evidence supports a positive relationship between snacking and increased nutrient intake in children, adolescents, adults, and older adults, and inadequate evidence is available to evaluate the relationship between eating frequency and nutrient intakes.

Implications

Americans are encouraged to eat nutrient-dense forms of foods for breakfast while staying within energy needs to facilitate achieving nutrient recommendations. Likewise nutrient-dense forms of foods are suggested for any snacks, if energy allowance permits this behavior without incurring weight gain.

Review of the Evidence

Individual behaviors influence the intake of foods and nutrients. The DGAC conducted systematic reviews to address selected behaviors and their association with nutrient intakes.

Breakfast Consumption

Without consideration of nutrient composition, some evidence supports a positive relationship between the behavior of breakfast eating and higher intakes of certain nutrients across different stages of the lifespan. The DGAC reviewed 15 studies published since 2004. Of these 15 studies, one systematic review included studies with children and adolescents (Rampersaud, 2005), while four primary studies included only adults (Kerver, 2006; Song, 2005; van der Heijden, 2007; Williams, 2005), nine evaluated children and/or adolescents (Affenito, 2005; Dubois, 2009; Matthys, 2007; Nelson, 2007; Stockman, 2005; Timlin, 2008; Williams, 2007; Williams, 2009; Woodruff, 2008), and one included adolescents and adults (Song, 2006). The exact same nutrients were not evaluated in all studies, but individuals who consumed breakfast on a daily basis consistently reported higher intakes of thiamin, niacin, riboflavin, vitamins B_6 and B_{12}, dietary folate, vitamins A and C, calcium, iron, magnesium, phosphorus, potassium, and zinc. In studies that included dietary fiber, breakfast intake was associated with higher intakes. An equal number of studies showed that breakfast consumers had higher, lower, or no difference in total fat, saturated fat, cholesterol, and sodium intakes compared to non-consumers of breakfast.

Snacking

Limited evidence published since 2004, supports a positive relationship between snacking and higher nutrient intakes at various stages of the lifespan. Seven studies were reviewed; three included children or adolescents (Macdiarmid, 2009; Maffeis, 2008; Sebastian, 2008), and four examined adults or older adults (Kerver, 2006; Ovaskainen, 2006; Stockman, 2005; Zizza, 2007). The same nutrients were not evaluated in all studies, but in general, snacking was associated with higher intakes of macronutrients and dietary folate, vitamin C, calcium, magnesium, iron, potassium, and dietary fiber but also higher intakes of total sugars and saturated fatty acids. Snacking by some adolescents and adults was associated with lower intakes of protein, fat, cholesterol, and iron, but data were inconsistent.

Eating Frequency

Only three cross-sectional studies were published since 2004 (Kerver, 2006; Macdiarmid, 2009; Storey, 2009) that met the criteria for review to evaluate the relationship between eating frequency and nutrient intakes. Given this lack of robust evidence, the DGAC was unable to draw a conclusion regarding nutrient intakes and eating frequency.

Relevant Contextual Issues

A clear and consistent operational definition of breakfast did not exist and varied across studies reviewed. In fact, breakfast consumption and breakfast skipping were defined uniquely in most studies. Likewise, consistent definitions for snacking and eating frequency were not used. A variety of nutrients were included in dietary intake analyses, and the possibility of publication bias for positive results exists.

Energy density of breakfast foods has an inverse relationship with daily intakes of selected micronutrients, including vitamins A, C, and E, and potassium, magnesium, and phosphorus, as well as dietary fiber (Kant, 2008). Consuming nutrient-dense breakfast foods within a total daily diet that is low in energy-density may facilitate meeting nutrient recommendations.

Chapter Summary

Americans are encouraged to lower overall energy intakes to match their energy needs. Energy-dense forms of foods, especially foods high in SoFAS, should be replaced with nutrient-dense forms of vegetables, fruits, whole grains, and fluid milk and milk products to increase intakes of shortfall nutrients and nutrients of concern—vitamin D, calcium, potassium, and dietary fiber. Women of reproductive capacity should consume foods rich in folate and iron, and older individuals should consume foods rich in vitamin B_{12} or the crystalline form of B_{12} supplements. A daily multivitamin/mineral supplement is unlikely to offer health benefits to healthy Americans. Breakfast consumption and some snacking may assist in meeting nutrient recommendations, notably if included foods are in nutrient-dense forms.

Needs for Future Research

Recommendations for further studies include:

Nutrients and Dietary Components Overconsumed

1. Develop and test behavior-based interventions designed to lower dietary intakes of nutrients and dietary components overconsumed, focusing on SoFAS.

   Rationale: SoFAS contribute a substantial number of calories to the typical American diet without adding important micronutrients. Interventions that are proven successful in lowering dietary components overconsumed are needed to assist consumers and health care providers.

Food Groups and Selected Dietary Components Underconsumed

2. Conduct clinical trials in children and adults to critically examine the impact of adherence to the 2010 *Dietary Guidelines for Americans* as a total dietary approach to a healthy lifestyle on body weight change, CVD, type 2 diabetes, cancer, and osteoporosis and related clinical endpoints.

   Rationale: Theoretically, food-based dietary guidance supports achievement of nutrient adequacy across age-sex groups. Total diets, including variation in eating and dietary patterns, compared to individual nutrients, have been insufficiently tested for their health outcomes.

3. Quantitatively and/or qualitatively investigate how the food environment facilitates or hinders achievement of food groups and dietary components recommendations, notably in individuals enrolled in food assistance programs, particularly children participating in school breakfast and lunch programs, and/or across various ethnic and cultural groups.

   Rationale: Compliance with dietary guidance is poor. Understanding the food environment at all levels will assist individuals and shape public policy toward intakes that meet recommendations for food groups and dietary components.

Vitamin D

4. Conduct high-quality, long-term dose-response studies with relevant health outcomes including bone as well as functional outcomes related to the immune system, autoimmune disorders, and chronic diseases such as coronary heart disease, hypertension, cancer, and diabetes.

Rationale: There is a need for additional research on the relation between threshold values of 25(OH)D and relevant functional outcomes at each life stage and in understudied populations.

5. Investigate the metabolic partitioning, fate, and mobilization of key vitamin D metabolites at recommended and greater than recommended levels.

   Rationale: Studies that assess the availability of stored vitamin D, and relative contributions of endogenously produced and dietary vitamin D, and impact of important confounders such as body weight and body fat on vitamin status are warranted (Brannon, 2008b).

Folate

6. Conduct studies on the long-term health impact of fortification on NTDs, CRC, stroke, cognitive function, and other health outcomes, such as emerging evidence suggesting that high folic acid intakes in some pregnant women may lead to asthma in their offspring (Whitrow, 2009), to fully understand the impact of this ecological experiment.

   Rationale: A substantial amount of time has elapsed since the US and Canada mandated folic acid fortification. Since 1998, many research studies have evaluated the benefits and risks of fortification. Much of the research demonstrated benefit, while some of the research has shown increased health risk. Further research is warranted.

Vitamin, Mineral, and Nutrient Supplements

7. Conduct studies on the precision in self-reported intakes of multivitamin/mineral supplements.

   Rationale: More than one-half of the population reports the use of nutrient supplements; however, the frequency and consistency of this use is sporadic for many. Greater accuracy in self-reported use of nutrient supplements is important to understanding short- and long-term health effects.

8. Develop accurate composition and bioavailability data across the multitude of vitamin, mineral, and nutrient supplements. Evaluate outcomes based on nutrient composition and bioavailability within the multivitamin/mineral matrix.

   Rationale: Precise composition of supplements is critical to determining interactions of nutrients within each supplement preparation and potential benefits and risks of the matrix of nutrients from supplements consumed with foods.

9. Conduct randomized controlled trials that rigorously test health outcomes, including safety and risk assessments, of nutrient supplements in a diverse range of healthy population groups.

   Rationale: Research on the efficacy and safety of nutrient supplements is vital to the guidance of public policy recommendations, given that the majority of Americans use nutrient supplements at any point in time.

Nutrient Adequacy and Eating Behaviors

10. Convene a consensus panel to define breakfast, breakfast consumers, and breakfast skipping; snacking; and eating frequency that can be consistently applied to studies.

    Rationale: Identifying healthful eating behaviors is important to primary prevention of chronic disease in Americans. Common definitions of specific eating behaviors are vital to testing and understanding the role of these behaviors in health and wellness.

11. Conduct longitudinal studies on the cumulative nutritional risks of breakfast skipping and/or health benefits of breakfast consumption. Identify critical components of breakfast and snacks, such as vegetables, fruits, whole grains, and/or fluid milk and milk products, and their related health benefits.

    Rationale: Breakfast intake is associated with positive outcomes such as improved school performance among children. Further understanding of other nutrition-related health benefits is needed.

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Part D. Section 2: Nutrient Adequacy—Tables

Table number	Table title
TABLE D2.1	Nutritional goals for age/sex groups, based on Dietary Reference Intakes and Dietary Guidelines recommendations, and USDA food patterns using these goals as targets
TABLE D2.2	Vitamin A: Selected food sources ranked by amounts of vitamin A and energy per standard food portion and per 100 grams of foods
TABLE D2.3	Vitamin C: Selected food sources ranked by amounts of vitamin C and energy per standard food portion and per 100 grams of foods
TABLE D2.4	Vitamin K: Selected food sources ranked by amounts of vitamin K and energy per standard food portion and per 100 grams of foods
TABLE D2.5	Vitamin E: Selected food sources ranked by amounts of vitamin E and energy per standard food portion and per 100 grams of foods
TABLE D2.6	Choline: Selected food sources ranked by amounts of choline and energy per standard food portion and per 100 grams of foods
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TABLE D2.18	Folate: Selected food sources ranked by amounts of folate and energy per standard food portion and per 100 grams of foods
TABLE D2.19	Iron: Selected food sources ranked by amounts of iron and energy per standard food portion and per 100 grams of foods
TABLE D2.20	Vitamin B_{12}: Selected food sources ranked by amounts of vitamin B_{12} and energy per standard food portion and per 100 grams of foods

Table D2.1. Nutritional goals for age/sex groups, based on Dietary Reference Intakes and Dietary Guidelines recommendations, and USDA food patterns using these goals as targets[1]

Nutrient (units)	Source of goal	Child 1-3	Female 4-8	Male 4-8	Female 9-13	Male 9-13	Female 14-18	Male 14-18	Female 19-30	Male 19-30	Female 31-50	Male 31-50	Female 51+	Male 51+
Macronutrients														
Protein (g)	RDA[2]	13	19	19	34	34	46	52	46	56	46	56	46	56
(% of calories)	AMDR[3]	5-20	10-30	10-30	10-30	10-30	10-30	10-30	10-35	10-35	10-35	10-35	10-35	10-35
Carbohydrate (g)	RDA	130	130	130	130	130	130	130	130	130	130	130	130	130
(% of calories)	AMDR	45-65	45-65	45-65	45-65	45-65	45-65	45-65	45-65	45-65	45-65	45-65	45-65	45-65
Total fiber (g)	14g/1000 kcal[4]	14	17	20	22	25	25	31	28	34	25	31	22	28
Total fat (% kcal)	AMDR	30-40	25-35	25-35	25-35	25-35	25-35	25-35	20-35	20-35	20-35	20-35	20-35	20-35
Saturated fat (% kcal)	DG[5]	<10%	<10%	<10%	<10%	<10%	<10%	<10%	<10%	<10%	<10%	<10%	<10%	<10%
Linoleic acid (g)	AI	7	10	10	10	12	11	16	12	17	12	17	11	14
(% kcal)	AMDR	5-10	5-10	5-10	5-10	5-10	5-10	5-10	5-10	5-10	5-10	5-10	5-10	5-10
α-Linolenic acid (g)	AI	0.7	0.9	0.9	1.0	1.2	1.1	1.6	1.1	1.6	1.1	1.6	1.1	1.6
(% kcal)	AMDR	0.6-1.2	0.6-1.2	0.6-1.2	0.6-1.2	0.6-1.2	0.6-1.2	0.6-1.2	0.6-1.2	0.6-1.2	0.6-1.2	0.6-1.2	0.6-1.2	0.6-1.2
Cholesterol (mg)	DG	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
Minerals														
Calcium (mg)	AI[6]	500	800	800	1300	1300	1300	1300	1000	1000	1000	1000	1200	1200
Iron (mg)	RDA	7	10	10	8	8	15	11	18	8	18	8	8	8
Magnesium (mg)	RDA	80	130	130	240	240	360	410	310	400	320	420	320	420
Phosphorus (mg)	RDA	460	500	500	1250	1250	1250	1250	700	700	700	700	700	700
Potassium (mg)	AI	3000	3800	3800	4500	4500	4700	4700	4700	4700	4700	4700	4700	4700
Sodium (mg)	UL[7]	<1500	<1900	<1900	<2200	<2200	<2300	<2300	<2300	<2300	<2300	<2300	<2300	<2300
Zinc (mg)	RDA	3	5	5	8	8	9	11	8	11	8	11	8	11
Copper (μg)	RDA	340	440	440	700	700	890	890	900	900	900	900	900	900
Selenium (μg)	RDA	20	30	30	40	40	55	55	55	55	55	55	55	55

(Table continues on next page.)

Table D2.1 (continued). Nutritional goals for age/sex groups, based on Dietary Reference Intakes and Dietary Guidelines recommendations, and USDA food patterns using these goals as targets[1]

Nutrient (units)	Source of goal	Child 1-3	Female 4-8	Male 4-8	Female 9-13	Male 9-13	Female 14-18	Male 14-18	Female 19-30	Male 19-30	Female 31-50	Male 31-50	Female 51+	Male 51+
Vitamins														
Vitamin A (µg RAE)	RDA	300	400	400	600	600	700	900	700	900	700	900	700	900
Vitamin D (µg)	AI	5	5	5	5	5	5	5	5	5	5	5	10	10
Vitamin E (mg AT)	RDA	6	7	7	11	11	15	15	15	15	15	15	15	15
Vitamin C (mg)	RDA	15	25	25	45	45	65	75	75	90	75	90	75	90
Thiamin (mg)	RDA	0.5	0.6	0.6	0.9	0.9	1	1.2	1.1	1.2	1.1	1.2	1.1	1.2
Riboflavin (mg)	RDA	0.5	0.6	0.6	0.9	0.9	1	1.3	1.1	1.3	1.1	1.3	1.1	1.3
Niacin (mg)	RDA	6	8	8	12	12	14	16	14	16	14	16	14	16
Vitamin B_6 (mg)	RDA	0.5	0.6	0.6	1	1	1.2	1.3	1.3	1.3	1.3	1.3	1.5	1.7
Vitamin B_{12} (µg)	RDA	0.9	1.2	1.2	1.8	1.8	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Choline (mg)	AI	200	250	250	375	375	400	550	425	550	425	550	425	550
Vitamin K (µg)	AI	30	55	55	60	60	75	75	90	120	90	120	90	120
Folate (µg DFE)	RDA	150	200	200	300	300	400	400	400	400	400	400	400	400
USDA Food pattern using goals as targets		1000	1200	1400	1600	1800	1800	2200	2000	2400	1800	2200	1600	2000

[1]USDA Food intake patterns at 2600, 2800, 3000, and 3200 calories were designed to meet the needs of males 14 to 18 and 19 to 30. Their nutritional goals are the same as for the patterns at 2200 and 2400 calories.
[2] Recommended Dietary Allowance, IOM.
[3] Acceptable Macronutrient Distribution Range, IOM.
[4] 14 grams per 1000 calories, IOM.
[5] Dietary Guidelines recommendation.
[6] Adequate Intake, IOM.
[7] Upper Limit, IOM.
Sources: IOM 2006, Britten et al., 2006.

Table D2.2. Vitamin A: Food sources ranked by amounts of vitamin A and energy per standard food portions and per 100 grams of foods (Amounts of vitamin A present in standard food portions are ≥ 20% of RDA for adult men, which is 900 μg RAE [1])

Food	Standard portion size	Calories in standard portion[2]	Vitamin A in standard portion (μg RAE)[2]	Calories per 100 grams[2]	Vitamin A per 100 grams (μg RAE) [2]
Organ meats (liver, giblets), various, cooked	3 ounces	133-169	1490-9126	157-199	1753-10737
Carrot juice	1 cup	94	2256	40	956
Braunschweiger (pork liver sausage)	2 slices (~1 ½ ounces)	118	1519	327	4220
Sweet potato, baked	1 medium	103	1096	90	961
Pumpkin, cooked from fresh or canned	½ cup	24-42	306-953	20-34	250-778
Carrots, cooked from fresh, frozen, or canned	½ cup	18-27	407-665	25-37	558-852
Spinach, cooked from fresh, frozen, or canned	½ cup	21-32	472-573	23-34	490-603
Carrot, raw	½ cup	25	509	41	835
Collards, cooked from fresh or frozen	½ cup	25-31	386-489	26-36	406-575
Kale, cooked from fresh or frozen	½ cup	18-20	443-478	28-30	681-735
Mixed vegetables, cooked from frozen or canned	½ cup	40-59	195-475	49-65	214-583
Turnip greens, cooked from fresh or frozen	½ cup	14-24	274-441	20-29	381-538
Fortified instant cereals (various)	1 packet	102-157	318-376	68-101	186-265
Fortified ready-to-eat cereals (various)	¾ - 1 ¼ cup (~1 ounce)	110-190	177-307	322-433	442-991
Beet greens, cooked from fresh	½ cup	19	276	27	383
Winter squash, cooked	½ cup	38	268	37	261
Mustard greens, cooked from fresh	½ cup	10	221	15	316
Pickled herring	3 ounces	223	219	262	258
Romaine lettuce	1 cup	8	205	17	436
Dandelion greens, cooked	½ cup	17	180	33	342
Chinese cabbage, cooked	½ cup	10	180	12	212

[1]Retinol activity equivalents.
[2]Source: US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. 2009. USDA National Nutrient Database for Standard Reference, Release 22. Available at: http://www.ars.usda.gov/ba/bhnrc/ndl.

Table D2.3. Vitamin C: Food sources ranked by amounts of vitamin C and energy per standard food portions and per 100 grams of foods (amounts of vitamin C present in standard food portions are ≥ 20% of RDA for adult men, which is 90 mg)

Food	Standard portion size	Calories in standard portion[1]	Vitamin C in standard portion (mg)[1]	Calories per 100 grams[1]	Vitamin C per 100 grams (mg)[1]
Guava	½ cup	37	126	68	228
Orange juice	1 cup	112	124	45	50
Peaches, frozen, sweetened	½ cup	118	118	94	94
Sweet red pepper, cooked from fresh	½ cup	19	115	28	171
Grapefruit juice	1 cup	96	94	39	38
Orange	1 medium	62	70	47	53
Vegetable juice cocktail	1 cup	46	67	19	28
Kiwi	1 medium	42	64	61	93
Fortified ready-to-eat cereals (various)	¾ - 1 1/3 cup (~1 ounce)	92-112	60-61	318-373	200-207
Grape juice cocktail	1 cup	128	60	51	24
Sweet red pepper, raw	½ cup	14	59	31	128
Strawberries, frozen, sweetened	½ cup	122	53	96	41
Broccoli, cooked from fresh and frozen	½ cup	26-27	37-51	28-35	40-65
Sweet green pepper, cooked from fresh	½ cup	19	50	28	74
Strawberries	½ cup	27	49	32	59
Brussels sprouts, cooked from fresh and frozen	½ cup	28	48	36	62
Kohlrabi, cooked	½ cup	24	45	29	54
Papaya	½ cup	27	43	39	62
Broccoli, raw	½ cup	15	39	34	89
Pineapple	½ cup	41	39	50	48
Edible pea pods, cooked	½ cup	34	38	42	48
Grapefruit	½ cup	38	38	33	33
Sweet green pepper, raw	½ cup	9	37	20	80
Cantaloupe	½ cup	27	29	34	37
Cauliflower, cooked from fresh and frozen	½ cup	14-17	28	19-23	31-44
Cabbage, cooked from fresh	½ cup	17	28	23	38
Grapefruit, canned	½ cup	76	27	60	21
Kale, cooked from fresh	½ cup	18	27	28	41
Sweet potato, canned	½ cup	91	26	91	26
Cauliflower, raw	½ cup	13	26	25	48

Table D2.3 (continued). Vitamin C: Food sources ranked by amounts of vitamin C and energy per standard food portions and per 100 grams of foods (amounts of vitamin C present in standard food portions are ≥ 20% of RDA for adult men, which is 90 mg)

Food	Standard portion size	Calories in standard portion[1]	Vitamin C in standard portion (mg)[1]	Calories per 100 grams[1]	Vitamin C per 100 grams (mg)[1]
Tangerines (mandarin oranges), canned	½ cup	77	25	61	20
Tangerine	1 medium	47	24	53	27
Mango	½ cup	54	23	65	28
Tomato juice	½ cup	21	22	17	18
Collards, cooked from frozen	½ cup	31	22	36	26
Chinese cabbage, cooked from fresh	½ cup	10	22	12	26
Asparagus, cooked from frozen	½ cup	16	22	18	24
Sweet potato, baked	1 medium	103	22	90	20
Raspberries, frozen, sweetened	½ cup	129	21	103	17
Red cabbage, raw	½ cup	11	20	31	57
Turnip greens, cooked from fresh	½ cup	14	20	20	27
Potato, baked	1 medium	145	20	93	13
Carambola (starfruit)	½ cup	17	19	31	34

[1]Source: US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. 2009. USDA National Nutrient Database for Standard Reference, Release 22. Available at: http://www.ars.usda.gov/ba/bhnrc/ndl.

Table D2.4. Vitamin K: Food sources ranked by amounts of vitamin K and energy per standard food portions and per 100 grams of foods (amounts of vitamin K present in standard food portions are ≥ 20% of RDA for adult men, which is 120 μg)

Food	Standard portion size	Calories in standard portion[1]	Vitamin K in standard portion (μg)[1]	Calories per 100 grams[1]	Vitamin K per 100 grams (μg g) [1]
Kale, cooked from fresh or frozen	½ cup	18-20	531-573	28-30	817-882
Collards, cooked from fresh or frozen	½ cup	25-31	418-530	26-36	440-623
Spinach, cooked from fresh, frozen, or canned	½ cup	21-32	444-514	23-34	462-541
Turnip greens, cooked from fresh or frozen	½ cup	14-24	265-426	20-29	368-519
Beet greens, cooked from fresh	½ cup	19	349	27	484
Dandelion greens, cooked from fresh	½ cup	17	290	33	551
Mustard greens, cooked from fresh	½ cup	10	210	15	300
Spinach egg noodles, cooked	1 cup	211	162	132	101
Brussels sprouts, cooked from fresh or frozen	½ cup	28-33	109-150	36-42	140-194
Spinach, raw	1 cup	7	145	23	483
Broccoli, cooked from fresh or frozen	½ cup	26-27	81-110	28-35	88-141
Cabbage, cooked from fresh	½ cup	17	82	23	109
Asparagus, cooked from frozen	½ cup	16	72	18	80
Green leaf lettuce	1 cup	5	63	15	174
Cabbage, raw	1 cup	18	53	25	76
Romaine lettuce	1 cup	8	48	17	103
Savoy cabbage	1 cup	19	48	27	69
Broccoli, raw	½ cup	15	46	34	102
Okra, cooked from fresh or frozen	½ cup	18-26	32-44	22-28	40-48
Tuna, canned in oil, drained	3 ounces	168	37	198	44
Dried plums (prunes), stewed	½ cup	133	32	107	26
Green peas, canned	½ cup	60	32	69	37
Cowpeas, cooked from frozen	½ cup	112	31	132	37
Green snap beans, canned	½ cup	18	30	23	39
Chinese cabbage, cooked from fresh	½ cup	10	29	12	34
Celery, cooked	½ cup	14	28	18	38
Kiwifruit	1 medium	42	28	61	40
Dried plums (prunes)	¼ cup	104	26	240	60
Rhubarb, cooked from frozen, sweetened	½ cup	139	25	116	21
Peas, edible-podded, cooked from frozen	½ cup	42	24	52	30

[1]Source: US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. 2009. USDA National Nutrient Database for Standard Reference, Release 22. Available at: http://www.ars.usda.gov/ba/bhnrc/ndl.

Table D2.5. Vitamin E: Food sources ranked by amounts of vitamin E and energy per standard food portions and per 100 grams of foods (amounts of vitamin E present in standard food portions are ≥ 10% of RDA for adults, which is 15 mg)

Food	Standard portion size	Calories in standard portion[1]	Vitamin E in standard portion (mg)[1]	Calories per 100 grams[1]	Vitamin E per 100 grams (mg)[1]
Fortified ready-to-eat cereals (various)	¾ - 1 1/3 cup (~1 ounce)	92-188	3.2-13.5	309-384	6.6-46.4
Almonds	1 ounce	163	7.4	575	26.2
Sunflower seeds, dry roasted	1 ounce	165	7.4	582	26.1
Sunflower oil, high linoleic	1 Tbsp	120	5.6	884	41.1
Cottonseed oil	1 Tbsp	120	4.8	884	35.3
Safflower oil, high oleic	1 Tbsp	120	4.6	884	34.1
Hazelnuts (filberts)	1 ounce	178	4.3	628	15.0
Spinach, cooked from fresh, frozen, or canned	½ cup	21-32	1.9-3.4	23-34	1.9-3.5
Mixed nuts, dry roasted	1 ounce	168	3.1	594	10.9
Peanut butter	2 Tbsp	188	2.9	588	9.0
Tomato paste	¼ cup	54	2.8	82	4.3
Pine nuts	1 ounce	191	2.7	673	9.3
Tomato puree	½ cup	48	2.5	38	2.0
Canola oil	1 Tbsp	124	2.4	884	17.5
Peanuts, dry roasted	1 ounce	166	2.2	585	7.8
Turnip greens, cooked from frozen	½ cup	24	2.2	29	2.7
Peanut oil	1 Tbsp	119	2.1	884	15.7
Corn oil	1 Tbsp	120	1.9	884	14.3
Olive oil	1 Tbsp	119	1.9	884	14.4
Sardines, canned in oil, drained	3 ounces	177	1.7	208	2.0
Soybean oil	1 Tbsp	120	1.7	884	12.1
Blue crab, cooked or canned	3 ounces	84-87	1.6	99-102	1.8
Brazil nuts	1 ounce	186	1.6	656	5.7
Orange roughy, cooked	3 ounces	89	1.6	105	1.9
Avocado	½ cup	117	1.5	160	2.1

[1]Source: US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. 2009. USDA National Nutrient Database for Standard Reference, Release 22. Available at: http://www.ars.usda.gov/ba/bhnrc/ndl.

Table D2.6. Choline: Food sources ranked by amounts of choline and energy per standard food portions and per 100 grams of foods (amounts of choline present in standard food portions are ≥ 10% of AI for adult men, which is 550 mg)

Food	Standard portion size	Calories in standard portion[1]	Choline in standard portion (mg)[1]	Calories per 100 grams[1]	Choline per 100 grams (mg)[1]
Organ meats (liver, giblets), various, cooked	3 ounces	133-169	133-356	157-199	157-418
Egg, hard-boiled	1 large	78	113	155	225
Beef, various cuts, lean, cooked	3 ounces	144-215	95-111	169-253	112-131
Pork, various cuts, lean, cooked	3 ounces	153-211	65-94	180-248	76-111
Braunschweiger (pork liver sausage)	2 slices (~1 ½ ounces)	118	92	327	256
Lamb, various cuts, lean, cooked	3 ounces	162-184	89-92	191-216	104-108
Herring, pickled	3 ounces	223	89	262	104
Ham, cured, lean	3 ounces	133	87	157	102
Corned beef	3 ounces	213	76	250	89
Salmon, smoked	3 ounces	99	76	117	89
Salmon, canned	3 ounces	118	75	139	88
Chicken breast, cooked	3 ounces	140	73	165	85
Cod, canned	3 ounces	89	72	105	85
Flatfish (flounder and sole), cooked	3 ounces	99	71	117	83
Turkey, cooked	3 ounces	144	70	170	83
Rockfish, cooked	3 ounces	103	69	121	81
Pollock (walleye), cooked	3 ounces	96	69	113	81
Clams, canned, drained	3 ounces	126	69	148	81
Shrimp, canned	3 ounces	85	69	100	81
Blue crab, cooked	3 ounces	87	69	102	81
Lobster, cooked	3 ounces	83	69	98	81
Sardines, canned in oil, drained	3 ounces	177	64	208	75
Soymilk, original and vanilla	1 cup	131	57	54	23
Salmon, cooked	3 ounces	184	56	216	66

[1]Source: US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. 2009. USDA National Nutrient Database for Standard Reference, Release 22. Available at: http://www.ars.usda.gov/ba/bhnrc/ndl.

Table D2.7. Magnesium: Selected food sources ranked by amounts of magnesium and energy per standard food portion and per 100 grams of foods (amounts of magnesium present in standard food portions are ≥ 10% of RDA for adult men, which is 420 mg)

Food	Standard portion size	Calories in standard portion[1]	Magnesium in standard portion (mg)[1]	Calories per 100 grams[1]	Magnesium per 100 grams (mg)[1]
Pumpkin/squash seed kernels, roasted	1 ounce	163	156	574	550
Brazil nuts, dried	1 ounce	186	107	656	376
Oat bran muffin	1 small	178	104	270	157
Halibut, cooked	3 ounces	119	91	140	107
Bran ready-to-eat cereal (100%)	1/3 cup (~1 ounce)	81	112	260	362
Spinach, cooked from fresh, frozen, or canned	½ cup	21-32	78-81	23-34	76-87
Almonds	1 ounce	163	76	575	268
Cashews, dry roasted	1 ounce	163	74	574	260
Soybeans, mature, cooked	½ cup	149	74	173	86
Pine nuts, dried	1 ounce	191	71	673	251
White beans, canned	½ cup	149	67	114	51
Mixed nuts with peanuts, dry roasted	1 ounce	168	64	594	225
Pollock, walleye, cooked	3 ounces	96	62	113	73
Soymilk	1 cup	131	61	54	25
Black beans, cooked	½ cup	114	60	132	70
Soybeans, green, cooked	½ cup	127	54	141	60
Tuna, yellowfin, cooked	3 ounces	118	54	139	64
Peanuts, dry roasted	1 ounce	166	50	585	176
Lima beans, cooked	½ cup	94	50	105	56
Flatfish (flounder and sole), cooked	3 ounces	99	49	117	58
Beet greens, cooked from fresh	½ cup	19	49	27	68
Navy beans, cooked	½ cup	127	48	140	53
Tofu, firm, nigari	½ cup	88	47	70	37
Okra, cooked from frozen	½ cup	26	47	28	51
Cowpeas, cooked	½ cup	100	46	116	53
Hazelnuts	1 ounce	178	46	628	163
English walnuts	1 ounce	185	45	654	158
Great northern beans, cooked	½ cup	104	44	118	50
Oat bran, cooked	½ cup	44	44	40	40
Plain yogurt, nonfat	8 ounce container	127	43	56	19
Buckwheat groats, roasted, cooked	½ cup	77	43	92	51
Brown rice, cooked	½ cup	109	43	112	44
Pinto beans, cooked	½ cup	122	43	143	50
Haddock, cooked	3 ounces	95	42	112	50

[1]Source: US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. 2009. USDA National Nutrient Database for Standard Reference, Release 22. Available at: http://www.ars.usda.gov/ba/bhnrc/ndl.

Table D2.8. Phosphorus: Food sources ranked by amounts of phosphorus and energy per standard food portions and per 100 grams of foods (amounts of phosphorus present in standard food portions are ≥ 25% of AI for adults, which is 700 mg)

Food	Standard portion size	Calories in standard portion[1]	Phosphorus in standard portion (mg)[1]	Calories per 100 grams[1]	Phosphorus per 100 grams (mg)[1]
Pasteurized process Swiss cheese	2 ounces	189	432	334	762
Sardines, canned in oil, drained	3 ounces	177	417	208	490
Beef liver, pan-fried	3 ounces	149	412	175	485
Pollock, cooked	3 ounces	96	410	113	482
Bran ready-to-eat cereal (100%)	½ cup (~1 ounce)	81	356	260	1150
Plain yogurt, whole, low-fat, and nonfat	8 ounce container	127-143	216-356	56-63	95-157
Pumpkin and squash seed kernels, roasted	1 ounce	163	333	574	1174
Sunflower seed kernels, roasted	1 ounce	165	327	582	1155
Clams, canned, drained	3 ounces	126	287	148	338
Swordfish, cooked	3 ounces	132	286	155	337
Salmon, canned	3 ounces	118	280	139	329
Tuna, light, canned in oil, drained	3 ounces	168	264	198	311
Chocolate milk, whole, reduced fat, and low-fat	1 cup	158-208	252-258	63-83	101-103
Evaporated milk, whole and nonfat	½ cup	100-169	250-256	78-134	195-203
Oat bran muffin	1 small	178	248	270	376
Milk, whole, reduced fat, low-fat, and skim	1 cup	83-149	205-247	34-61	84-101
Chicken giblets, cooked	3 ounces	133	246	157	289
Flatfish (flounder and sole), cooked	3 ounces	99	246	117	289
Halibut, cooked	3 ounces	119	242	140	285
Swiss cheese	1 ½ ounces	162	241	380	567
Pork, cooked, various cuts	3 ounces	153-337	180-239	180-397	212-281
Alaska king crab, cooked	3 ounces	82	238	97	280
Sockeye salmon, cooked	3 ounces	184	235	216	276
Perch, cooked	3 ounces	103	235	121	277
Rainbow trout, cooked	3 ounces	144	226	169	266
Ricotta cheese, whole and part skim	½ cup	170-216	196-225	138-174	158-183
Part skim mozzarella cheese	1 ½ ounces	128	223	302	524
Cod, canned	3 ounces	89	221	105	260
Blue crab, canned	3 ounces	84	221	99	260

Table D2.8 (continued). Phosphorus: Food sources ranked by amounts of phosphorus and energy per standard food portions and per 100 grams of foods (amounts of phosphorus present in standard food portions are ≥ 25% of AI for adults, which is 700 mg)

Food	Standard portion size	Calories in standard portion[1]	Phosphorus in standard portion (mg)[1]	Calories per 100 grams[1]	Phosphorus per 100 grams (mg)[1]
Low-fat buttermilk (1%)	1 cup	98	218	40	89
Cheddar cheese	1 ½ ounces	171	218	403	512
Soybeans, mature, cooked	½ cup	149	211	173	245
Provolone cheese	1 ½ ounces	149	211	351	496
Yellowfin tuna, cooked	3 ounces	118	208	139	245
Brazil nuts, dried	1 ounce	186	206	656	725
Haddock, cooked	3 ounces	95	205	112	241
Beef, cooked, various cuts	3 ounces	151-215	178-200	178-253	209-235
Muenster cheese	1 ½ ounces	156	199	368	468
Lamb, cooked, various cuts	3 ounces	184-294	175-197	216-346	206-232
Turkey giblets, cooked	3 ounces	169	196	199	231
Rockfish, cooked	3 ounces	103	194	121	228
Cured ham	3 ounces	133-207	182-193	157-243	214-227
Cod, cooked	3 ounces	89	190	105	223
Cottage cheese, nonfat, 1% and 2%	½ cup	52-97	138-184	72-86	134-190
Turkey, cooked	3 ounces	144	181	170	213
Lentils, cooked	½ cup	115	178	116	180
Blue crab, cooked	3 ounces	87	175	102	206
Chicken, cooked	3 ounces	201	173	237	204

[1]Source: US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. 2009. USDA National Nutrient Database for Standard Reference, Release 22. Available at: http://www.ars.usda.gov/ba/bhnrc/ndl.

Table D2.9. Functions of nutrients of concern

Nutrient	Function
Calcium	Calcium is the key nutrient in the development and maintenance of bones; additionally calcium aids in blood clotting and muscle and nerve functioning.
Vitamin D	Vitamin D aids in the intestinal absorption of calcium and phosphorus, so it helps to maintain serum levels of these minerals in the body at normal levels. Vitamin D also plays roles in cellular metabolism, which involve antiproliferation and prodifferentiation actions.
Potassium	Potassium assists in muscle contraction, maintaining fluid and electrolyte balance in cells, transmitting nerve impulses, and releasing energy during metabolism. Diets rich in potassium lower blood pressure, blunt the adverse effects of salt on blood pressure, may reduce the risk of developing kidney stones, and may decrease bone loss.
Dietary Fiber	Fiber helps maintain the health of the digestive tract and promotes proper bowel functioning.

Source: Adapted from *Dietary Reference Intakes: The Essential Guide to Nutrient Requirements*, (IOM, 2006).

Table D2.10. Vitamin D: Food sources ranked by amounts of vitamin D and energy per standard food portions and per 100 grams of foods (amounts of vitamin D present in standard food portions are ≥ 10% of AI for adults 19-50, which is 5 μg)

Food	Standard portion size	Calories in standard portion[1]	Vitamin D in standard portion (μg) [1]	Calories per 100 grams[1]	Vitamin D per 100 grams (μg) [1]
Salmon, sockeye, cooked	3 ounces	184	19.8	216	23.3
Salmon, smoked	3 ounces	99	14.5	117	17.1
Salmon, canned	3 ounces	118	11.6	139	13.7
Rockfish, cooked	3 ounces	103	6.5	121	7.7
Tuna, light, canned in oil, drained	3 ounces	168	5.7	198	6.7
Sardine, canned in oil, drained	3 ounces	177	4.1	208	4.8
Tuna, light, canned in water, drained	3 ounces	99	3.8	116	4.5
Whole milk[2]	1 cup	149	3.2	61	1.3
Whole chocolate milk[2]	1 cup	208	3.2	83	1.3
Reduced fat chocolate milk (2%)[2]	1 cup	190	3.0	76	1.2
Milk (nonfat, 1% and 2%)[2]	1 cup	83-122	2.9	34-50	1.2
Low-fat chocolate milk (1%)[2]	1 cup	158	2.8	63	1.1
Soymilk[2]	1 cup	104	2.7	43	1.1
Evaporated milk, nonfat[2]	½ cup	100	2.6	78	2
Flatfish (flounder and sole), cooked	3 ounces	99	2.5	117	3.0
Fortified ready-to-eat cereals (various) [2]	¾ - 1 ¼ cup (~1 ounce)	92-190	0.9-2.5	309-387	2.9-8.3
Rice drink[2]	1 cup	113	2.4	47	1.0
Herring, pickled	3 ounces	223	2.4	262	2.8
Pork, cooked (various cuts)	3 ounces	153-337	0.6-2.2	180-397	0.7-2.6
Orange juice[2]	½ cup	59	1.7	47	1.4
Cod, cooked	3 ounces	89	1.0	105	1.2
Beef liver, cooked	3 ounces	149	1.0	175	1.2
Cured ham	3 ounces	133-207	0.6-0.8	157-243	0.7-0.9
Egg, hard-boiled	1 large	78	0.7	155	1.3
Shiitake mushrooms	½ cup	41	0.6	56	0.8
Canadian bacon	2 slices (~1 ½ ounces)	87	0.5	185	1.1

[1]Source: US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. 2009. USDA National Nutrient Database for Standard Reference, Release 22. Available at: http://www.ars.usda.gov/ba/bhnrc/ndl.
[2]Vitamin D fortified.

Table D2.11. Food sources of vitamin D listed in descending order by percentages of their contribution to intake among the US population ages 2+, WWEIA, NHANES 2005-2006

Food category	Contribution to intake, %	Cumulative contribution, %
Milk, milk drinks and desserts, yogurt	52.1	52.1
Finfish and shellfish	8.6	60.7
Ready-to-eat and cooked cereal	6.5	67.2
Meat, poultry, franks, sausages, lunch meats	6.2	73.4
Eggs and egg products	5.0	78.4
Meat, poultry, fish items with sauces, gravies, bread, other starch, and/or vegetables	5.0	83.4
Grain mixtures	3.3	86.7
Orange juice	3.1	89.8
Infant formulas	1.7	91.5
Cheese and cheese mixtures	1.6	93.1
Cappuccino, frappuccino, latte	1.2	94.3
Butter and margarine	0.9	95.2

Source: What We Eat in America, NHANES, 2005-2006, all individuals (excluding breast-fed children), Day 1, weighted. Vitamin D Addendum to USDA Food and Nutrient Database for Dietary Studies 3.0 (2009) www.ars.usda.gov/ba/bhnrc/fsrg. Unpublished Data: USDA, Agricultural Research Service, Food Surveys Research Group. Table available at www.dietaryguidelines.gov

Table D2.12. Calcium: Food sources ranked by amounts of calcium and energy per standard food portion and per 100 grams of foods (amounts of calcium present in standard food portions are ≥ 20% of AI for adults 19-50, which is 1000 mg)

Food	Standard portion size	Calories in standard portion[1]	Calcium in standard portion (mg)[1]	Calories per 100 grams[1]	Calcium per 100 grams (mg)[1]
Fortified ready-to-eat cereals (various)	¾ - 1 cup (~1 ounce)	100-210	250-1000	309-373	1818-3333
Orange juice, calcium fortified	1 cup	117	500	47	201
Plain yogurt, nonfat	8 ounces	127	452	56	199
Romano cheese	1.5 ounces	165	452	387	1064
Pasteurized process Swiss cheese	2 ounces	189	438	334	772
Evaporated milk, nonfat	½ cup	100	371	78	290
Tofu, raw, regular, prepared with calcium sulfate	½ cup	94	434	76	350
Plain yogurt, low-fat	8 ounces	143	415	63	183
Fruit yogurt, low-fat	8 ounces	232	345	102	152
Ricotta cheese, part skim	½ cup	171	337	138	272
Swiss cheese	1.5 ounces	162	336	380	791
Sardines, canned in oil, drained	3 ounces	177	325	208	382
Pasteurized process American cheese food	2 ounces	187	323	330	570
Provolone cheese	1.5 ounces	149	321	351	756
Mozzarella cheese, part-skim	1.5 ounces	128	311	302	731
Cheddar cheese	1.5 ounces	171	307	403	721
Muenster cheese	1.5 ounces	156	305	368	717
Low-fat milk (1%)	1 cup	102	305	42	125
Soymilk, original and vanilla, with added calcium	1 cup	104	299	43	123
Skim milk (nonfat)	1 cup	83	299	34	122
Reduced fat milk (2%)	1 cup	122	293	50	120
Low-fat chocolate milk (1%)	1 cup	158	290	63	116
Low-fat buttermilk (1%)	1 cup	98	284	40	116
Rice milk, with added calcium	1 cup	113	283	47	118
Whole chocolate milk	1 cup	208	280	83	112
Whole milk	1 cup	149	276	61	113
Plain yogurt, whole milk	8 ounces	138	275	61	121
Reduced fat chocolate milk (2%)	1 cup	190	272	76	109
Ricotta cheese, whole milk	½ cup	216	257	174	207
Tofu, firm, prepared with calcium sulfate and magnesium chloride	½ cup	88	253	70	201

[1]Data source: US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. 2009. USDA National Nutrient Database for Standard Reference, Release 22. Available at: http://www.ars.usda.gov/ba/bhnrc/ndl.

Table D2.13. Food sources of calcium listed in descending order by percentages of their contribution to intake among the US population ages 2+, WWEIA, NHANES 2005-2006

Food category	Contribution to intake, %	Cumulative contribution, %
Reduced fat milk (2% and 1%)	12.2	12.2
Regular cheese	9.2	21.4
Whole milk	6.1	27.5
Pizza	6.1	33.6
Miscellaneous	5.7	39.3
Yeast breads	5.4	44.7
Skim milk	4.5	49.2
Dairy desserts	4.0	53.2
Mexican mixed dishes	3.8	57.0
Pasta and pasta dishes	3.0	60.0
100% orange/grapefruit juice	2.6	62.5
Ready-to-eat cereals	2.2	64.8
Grain-based desserts	2.1	66.9
Reduced fat cheese	2.0	68.9

Data source: Sources of Calcium Among the US Population, 2005-06. Risk Factor Monitoring and Methods Branch Website. Applied Research Program. National Cancer Institute. http://riskfactor.cancer.gov/diet/foodsources/calcium/ .

Table D2.14. Potassium: Food sources ranked by amounts of potassium and energy per standard food portion and per 100 grams of foods (the AI for potassium for adults is 4700 mg)

Food	Standard portion size	Calories in standard portion[1]	Potassium in standard portion (mg)[1]	Calories per 100 grams[1]	Potassium per 100 grams (mg)[1]
Potato, baked, flesh and skin	1 sm. potato	128	738	93	535
Prune juice, canned	1 cup	182	707	71	276
Carrot juice, canned	1 cup	94	689	40	292
Tomato paste	¼ cup	54	664	82	1014
Beet greens, cooked from fresh	½ cup	19	654	27	909
White beans, canned	½ cup	149	595	114	454
Tomato juice, canned	1 cup	41	556	17	229
Plain yogurt, nonfat	8 ounces	127	579	56	255
Tomato puree	½ cup	48	549	38	439
Sweet potato, baked in skin	1 medium	103	542	90	475
Clams, canned	3 ounces	126	534	148	628
Plain yogurt, low-fat	8 ounces	143	531	63	234
Orange juice, fresh	1 cup	112	496	45	200
Halibut, cooked	3 ounces	119	490	140	576
Soybeans, green, cooked	½ cup	127	485	141	539
Tuna, yellowfin, cooked	3 ounces	118	484	139	569
Lima beans, cooked	½ cup	108	478	115	508
Soybeans, mature, cooked	½ cup	149	443	173	515
Rockfish, Pacific, cooked	3 ounces	103	442	121	520
Cod, Pacific, cooked	3 ounces	89	439	105	517
Evaporated milk, nonfat	½ cup	100	425	78	332
Low-fat chocolate milk (1%)	1 cup	158	425	63	170
Reduced fat chocolate milk (2%)	1 cup	190	422	76	169
Bananas	1 medium	105	422	89	358
Spinach, cooked from fresh or canned	½ cup	21-25	370-419	23	346-466
Tomato sauce	½ cup	29	405	24	331
Peaches, dried, uncooked	¼ cup	96	398	239	996
Prunes, stewed	½ cup	133	398	107	321
Skim milk (nonfat)	1 cup	83	382	34	156
Rainbow trout, cooked	3 ounces	128	381	150	448
Apricots, dried, uncooked	¼ cup	78	378	241	1162
Pinto beans, cooked	½ cup	122	373	143	436
Pork loin, center rib, lean, roasted	3 ounces	190	371	223	437
Low-fat buttermilk (1%)	1 cup	98	370	40	151
Low-fat milk (1%)	1 cup	102	366	42	150
Lentils, cooked	½ cup	115	365	116	369
Plantains, cooked	½ cup	89	358	116	465
Kidney beans, cooked	½ cup	112	358	127	405

[1]Source: US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. 2009. USDA National Nutrient Database for Standard Reference, Release 22. Available at: http://www.ars.usda.gov/ba/bhnrc/ndl.

Table D2.15. Food sources of potassium listed in descending order by percentages of their contribution to intake among the US population ages 2+, WWEIA, NHANES 2005-2006

Food category	Contribution to intake, %	Cumulative contribution, %
Reduced fat milk (2% and 1%)	5.9	5.9
Coffee	5.2	11.1
Chicken and chicken mixed dishes	4.5	15.6
Beef and beef mixed dishes	3.6	19.2
100% orange/grapefruit juice	3.4	22.6
Fried white potatoes	3.3	25.9
Potato/corn/other chips	3.2	29.1
Whole milk	2.9	32.0
Other white potatoes	2.9	34.9
Pasta and pasta dishes	2.7	37.6
Mexican mixed dishes	2.6	40.2
Pizza	2.6	42.8
Dairy desserts	2.5	45.3
Yeast breads	2.4	47.7
Skim milk	2.2	49.9
Soups	2.2	52.1
Bananas	2.1	54.2
Tea	2.1	56.3
Burgers	1.9	58.2
Alcoholic beverages	1.9	60.1
100% fruit juice, not orange/grapefruit	1.9	62.0
Nuts/seeds and nut/seed mixed dishes	1.8	63.8
Grain-based desserts	1.8	65.6
Cold cuts	1.8	67.4
Other fish and fish mixed dishes	1.6	69.0
Ready-to-eat cereals	1.5	70.5
Beans	1.5	72.0
Condiments	1.5	73.5
Yogurt	0.9	74.4

Source: Sources of Potassium Among the US Population, 2005-06. Risk Factor Monitoring and Methods Branch Website. Applied Research Program. National Cancer Institute. http://riskfactor.cancer.gov/diet/foodsources/potassium/ .

Table D2.16. Dietary fiber: Food sources ranked by amounts of dietary fiber and energy per standard food portion and per 100 grams of foods (amounts of dietary fiber present in standard food portions are ≥ 10% of AI for adult women, which is 25 g)

Food	Standard portion size	Calories in standard portion[1]	Dietary fiber in standard portion (g) [1]	Calories per 100 grams[1]	Dietary fiber per 100 grams (g) [1]
Navy beans, cooked	½ cup	127	9.6	140	10.5
Bran ready-to-eat cereal (100%)	1/3 cup (~1 ounce)	81	9.1	260	29.3
Split peas, cooked	½ cup	116	8.1	118	8.3
Lentils, cooked	½ cup	115	7.8	116	7.9
Pinto beans, cooked	½ cup	122	7.7	143	9.0
Black beans, cooked	½ cup	114	7.5	132	8.7
Artichoke, globe or French, cooked from fresh	½ cup hearts	45	7.2	53	8.6
Kidney beans, canned	½ cup	108	6.8	84	5.3
Lima beans, cooked	½ cup	108	6.6	115	7.0
White beans, canned	½ cup	149	6.3	114	4.8
Chickpeas, cooked	½ cup	134	6.2	164	7.6
Great northern beans, cooked	½ cup	104	6.2	118	7.0
Cowpeas, cooked	½ cup	100	5.6	116	6.5
Pear	1 medium	103	5.5	58	3.1
Soybeans, mature, cooked	½ cup	149	5.2	173	6.0
Plain rye wafer crackers	2 wafers	73	5.0	334	22.9
Bran ready-to-eat cereals (various)	1/3-3/4 cup (~1 ounce)	88-91	2.6-5.0	309-402	9.1-17.6
Asian pear	1 small	51	4.4	42	3.6
Green peas, cooked from fresh, frozen, or canned	½ cup	59-67	3.5-4.4	69-84	4.1-5.5
Whole wheat English muffin	1 muffin	134	4.4	203	6.7
Bulgur, cooked	½ cup	76	4.1	83	4.5
Mixed vegetables, cooked from frozen	½ cup	59	4.0	65	4.4
Raspberries	½ cup	32	4.0	52	6.5
Sweet potato, baked in skin	1 medium	103	3.8	90	3.3
Blackberries	½ cup	31	3.8	43	5.3
Potato, baked, with skin	1 medium	161	3.8	93	2.2
Soybeans, green, cooked	½ cup	127	3.8	141	4.2
Stewed prunes	½ cup	133	3.8	107	3.1
Shredded wheat ready-to-eat cereal (various)	½ cup (~1 ounce)	95-100	2.7-3.8	334-352	9.6-13.4
Figs, dried	¼ cup	93	3.7	249	9.8
Apple, with skin	1 small	77	3.6	52	2.4
Pumpkin, canned	½ cup	42	3.6	34	2.9

Table D2.16 (continued). Dietary fiber: Food sources ranked by amounts of dietary fiber and energy per standard food portion and per 100 grams of foods (amounts of dietary fiber present in standard food portions are ≥ 10% of AI for adult women, which is 25 g)

Food	Standard portion size	Calories in standard portion[1]	Dietary fiber in standard portion (g)[1]	Calories per 100 grams[1]	Dietary fiber per 100 grams (g)[1]
Spinach, cooked from frozen or canned	½ cup	25-32	2.6-3.5	23-34	2.4-3.7
Almonds	1 ounce	163	3.5	575	12.2
Sauerkraut, canned, solids and liquids	½ cup	22	3.4	19	2.9
Whole wheat spaghetti, cooked	½ cup	87	3.1	124	4.5
Banana	1 medium	105	3.1	89	2.6
Orange	1 medium	62	3.1	47	2.4
Guava	1 fruit	37	3.0	68	5.4
Oat bran muffin	1 small	178	3.0	270	4.6
Pearled barley, cooked	½ cup	97	3.0	123	3.8
Dates	¼ cup	104	2.9	282	8.0
Winter squash, cooked	½ cup	38	2.9	37	2.8
Parsnips, cooked	½ cup	55	2.8	71	3.6
Tomato paste	¼ cup	54	2.7	82	4.1
Collards, cooked from fresh	½ cup	25	2.7	26	2.8
Broccoli, cooked from fresh or frozen	½ cup	26-27	2.6-2.8	28-35	3.0-3.3
Okra, cooked from frozen	½ cup	26	2.6	28	2.8
Turnip greens, cooked from fresh or frozen	½ cup	14-24	2.5-2.8	20-29	3.4-3.5

[1]Source: US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. 2009. USDA National Nutrient Database for Standard Reference, Release 22. Available at: http://www.ars.usda.gov/ba/bhnrc/ndl.

Table D2.17. Food sources of dietary fiber listed in descending order by percentages of their contribution to intake among the US population ages 2+, WWEIA< NHANES 2005-2006

Food category	Contribution to intake, %	Cumulative contribution, %
Yeast breads	8.9	8.9
Mexican mixed dishes	7.0	15.9
Ready-to-eat cereals	5.6	21.5
Pasta and pasta dishes	5.3	26.8
Beans	4.2	31.0
Grain-based desserts	4.1	35.1
Pizza	3.9	39.0
Fried white potatoes	3.5	42.5
Nuts/seeds and nut/seed mixed dishes	3.4	46.0
Potato/corn/other chips	3.2	49.2
Apples and pears	3.0	52.2
Bananas	2.6	54.9
Chicken and chicken mixed dishes	2.5	57.3
Other white potatoes	2.4	59.7
Soups	2.1	61.8

Source: Sources of Fiber Among the US Population, 2005-06. Risk Factor Monitoring and Methods Branch Website. Applied Research Program. National Cancer Institute. http://riskfactor.cancer.gov/diet/foodsources/fiber/ .

Table D2.18. Folate: Food sources ranked by amounts of folate and energy per standard food portion and per 100 grams of foods (amounts of folate present in standard food portions are ≥ 10% of RDA for adults, which is 400 μg DFE)

Food	Standard portion size	Calories in standard portion[1]	Folate in standard portion (μg DFE)[1]	Calories per 100 grams[1]	Folate per 100 grams (μg DFE)[1]
Fortified ready-to-eat cereals (various)	1 cup (~1 ounce)	109-218	169-701	309-416	296-2630
Fortified instant cereals (various)	1 packet or ½ cup	56-157	138-378	42-101	89-282
Organ meats (liver, giblets), various, cooked	3 ounces	133-169	218-491	157-199	257-578
Lentils, cooked	½ cup	115	179	116	181
Cowpeas, cooked	½ cup	100	179	116	208
Pinto beans, cooked	½ cup	122	147	143	172
Chickpeas, cooked	½ cup	134	141	164	172
Okra, cooked from frozen	½ cup	26	134	28	146
Asparagus, cooked from fresh, frozen, or canned	½ cup	16-23	116-134	18-22	96-149
Spinach, cooked from fresh, frozen, or canned	½ cup	21-32	105-131	23-34	98-146
Black beans, cooked	½ cup	114	128	132	149
Navy beans, cooked	½ cup	127	127	140	140
Kidney beans, cooked	½ cup	112	115	127	130
Egg noodles, enriched, cooked	½ cup	110	110	138	138
Orange juice, from concentrate	1 cup	112	110	45	44
Rice, white, enriched, cooked	½ cup	97	107	123	136
Soybeans, green, cooked	½ cup	127	100	141	111
English muffin, enriched	1 muffin	140	94	270	180
Bagel, enriched	1 small (3” dia)	190	92	257	226
Oat bran muffin	1 small	178	92	270	139
Great northern beans, cooked	½ cup	104	90	118	102
Collards, cooked from fresh or frozen	½ cup	25-31	65-88	26-36	76-93
Hard roll	1 roll	167	86	293	151
Pretzels, hard, salted	5 twists	114	86	380	286
White beans, canned	½ cup	149	85	114	65
Turnip greens, cooked from fresh or canned	½ cup	14	66-85	19-20	92-118
Broccoli, cooked from fresh or frozen	½ cup	26-27	52-84	28-35	56-108

(Table continues on next page.)

Table D2.18 (continued). Folate: Food sources ranked by amounts of folate and energy per standard food portion and per 100 grams of foods (amounts of folate present in standard food portions are ≥ 10% of RDA for adults, which is 400 μg DFE)

Food	Standard portion size	Calories in standard portion[1]	Folate in standard portion (μg DFE)[1]	Calories per 100 grams[1]	Folate per 100 grams (μg DFE)[1]
Spaghetti, cooked	½ cup	111	83	158	119
Chickpeas, canned	½ cup	143	80	119	67
Brussels sprouts, cooked from fresh or frozen	½ cup	28-33	47-78	36-42	60-101
Lima beans, cooked	½ cup	108	78	115	83
Artichoke, globe or French, cooked from fresh	½ cup hearts	45	75	53	89
Corn muffin	1 small	201	74	305	112
Beets, cooked from fresh	½ cup	37	68	44	80
Sunflower seed kernels, dry roasted	1 ounce	165	67	582	237
Cornmeal, degermed, enriched	2 Tbsp	61	65	355	374
Split peas, cooked	½ cup	116	64	118	65
Cowpeas, canned	½ cup	92	61	77	51
Sweet corn, canned	½ cup	83	51	79	49
Mustard greens, cooked from fresh or frozen	½ cup	10-14	51-52	15-19	70-73
Flour tortilla	1 tortilla (6" dia)	94	50	312	168
Green peas, cooked from fresh or frozen	½ cup	62-67	47-50	78-84	59-63
Wheat flour, white, enriched	2 Tbsp	62	49	361	288
Baked potato, flesh and skin	1 medium	161	48	93	28
Soybeans, mature, cooked	½ cup	149	46	173	54
Parsnips, cooked	½ cup	55	45	71	58
White bread	1 slice	66	43	266	171

[1]Source: US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. 2009. USDA National Nutrient Database for Standard Reference, Release 22. Available at: http://www.ars.usda.gov/ba/bhnrc/ndl.

Table D2.19. Iron: Food sources ranked by amounts of iron and energy per standard food portion and per 100 grams of food (amounts of iron present in standard food portions listed are ≥ 10% of RDA for teen and adult females, which is 18 mg)

Food	Standard portion size	Calories in standard portion[1]	Iron in standard portion (mg)[1]	Calories per 100 grams[1]	Iron per 100 grams (mg)[1]
Clams, canned, drained	3 ounces	126	23.8	148	28.0
Fortified ready-to-eat cereals (various)	¾ -1 1/3 cup (~1 ounce)	56-175	4.2-18.1	309-402	8.2-62.0
Fortified instant cereals (various)	1 packet	102-166	3.8-17.2	42-101	2.5-6.7
Organ meats (liver, giblets), various, cooked	3 ounces	133-187	4.3-15.2	157-220	5.1-18.0
Oysters, eastern, wild, cooked	3 ounces	116	10.2	137	12.0
Soybeans, mature, cooked	½ cup	149	4.4	173	5.1
Bagel, enriched	1 small (3" dia)	177	4.2	257	6.1
Braunschweiger (pork liver sausage)	2 slices (~1 ½ ounce)	118	4.0	327	11.2
White beans, canned	½ cup	149	3.9	114	3.0
Lentils, cooked	½ cup	115	3.3	116	3.3
Spinach, cooked from fresh, frozen or canned	½ cup	21-32	1.9-3.2	23-34	2.0-3.6
Beef, chuck, blade roast, lean, 0" fat, all grades, cooked	3 ounces	215	3.1	253	3.7
Sardines, canned in oil, drained	3 ounces	177	2.5	208	2.9
Chickpeas, cooked	½ cup	134	2.4	164	2.9
English muffin, enriched	1 muffin	140	2.4	270	4.7
Pumpkin and squash seed kernels, roasted	1 ounce	163	2.3	574	8.1
Duck, meat only, roasted	3 ounces	171	2.3	201	2.7
Soybeans, green, cooked	½ cup	127	2.3	141	2.5
Lima beans, cooked	½ cup	108	2.3	115	2.4
Ground beef (85% lean/15% fat), cooked	3 ounces	212	2.2	250	2.6
Navy beans, cooked	½ cup	127	2.2	140	2.4
Cowpeas, cooked	½ cup	100	2.2	116	2.5
Kidney beans, cooked	½ cup	112	2.0	127	2.2
Beef, rib, 1/8" fat, all grades	3 ounces	298	2.0	351	2.4
Beef, bottom round, 0" fat, all grades, cooked	3 ounces	159	1.9	187	2.2
Lamb, shoulder, arm, lean, ¼" fat, choice, cooked	3 ounces	163	1.9	192	2.2
Great northern beans, cooked	½ cup	104	1.9	118	2.1
Baked potato, flesh and skin	1 medium	161	1.9	93	1.1
Black beans, cooked	½ cup	114	1.8	132	2.1

[1]Source: US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. 2009. USDA National Nutrient Database for Standard Reference, Release 22. Available at: http://www.ars.usda.gov/ba/bhnrc/ndl.

Table D2.20. Vitamin B_{12}: Food sources ranked by amounts of vitamin B_{12} and energy per standard food portions and per 100 grams of foods (amounts of Vitamin B_{12} present in standard food portions are ≥ 50% of RDA for adult men, which is 2.4 μg)

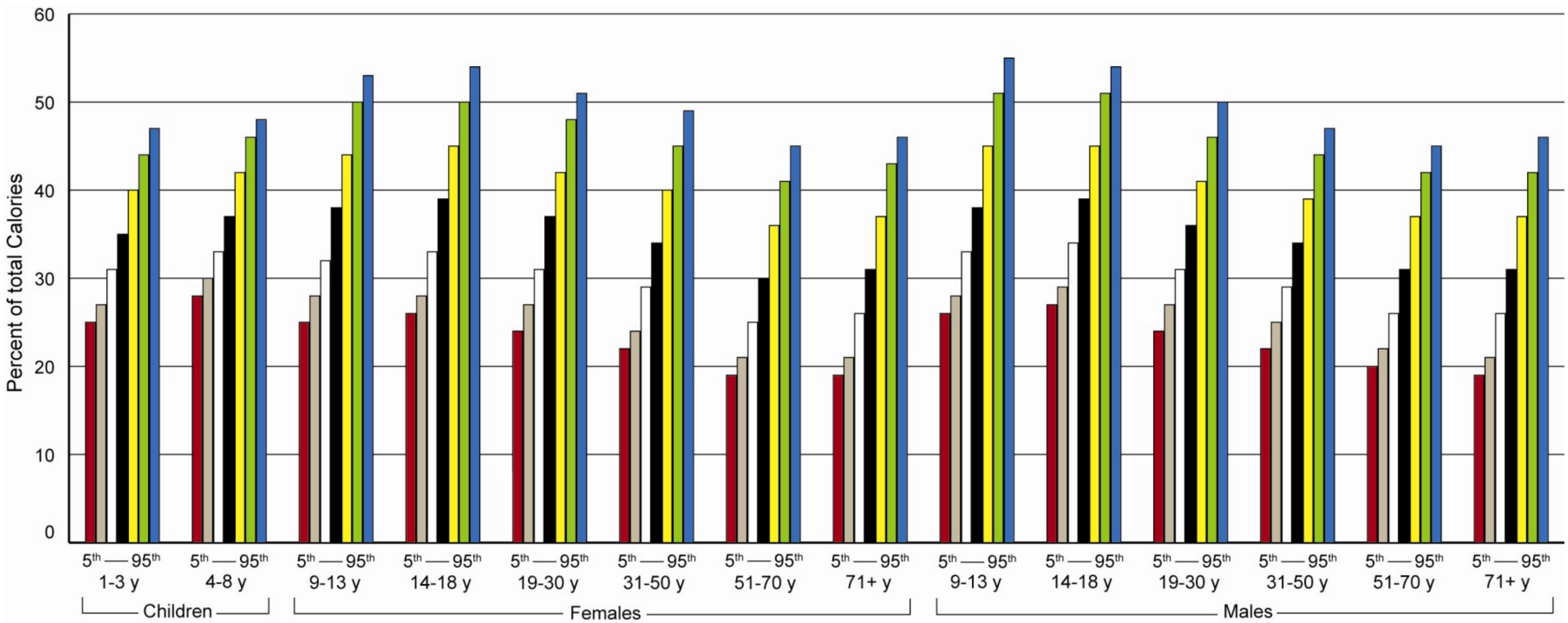
Food	Standard portion size	Calories in standard portion[1]	Vitamin B_{12} in standard portion (μg) [1]	Calories per 100 grams[1]	Vitamin B_{12} per 100 grams (μg) [1]
Clams, canned, drained	3 ounces	126	84.1	148	98.9
Organ meats (liver, giblets), various, cooked	3 ounces	133-169	8.0-70.7	157-199	9.4-83.1
Ready-to-eat cereals (various)	¾ - 1 1/3 cup (~1 ounce)	81-190	1.5-20.7	260-400	2.7-6.0
Oysters, eastern, raw	3 ounces	58	16.5	68	19.5
Alaska king crab, cooked	3 ounces	82	9.8	97	11.5
Sardines, canned in oil, drained	3 ounces	177	7.6	208	8.9
Braunschweiger (pork liver sausage)	2 slices (~1 ½ ounces)	118	7.2	327	20.1
Blue crab, cooked	3 ounces	87	6.2	102	7.3
Salmon, cooked from fresh, smoked, or canned	3 ounces	99-184	2.8-4.9	117-216	3.3-5.8
Rainbow trout, cooked	3 ounces	144	4.2	169	5.0
Pickled herring	3 ounces	223	3.6	262	4.3
Pollock, walleye, cooked	3 ounces	96	3.6	113	4.2
Lobster, cooked	3 ounces	83	2.6	98	3.1
Tuna, light, canned in water	3 ounces	99	2.5	116	3.0
Ground beef (75% lean/25% fat), cooked	3 ounces	236	2.4	278	2.8
Lamb, cooked, various cuts	3 ounces	197-237	1.84-2.25	232-279	2.16-2.65
Beef, cooked, various cuts	3 ounces	194-298	1.24-2.18	228-351	1.46-2.56
Flatfish (flounder and sole), cooked	3 ounces	99	2.13	117	2.51
Swordfish, cooked	3 ounces	132	1.72	155	2.02
Rice milk, unsweetened	1 cup	113	1.51	47	0.63
Plain yogurt, nonfat	8 ounces	127	1.38	56	0.61
Reduced fat milk (2%)	1 cup	122	1.29	50	0.53
Plain yogurt, low-fat	8 ounces	143	1.27	63	0.56
Skim milk (nonfat)	1 cup	83	1.23	34	0.5

[1]Source: US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. 2009. USDA National Nutrient Database for Standard Reference, Release 22. Available at: http://www.ars.usda.gov/ba/bhnrc/ndl.

Part D. Section 2: Nutrient Adequacy—Figures

Figure D2.1. Distribution of usual intakes of SoFAS (solid fats and added sugars) as percent of total Calories, by age/sex group

Bars show, from left to right, percent of Calories from SoFAS at the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles.

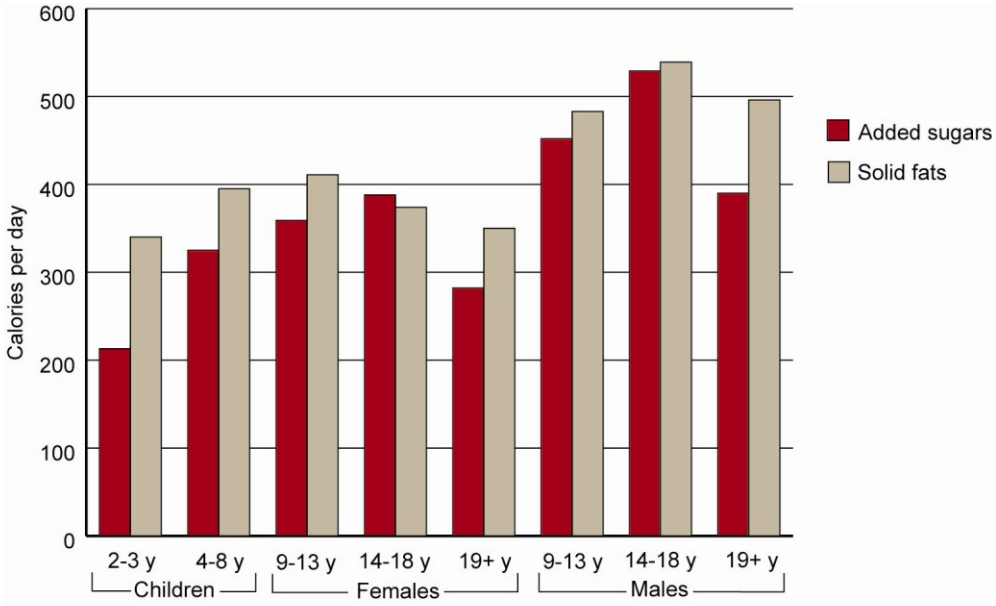


Source: Selected Intakes as Ratios of Energy Intake, US Population, 2001-04. Risk Factor Monitoring and Methods Branch Web site. Applied Research Program. National Cancer Institute. http://riskfactor.cancer.gov/diet/usualintakes/energy/. Updated April 13, 2010. Accessed April 22, 2010.

Figure D2.1. Data points. All values are in percent of total Calories.

Age/sex group	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile
Children, 1 to 3 years	25	27	31	35	40	44	47
Children, 4 to 8 years	28	30	33	37	42	46	48
Females, 9 to 13 years	25	28	32	38	44	50	53
Females, 14 to 18 years	26	28	33	39	45	50	54
Females, 19 to 30 years	24	27	31	37	42	48	51
Females, 31 to 50 years	22	24	29	34	40	45	49
Females, 51 to 70 years	19	21	25	30	36	41	45
Females, 71+ years	19	21	26	31	37	43	46
Males, 9 to 13 years	26	28	33	38	45	51	55
Males, 14 to 18 years	27	29	34	39	45	51	54
Males, 19 to 30 years	24	27	31	36	41	46	50
Males, 31 to 50 years	22	25	29	34	39	44	47
Males, 51 to 70 years	20	22	26	31	37	42	45
Males, 71+ years	19	21	26	31	37	42	46

Figure D2.2. Comparison of mean usual daily intake of Calories from solid fats and from added sugars, by age/sex group



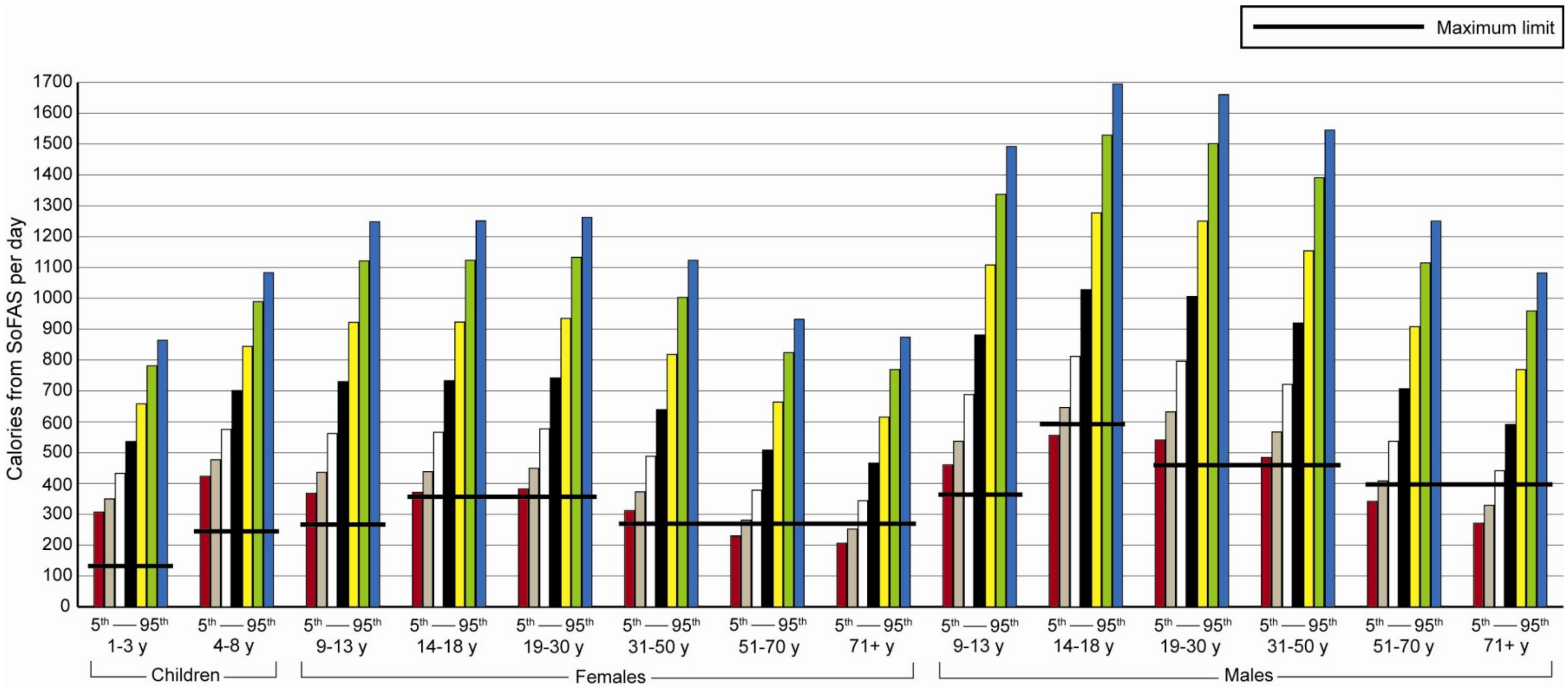
Source: Usual Dietary Intakes: Food Intakes, US Population, 2001-04. Risk Factor Monitoring and Methods Branch Web site. Applied Research Program. National Cancer Institute. http://riskfactor.cancer.gov/diet/usualintakes/pop/. Updated April 13, 2010. Accessed April 22, 2010.

Figure D2.1. Data points. All values are in Calories.

Age/sex group	Added sugars	Solid fats
Children, 2 to 3 years	213	340
Children, 4 to 8 years	325	395
Females, 9 to 13 years	359	411
Females, 14 to 18 years	388	374
Females, 19+ years	282	350
Males, 9 to 13 years	452	483
Males, 14 to 18 years	529	539
Males, 19+ years	390	496

Figure D2.3. Distribution of usual daily intakes of SoFAS (solid fats and added sugars) in Calories, in comparison to maximum limits, by age/sex group

Bars show, from left to right, Calories from SoFAS at the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles. Horizontal line shows maximum recommended limit for each age/sex group.



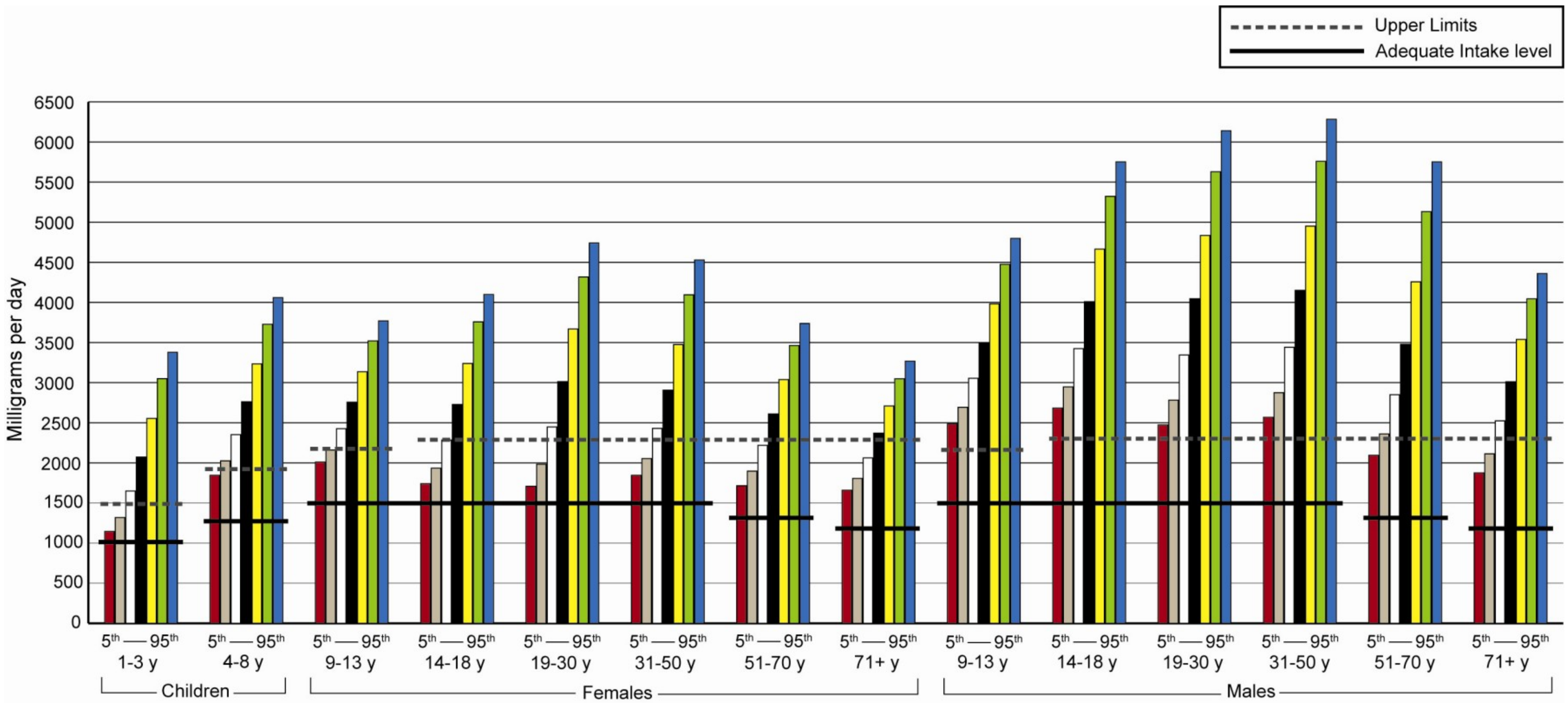
Source: Usual Dietary Intakes: Food Intakes, US Population, 2001-04. Risk Factor Monitoring and Methods Branch Web site. Applied Research Program. National Cancer Institute. http://riskfactor.cancer.gov/diet/usualintakes/pop/. Updated April 13, 2010. Accessed April 22, 2010.

Figure D2.3. Data points. All values are in Calories.

Age/sex group	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Maximum limit
Children, 1 to 3 years	307	350	433	536	658	781	864	137
Children, 4 to 8 years	423	477	575	701	844	989	1083	258
Females, 9 to 13 years	368	436	562	730	922	1121	1248	266
Females, 14 to 18 years	371	438	566	733	923	1123	1251	330
Females, 19 to 30 years	382	449	577	742	935	1133	1262	330
Females, 31 to 50 years	312	373	488	639	818	1003	1123	266
Females, 51 to 70 years	230	281	378	508	664	824	932	266
Females, 71+ years	206	252	344	466	615	769	874	266
Males, 9 to 13 years	460	537	688	881	1108	1337	1492	362
Males, 14 to 18 years	556	646	812	1028	1277	1529	1694	596
Males, 19 to 30 years	541	632	796	1006	1250	1501	1660	459
Males, 31 to 50 years	484	567	721	920	1154	1391	1545	459
Males, 51 to 70 years	342	408	537	707	908	1115	1250	395
Males, 71+ years	271	329	441	591	769	959	1082	395

Figure D2.4. Distribution of usual daily intakes of sodium, in milligrams, in comparison to Adequate Intake (AI) levels and Tolerable Upper Intake Limits (UL), by age/sex group

Bars show, from left to right, usual sodium intakes at the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles. Solid horizontal line shows AI and dotted horizontal line shows UL for each age/sex group.



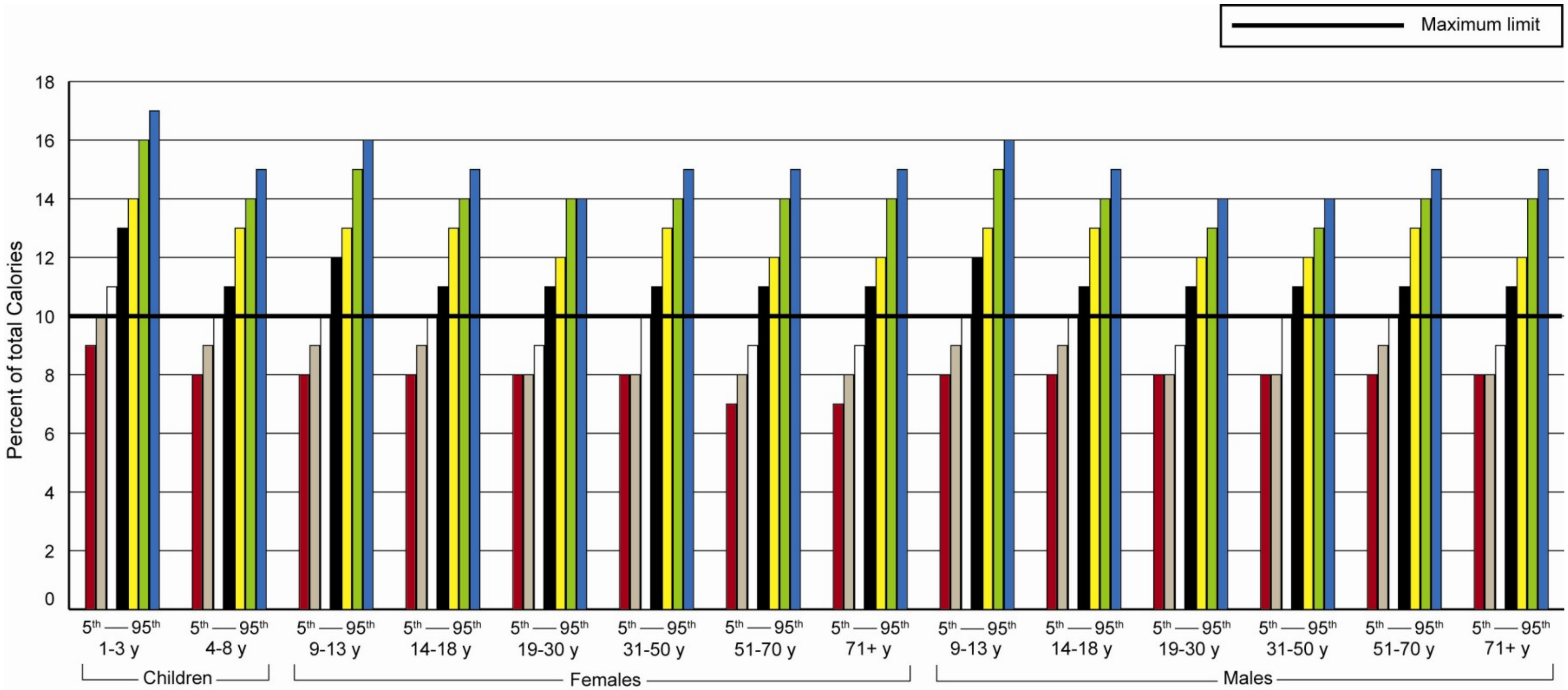
Source: Sodium (mg): Usual Intakes from Food and Water, 2003-2006, Compared to Adequate Intakes and Tolerable Upper Intake Levels. Food Surveys Research Group, Agricultural Research Service, USDA. What We Eat in America, NHANES 2003-2006. Web site: http://www.ars.usda.gov/Services/docs.htm?docid=18349. Updated April 1, 2010. Accessed April 22, 2010.

Figure D2.4. Data points. All values are in milligrams.

Age/sex group	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Adequate Intake	Upper Limit
Children, 1 to 3 years	1144	1318	1648	2071	2554	3049	3379	1000	1500
Children, 4 to 8 years	1844	2025	2352	2761	3233	3727	4059	1200	1900
Females, 9 to 13 years	2009	2159	2426	2757	3135	3520	3770	1500	2200
Females, 14 to 18 years	1740	1934	2284	2727	3238	3758	4098	1500	2300
Females, 19 to 30 years	1707	1983	2448	3012	3668	4318	4741	1500	2300
Females, 31 to 50 years	1845	2053	2430	2907	3474	4094	4528	1500	2300
Females, 51 to 70 years	1715	1897	2219	2609	3038	3463	3737	1300	2300
Females, 71+ years	1658	1805	2062	2370	2709	3047	3267	1200	2300
Males, 9 to 13 years	2485	2692	3055	3495	3982	4474	4798	1500	2200
Males, 14 to 18 years	2682	2947	3424	4009	4664	5322	5752	1500	2300
Males, 19 to 30 years	2473	2782	3344	4045	4835	5628	6139	1500	2300
Males, 31 to 50 years	2567	2875	3441	4151	4951	5758	6283	1500	2300
Males, 51 to 70 years	2094	2360	2849	3478	4256	5131	5751	1300	2300
Males, 71+ years	1875	2112	2524	3011	3538	4044	4360	1200	2300

Figure D2.5. Distribution of usual daily intakes of saturated fatty acids as a percent of total Calories in comparison to maximum limit, by age/sex group

Bars show, from left to right, percent of Calories from saturated fatty acids at the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles. Horizontal line shows maximum recommended limit.



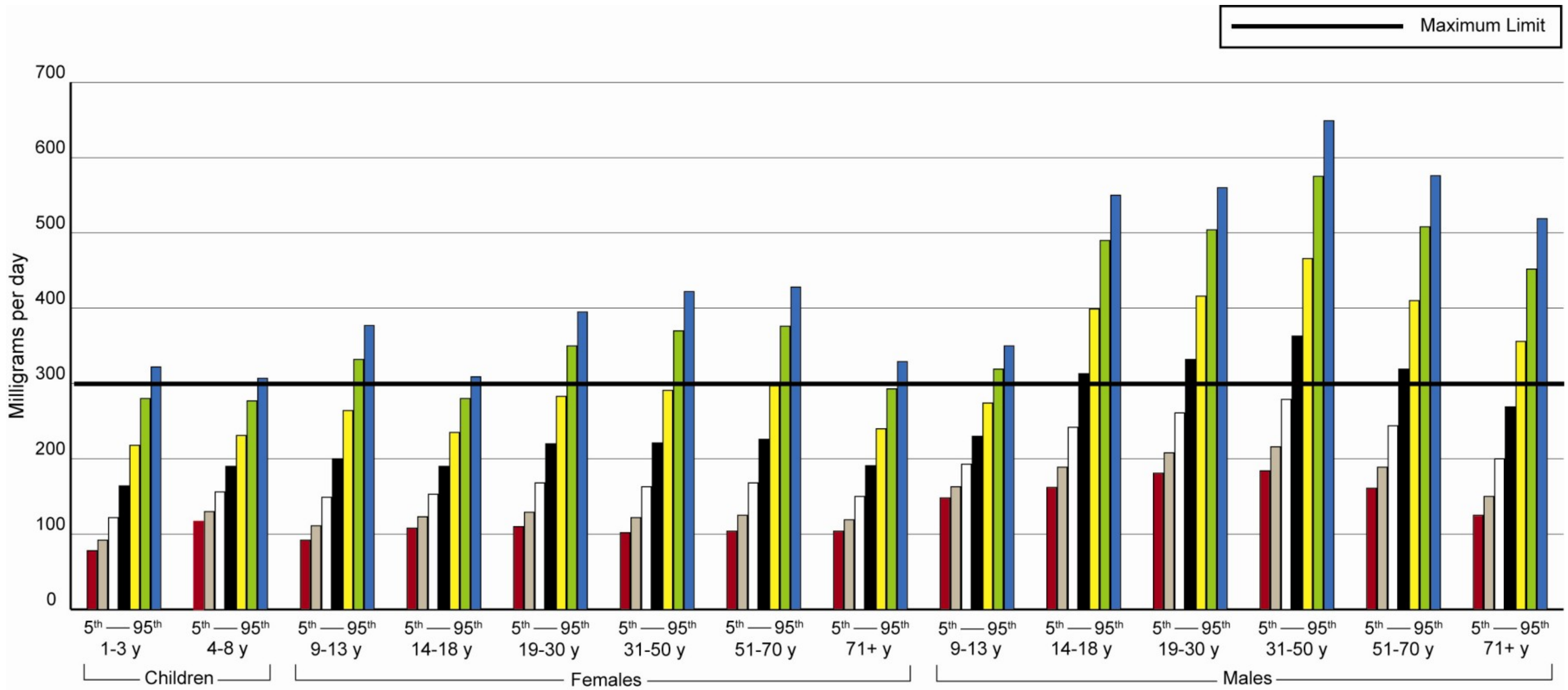
Source: Usual Energy Intake from Saturated Fat. Risk Factor Monitoring and Methods Branch Web site. Applied Research Program. National Cancer Institute. http://riskfactor.cancer.gov/diet/usualintakes/energy/t4.html. Updated April 13, 2010. Accessed April 22, 2010.

Figure D2.5. Data points. All values are as a percent of total Calories.

Age/sex group	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Maximum limit
Children, 1 to 3 years	9	10	11	13	14	16	17	10
Children, 4 to 8 years	8	9	10	11	13	14	15	10
Females, 9 to 13 years	8	9	10	12	13	15	16	10
Females, 14 to 18 years	8	9	10	11	13	14	15	10
Females, 19 to 30 years	8	8	9	11	12	14	14	10
Females, 31 to 50 years	8	8	10	11	13	14	15	10
Females, 51 to 70 years	7	8	9	11	12	14	15	10
Females, 71+ years	7	8	9	11	12	14	15	10
Males, 9 to 13 years	8	9	10	12	13	15	16	10
Males, 14 to 18 years	8	9	10	11	13	14	15	10
Males, 19 to 30 years	8	8	9	11	12	13	14	10
Males, 31 to 50 years	8	8	10	11	12	13	14	10
Males, 51 to 70 years	8	9	10	11	13	14	15	10
Males, 71+ years	8	8	9	11	12	14	15	10

Figure D2.6. Distribution of usual daily intakes of cholesterol, in milligrams, in comparison to maximum limit, by age/sex group

Bars show, from left to right, usual cholesterol intakes at the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles. Horizontal line shows maximum recommended limit.



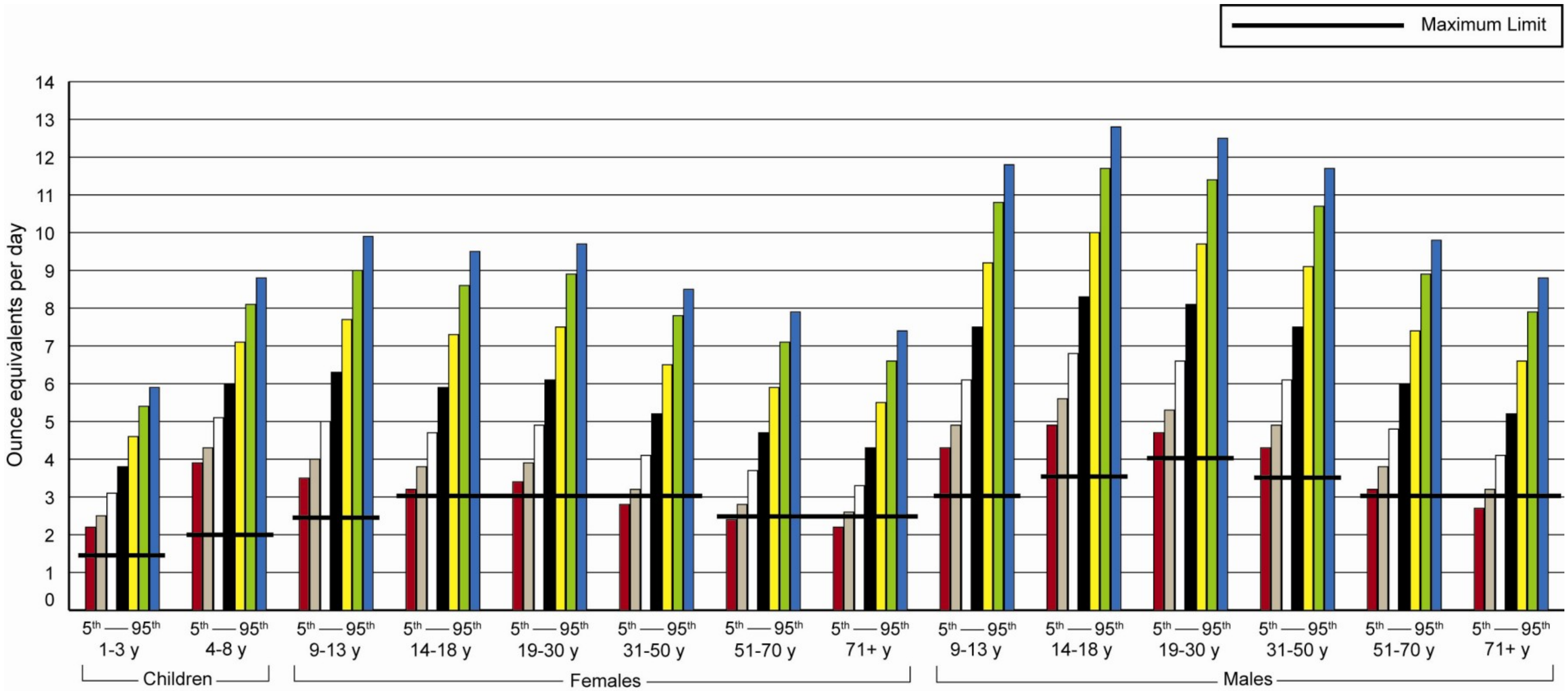
Source: Cholesterol (mg): Usual Intakes from Food and Water, 2003-2006, Compared to the Recommendation of Below 300 mg. Food Surveys Research Group, Agricultural Research Service, USDA. What We Eat in America, NHANES 2003-2006. Website: http://www.ars.usda.gov/Services/docs.htm?docid=18349 Updated April 1, 2010. Accessed April 22, 2010.

Figure D2.6. Data points. All values are in milligrams.

Age/sex group	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Maximum limit
Children, 1 to 3 years	78	92	122	164	218	280	322	300
Children, 4 to 8 years	117	130	156	190	231	277	307	300
Females, 9 to 13 years	92	111	149	200	264	332	377	300
Females, 14 to 18 years	108	123	153	190	235	280	309	300
Females, 19 to 30 years	110	129	168	220	283	350	395	300
Females, 31 to 50 years	102	122	163	221	291	370	422	300
Females, 51 to 70 years	104	125	168	226	297	376	428	300
Females, 71+ years	104	119	150	191	240	293	329	300
Males, 9 to 13 years	148	163	193	230	274	319	350	300
Males, 14 to 18 years	162	189	242	313	399	490	550	300
Males, 19 to 30 years	181	208	261	332	416	504	560	300
Males, 31 to 50 years	184	216	279	363	466	575	649	300
Males, 51 to 70 years	161	189	244	319	410	508	576	300
Males, 71+ years	125	150	200	269	356	452	519	300

Figure D2.7. Distribution of usual daily intakes of refined grains, in ounce equivalents, in comparison to maximum limits, by age/sex group

Bars show, from left to right, usual refined grains intakes at the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles. Horizontal line shows maximum recommended limit for each age/sex group.



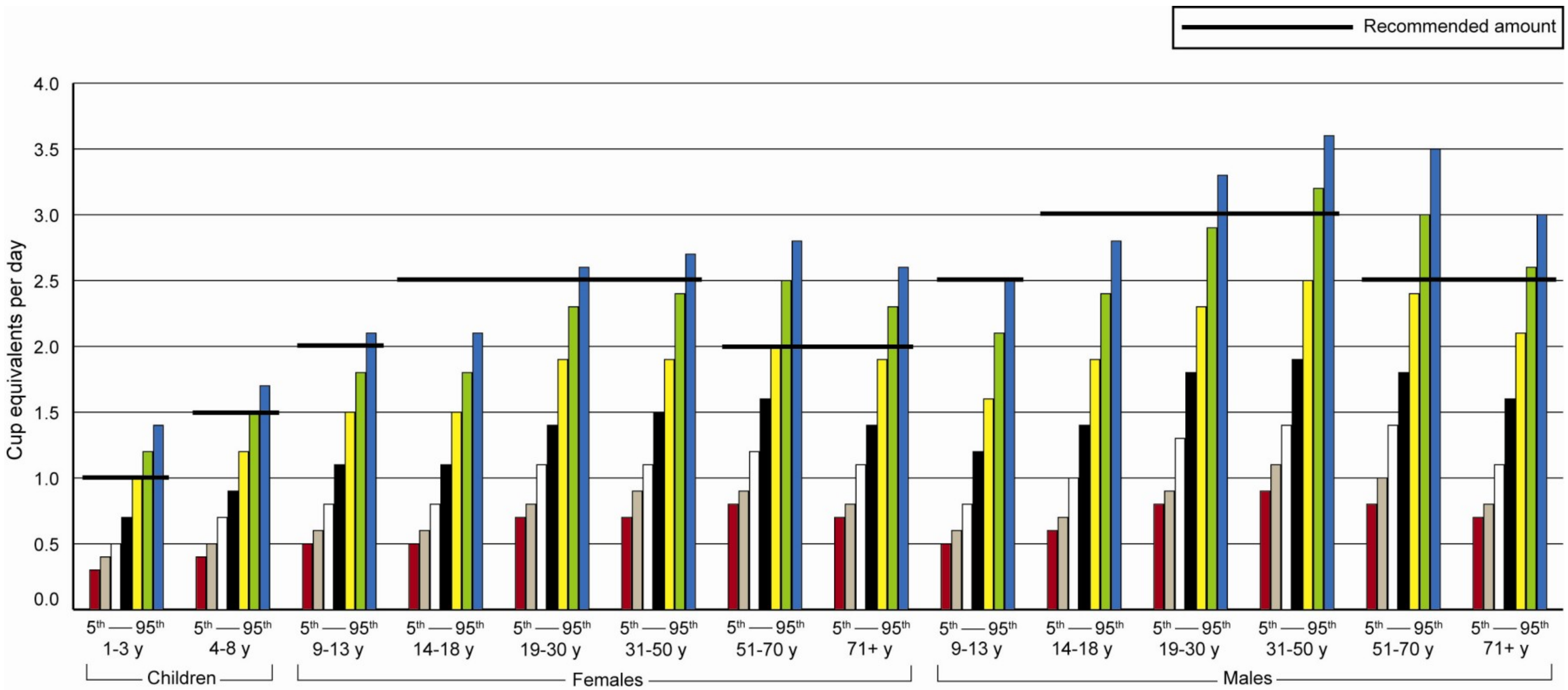
Source: Usual Intake of Non-whole Grains. Risk Factor Monitoring and Methods Branch Web site. Applied Research Program. National Cancer Institute. http://riskfactor.cancer.gov/diet/usualintakes/pop/t16.html. Updated April 13, 2010. Accessed April 22, 2010.

Figure D2.7. Data points. All values are in ounce equivalents of refined grains.

Age/sex group	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Maximum limit
Children, 1 to 3 years	2.2	2.5	3.1	3.8	4.6	5.4	5.9	1.5
Children, 4 to 8 years	3.9	4.3	5.1	6.0	7.1	8.1	8.8	2
Females, 9 to 13 years	3.5	4.0	5.0	6.3	7.7	9.0	9.9	2.5
Females, 14 to 18 years	3.2	3.8	4.7	5.9	7.3	8.6	9.5	3
Females, 19 to 30 years	3.4	3.9	4.9	6.1	7.5	8.9	9.7	3
Females, 31 to 50 years	2.8	3.2	4.1	5.2	6.5	7.8	8.5	3
Females, 51 to 70 years	2.4	2.8	3.7	4.7	5.9	7.1	7.9	2.5
Females, 71+ years	2.2	2.6	3.3	4.3	5.5	6.6	7.4	2.5
Males, 9 to 13 years	4.3	4.9	6.1	7.5	9.2	10.8	11.8	3
Males, 14 to 18 years	4.9	5.6	6.8	8.3	10.0	11.7	12.8	3.5
Males, 19 to 30 years	4.7	5.3	6.6	8.1	9.7	11.4	12.5	4
Males, 31 to 50 years	4.3	4.9	6.1	7.5	9.1	10.7	11.7	3.5
Males, 51 to 70 years	3.2	3.8	4.8	6.0	7.4	8.9	9.8	3
Males, 71+ years	2.7	3.2	4.1	5.2	6.6	7.9	8.8	3

Figure D2.8. Distribution of usual daily intakes of vegetables, in cup equivalents, in comparison to recommended intake levels, by age/sex group

Bars show, from left to right, usual vegetable intakes at the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles. Horizontal line shows recommended intake level for each age/sex group.



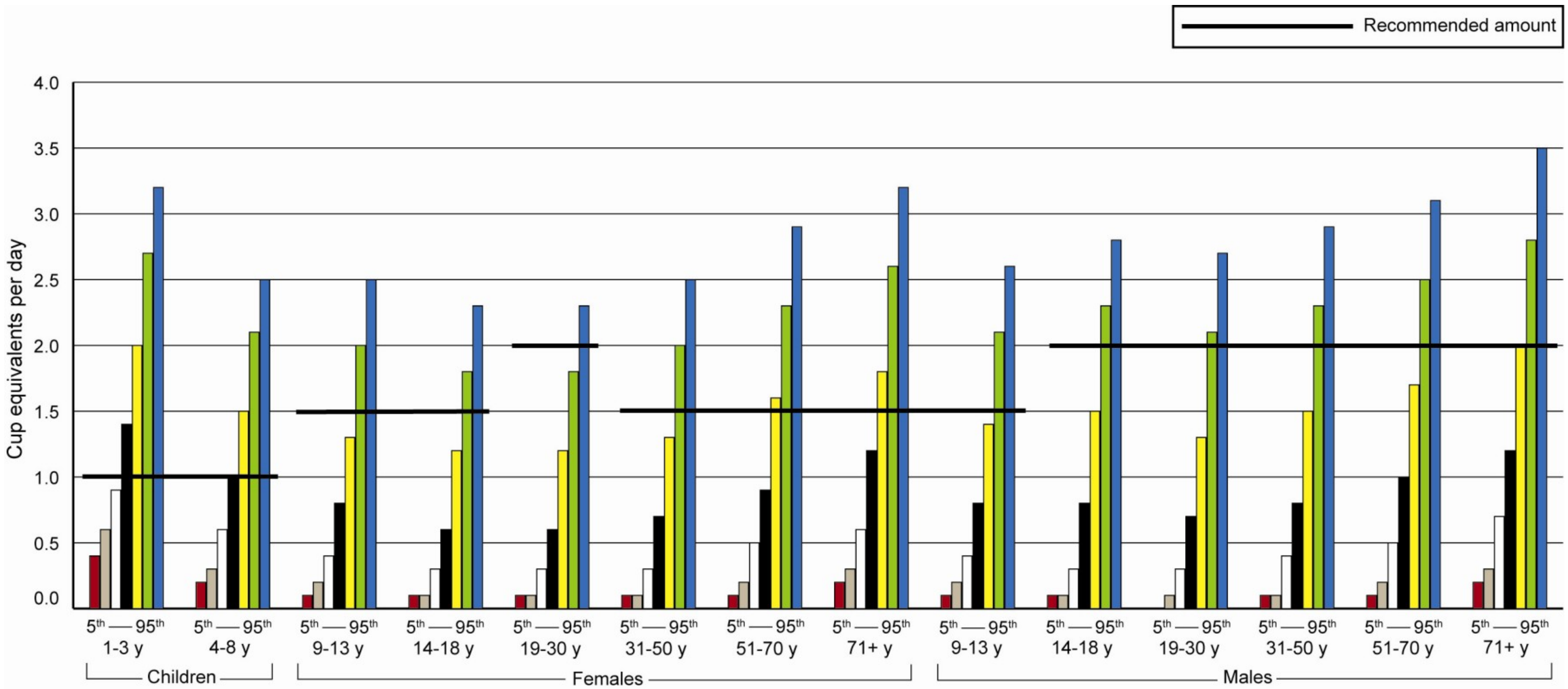
Source: Usual Intake of Total Vegetables, Including Cooked Dry Beans & Peas. Risk Factor Monitoring and Methods Branch Web site. Applied Research Program. National Cancer Institute. http://riskfactor.cancer.gov/diet/usualintakes/pop/t14.html. Updated April 13, 2010. Accessed April 22, 2010.

Figure D2.8. Data points. All values are in cup equivalents of vegetables.

Age/sex group	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Recommended amount
Children, 1 to 3 years	0.3	0.4	0.5	0.7	1.0	1.2	1.4	1
Children, 4 to 8 years	0.4	0.5	0.7	0.9	1.2	1.5	1.7	1.5
Females, 9 to 13 years	0.5	0.6	0.8	1.1	1.5	1.8	2.1	2
Females, 14 to 18 years	0.5	0.6	0.8	1.1	1.5	1.8	2.1	2.5
Females, 19 to 30 years	0.7	0.8	1.1	1.4	1.9	2.3	2.6	2.5
Females, 31 to 50 years	0.7	0.9	1.1	1.5	1.9	2.4	2.7	2.5
Females, 51 to 70 years	0.8	0.9	1.2	1.6	2.0	2.5	2.8	2
Females, 71+ years	0.7	0.8	1.1	1.4	1.9	2.3	2.6	2
Males, 9 to 13 years	0.5	0.6	0.8	1.2	1.6	2.1	2.5	2.5
Males, 14 to 18 years	0.6	0.7	1.0	1.4	1.9	2.4	2.8	3
Males, 19 to 30 years	0.8	0.9	1.3	1.8	2.3	2.9	3.3	3
Males, 31 to 50 years	0.9	1.1	1.4	1.9	2.5	3.2	3.6	3
Males, 51 to 70 years	0.8	1.0	1.4	1.8	2.4	3.0	3.5	2.5
Males, 71+ years	0.7	0.8	1.1	1.6	2.1	2.6	3.0	2.5

Figure D2.9. Distribution of usual daily intakes of fruits, in cup equivalents, in comparison to recommended intake levels, by age/sex group

Bars show, from left to right, usual fruit intakes at the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles. Horizontal line shows recommended intake level for each age/sex group.



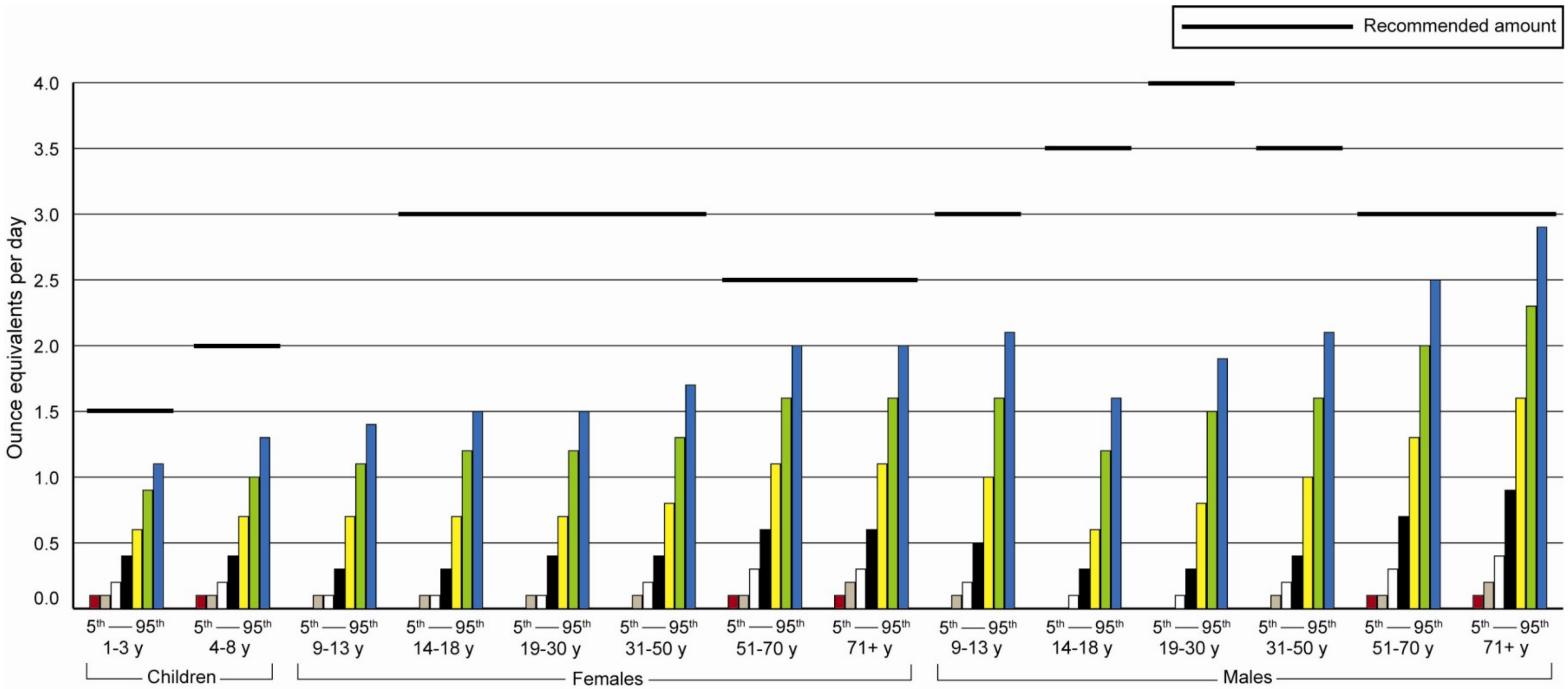
Source: Usual Intake of Total Fruit. Risk Factor Monitoring and Methods Branch Web site. Applied Research Program. National Cancer Institute. http://riskfactor.cancer.gov/diet/usualintakes/pop/t3.html. Updated April 13, 2010. Accessed April 22, 2010.

Figure D2.9. Data points. All values are in cup equivalents of fruits.

Age/sex group	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Recommended amount
Children, 1 to 3 years	0.4	0.6	0.9	1.4	2.0	2.7	3.2	1
Children, 4 to 8 years	0.2	0.3	0.6	1.0	1.5	2.1	2.5	1
Females, 9 to 13 years	0.1	0.2	0.4	0.8	1.3	2.0	2.5	1.5
Females, 14 to 18 years	0.1	0.1	0.3	0.6	1.2	1.8	2.3	1.5
Females, 19 to 30 years	0.1	0.1	0.3	0.6	1.2	1.8	2.3	2
Females, 31 to 50 years	0.1	0.1	0.3	0.7	1.3	2.0	2.5	1.5
Females, 51 to 70 years	0.1	0.2	0.5	0.9	1.6	2.3	2.9	1.5
Females, 71+ years	0.2	0.3	0.6	1.2	1.8	2.6	3.2	1.5
Males, 9 to 13 years	0.1	0.2	0.4	0.8	1.4	2.1	2.6	1.5
Males, 14 to 18 years	0.1	0.1	0.3	0.8	1.5	2.3	2.8	2
Males, 19 to 30 years	0.0	0.1	0.3	0.7	1.3	2.1	2.7	2
Males, 31 to 50 years	0.1	0.1	0.4	0.8	1.5	2.3	2.9	2
Males, 51 to 70 years	0.1	0.2	0.5	1.0	1.7	2.5	3.1	2
Males, 71+ years	0.2	0.3	0.7	1.2	2.0	2.8	3.5	2

Figure D2.10. Distribution of usual daily intakes of whole grains, in ounce equivalents, in comparison to recommended intake levels, by age/sex group

Bars show, from left to right, usual whole grains intakes at the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles. Horizontal line shows recommended intake level for each age/sex group.



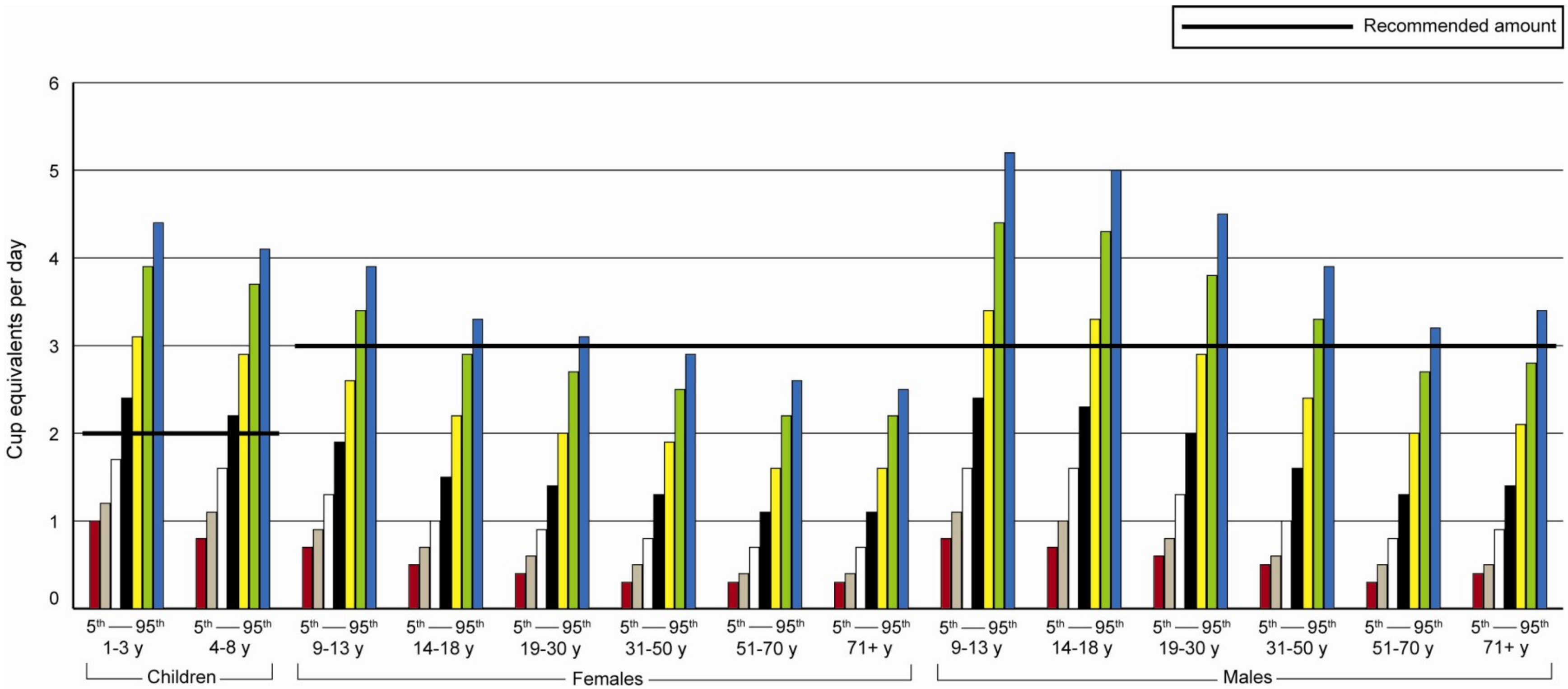
Source: Usual Intake of Whole Grains. Risk Factor Monitoring and Methods Branch Web site. Applied Research Program. National Cancer Institute. http://riskfactor.cancer.gov/diet/usualintakes/pop/t15.html. Updated April 13, 2010. Accessed April 22, 2010.

Figure D2.10. Data points. All values are in ounce equivalents of whole grains.

Age/sex group	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Recommended amount
Children, 1 to 3 years	0.1	0.1	0.2	0.4	0.6	0.9	1.1	1.5
Children, 4 to 8 years	0.1	0.1	0.2	0.4	0.7	1.0	1.3	2
Females, 9 to 13 years	0.0	0.1	0.1	0.3	0.7	1.1	1.4	2.5
Females, 14 to 18 years	0.0	0.1	0.1	0.3	0.7	1.2	1.5	3
Females, 19 to 30 years	0.0	0.1	0.1	0.4	0.7	1.2	1.5	3
Females, 31 to 50 years	0.0	0.1	0.2	0.4	0.8	1.3	1.7	3
Females, 51 to 70 years	0.1	0.1	0.3	0.6	1.1	1.6	2.0	2.5
Females, 71+ years	0.1	0.2	0.3	0.6	1.1	1.6	2.0	2.5
Males, 9 to 13 years	0.0	0.1	0.2	0.5	1.0	1.6	2.1	3
Males, 14 to 18 years	0.0	0.0	0.1	0.3	0.6	1.2	1.6	3.5
Males, 19 to 30 years	0.0	0.0	0.1	0.3	0.8	1.5	1.9	4
Males, 31 to 50 years	0.0	0.1	0.2	0.4	1.0	1.6	2.1	3.5
Males, 51 to 70 years	0.1	0.1	0.3	0.7	1.3	2.0	2.5	3
Males, 71+ years	0.1	0.2	0.4	0.9	1.6	2.3	2.9	3

Figure D2.11. Distribution of usual daily intakes of milk and milk products, in cup equivalents, in comparison to recommended intake levels, by age/sex group

Bars show, from left to right, usual milk and milk product intakes at the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles. Horizontal line shows recommended intake level for each age/sex group.



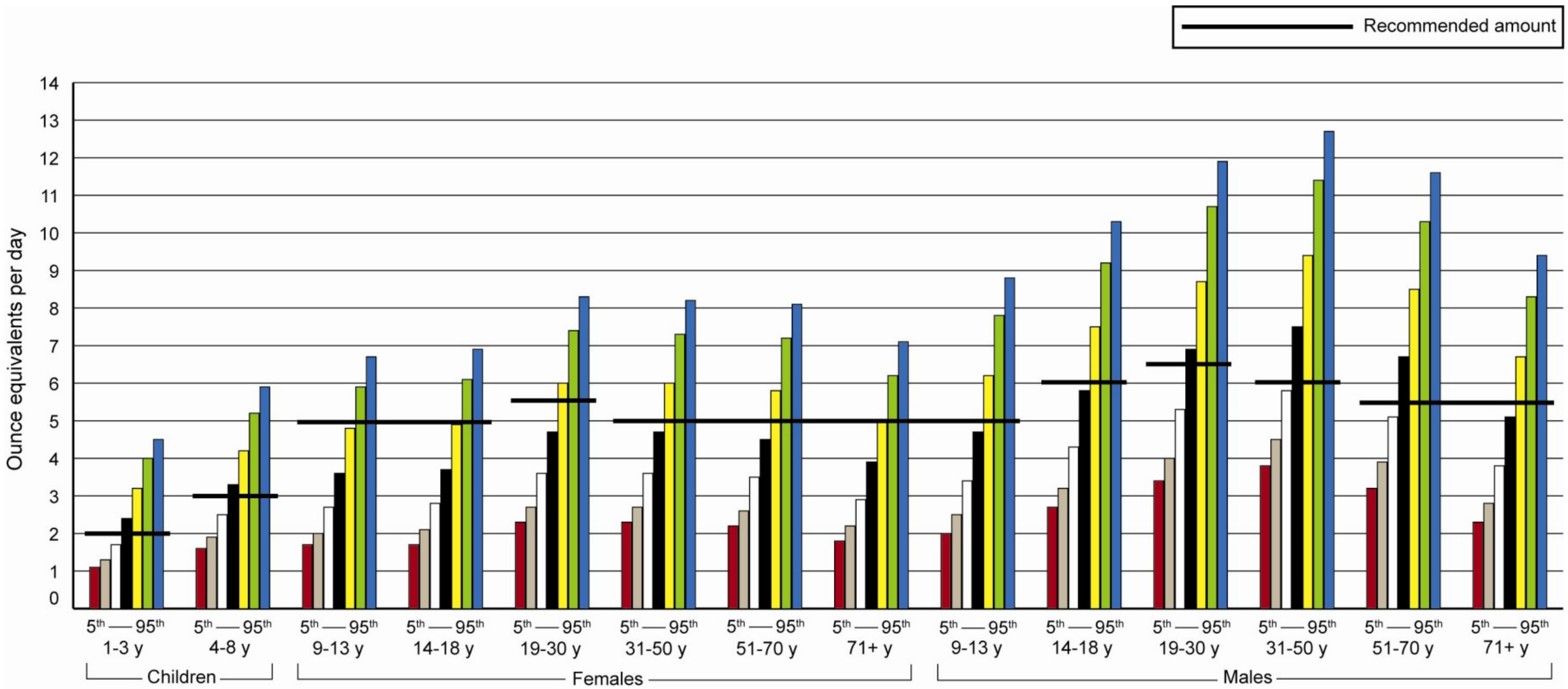
Source: Usual Intake of Total Milk, Yogurt, & Cheese. Risk Factor Monitoring and Methods Branch Web site. Applied Research Program. National Cancer Institute. http://riskfactor.cancer.gov/diet/usualintakes/pop/t32.html. Updated April 13, 2010. Accessed April 22, 2010.

Figure D2.11. Data points. All values are in cup equivalents of milk.

Age/sex group	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Recommended amount
Children, 1 to 3 years	1.0	1.2	1.7	2.4	3.1	3.9	4.4	2
Children, 4 to 8 years	0.8	1.1	1.6	2.2	2.9	3.7	4.1	2
Females, 9 to 13 years	0.7	0.9	1.3	1.9	2.6	3.4	3.9	3
Females, 14 to 18 years	0.5	0.7	1.0	1.5	2.2	2.9	3.3	3
Females, 19 to 30 years	0.4	0.6	0.9	1.4	2.0	2.7	3.1	3
Females, 31 to 50 years	0.3	0.5	0.8	1.3	1.9	2.5	2.9	3
Females, 51 to 70 years	0.3	0.4	0.7	1.1	1.6	2.2	2.6	3
Females, 71+ years	0.3	0.4	0.7	1.1	1.6	2.2	2.5	3
Males, 9 to 13 years	0.8	1.1	1.6	2.4	3.4	4.4	5.2	3
Males, 14 to 18 years	0.7	1.0	1.6	2.3	3.3	4.3	5.0	3
Males, 19 to 30 years	0.6	0.8	1.3	2.0	2.9	3.8	4.5	3
Males, 31 to 50 years	0.5	0.6	1.0	1.6	2.4	3.3	3.9	3
Males, 51 to 70 years	0.3	0.5	0.8	1.3	2.0	2.7	3.2	3
Males, 71+ years	0.4	0.5	0.9	1.4	2.1	2.8	3.4	3

Figure D2.12. Distribution of usual daily intakes of meat, poultry, fish, eggs, soy products, nuts, and seeds, in ounce equivalents, in comparison to recommended intake levels, by age/sex group

Bars show, from left to right, usual meat, poultry, fish, eggs, soy products, nuts, and seeds intakes at the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles. Horizontal line shows recommended intake level for each age/sex group.



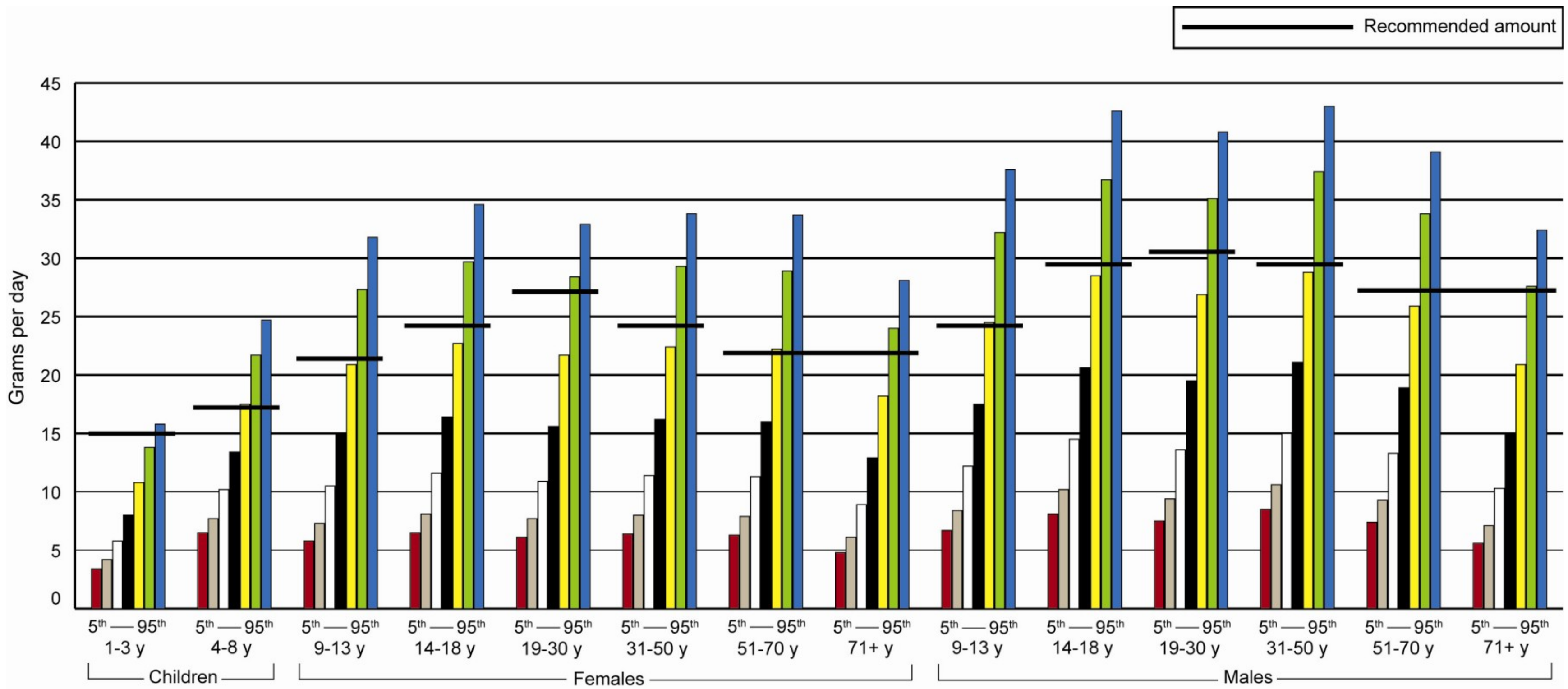
Source: Usual Intake of Total Meat, Fish, Poultry, Eggs, Soy Products, Nuts, & Seeds. Risk Factor Monitoring and Methods Branch Web site. Applied Research Program. National Cancer Institute. http://riskfactor.cancer.gov/diet/usualintakes/pop/t28.html. Updated April 13, 2010. Accessed April 22, 2010.

Figure D2.12. Data points. All values are in ounce equivalents.

Age/sex group	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Recommended amount
Children, 1 to 3 years	1.1	1.3	1.7	2.4	3.2	4.0	4.5	2
Children, 4 to 8 years	1.6	1.9	2.5	3.3	4.2	5.2	5.9	3
Females, 9 to 13 years	1.7	2.0	2.7	3.6	4.8	5.9	6.7	5
Females, 14 to 18 years	1.7	2.1	2.8	3.7	4.9	6.1	6.9	5
Females, 19 to 30 years	2.3	2.7	3.6	4.7	6.0	7.4	8.3	5.5
Females, 31 to 50 years	2.3	2.7	3.6	4.7	6.0	7.3	8.2	5
Females, 51 to 70 years	2.2	2.6	3.5	4.5	5.8	7.2	8.1	5
Females, 71+	1.8	2.2	2.9	3.9	5.0	6.2	7.1	5
Males, 9 to 13 years	2.0	2.5	3.4	4.7	6.2	7.8	8.8	5
Males, 14 to 18 years	2.7	3.2	4.3	5.8	7.5	9.2	10.3	6
Males, 19 to 30 years	3.4	4.0	5.3	6.9	8.7	10.7	11.9	6.5
Males, 31 to 50 years	3.8	4.5	5.8	7.5	9.4	11.4	12.7	6
Males, 51 to 70 years	3.2	3.9	5.1	6.7	8.5	10.3	11.6	5.5
Males, 71+ years	2.3	2.8	3.8	5.1	6.7	8.3	9.4	5.5

Figure D2.13. Distribution of usual daily intakes of oils, in grams, in comparison to recommended intake levels, by age/sex group

Bars show, from left to right, usual oils intakes at the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles. Horizontal line shows recommended intake level for each age/sex group.

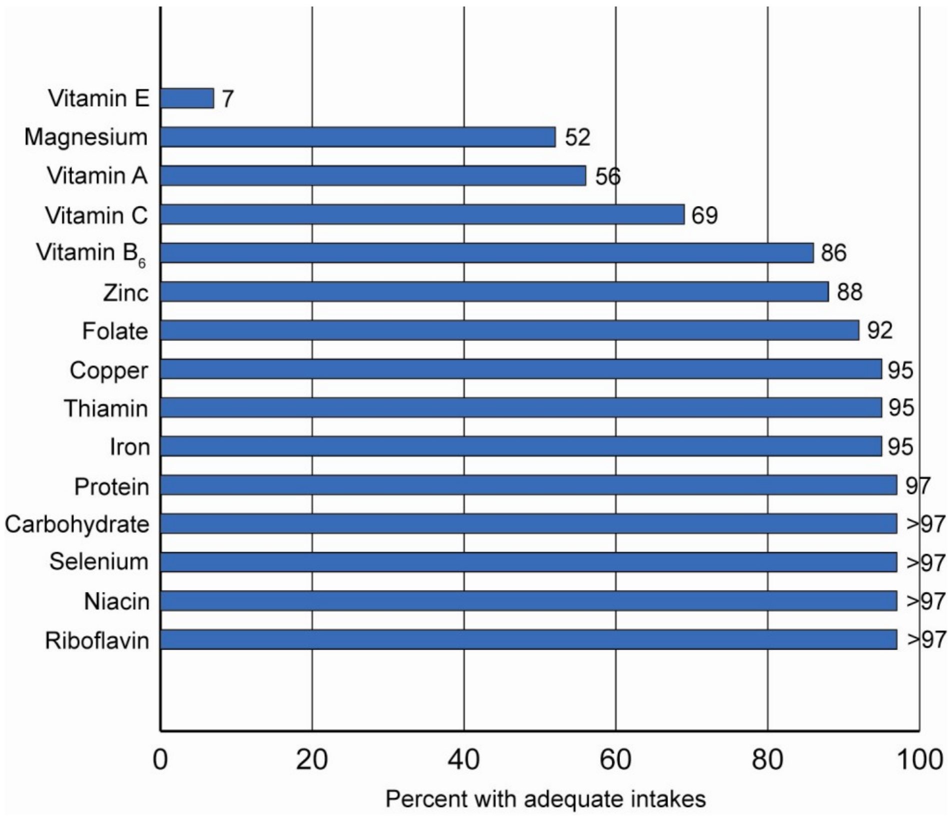


Source: Usual Intake of Oils. Risk Factor Monitoring and Methods Branch Web site. Applied Research Program. National Cancer Institute. http://riskfactor.cancer.gov/diet/usualintakes/pop/t33.html. Updated April 13, 2010. Accessed April 22, 2010.

Figure D2.13. Data points. All values are in grams.

Age/sex group	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Recommended amount
Children, 1 to 3 years	4.2	5.8	8.0	10.8	13.8	15.8	15
Children, 4 to 8 years	7.7	10.2	13.4	17.5	21.7	24.7	17
Females, 9 to 13 years	7.3	10.5	15.0	20.9	27.3	31.8	22
Females, 14 to 18 years	8.1	11.6	16.4	22.7	29.7	34.6	24
Females, 19 to 30 years	7.7	10.9	15.6	21.7	28.4	32.9	27
Females, 31 to 50 years	8.0	11.4	16.2	22.4	29.3	33.8	24
Females, 51 to 70 years	7.9	11.3	16.0	22.2	28.9	33.7	22
Females, 71+ years	6.1	8.9	12.9	18.2	24.0	28.1	22
Males, 9 to 13 years	8.4	12.2	17.5	24.5	32.2	37.6	24
Males, 14 to 18 years	10.2	14.5	20.6	28.5	36.7	42.6	29
Males, 19 to 30 years	9.4	13.6	19.5	26.9	35.1	40.8	31
Males, 31 to 50 years	10.6	15.0	21.1	28.8	37.4	43.0	29
Males, 51 to 70 years	9.3	13.3	18.9	25.9	33.8	39.1	27
Males, 71+ years	7.1	10.3	14.9	20.9	27.6	32.4	27

Figure D2.14. Level of adequacy expressed as estimated percentages of Americans with nutrient intakes from food above their requirements (EARs)

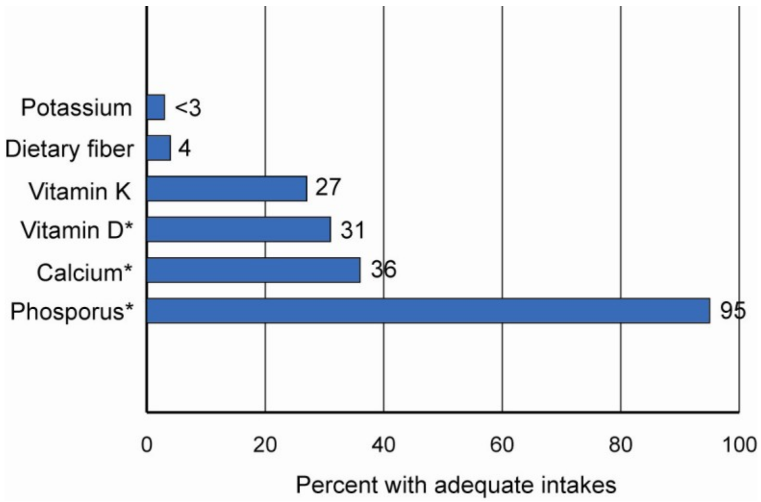


Source: Moshfegh, Alanna; Goldman, Joseph; and Cleveland, Linda. 2005. *What We Eat in America*, NHANES 2001-2002: Usual Nutrient Intakes from Food Compared to Dietary Reference Intakes. U.S. Department of Agriculture, Agricultural Research Service.

Figure D2.14. Data points.

Nutrient	Percent with adequate intakes
Vitamin E	7
Magnesium	52
Vitamin A	56
Vitamin C	69
Vitamin B_6	86
Zinc	88
Folate	92
Copper	95
Thiamin	95
Iron	95
Protein	97
Carbohydrate	>97
Selenium	>97
Niacin	>97
Riboflavin	>97

Figure D2.15. Level of adequacy expressed as estimated percentages of Americans with nutrient intakes from food above the Adequate Intake (AI) level



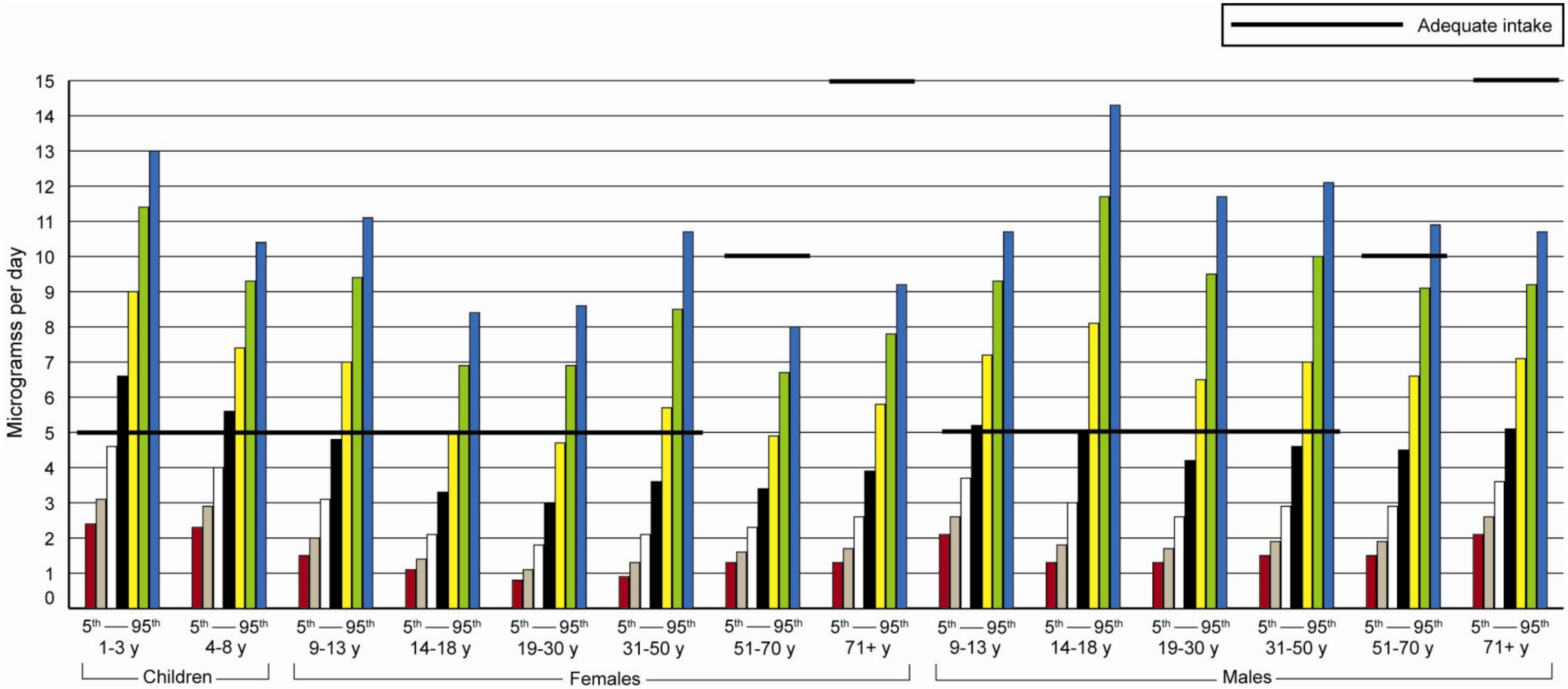
Sources:
Moshfegh, Alanna; Goldman, Joseph; and Cleveland, Linda. 2005. *What We Eat in America*, NHANES 2001-2002: Usual Nutrient Intakes from Food Compared to Dietary Reference Intakes. U.S. Department of Agriculture, Agricultural Research Service.
Moshfegh, Alanna; Goldman, Joseph; Ahuja, Jaspreet; Rhodes, Donna; and LaComb, Randy. 2009. *What We Eat in America*, NHANES 2005-2006: Usual Nutrient Intakes from Food and Water Compared to 1997 Dietary Reference Intakes for Vitamin D, Calcium, Phosphorus, and Magnesium. U.S. Department of Agriculture, Agricultural Research Service.

Figure D2.15. Data points.

Nutrient	Percent with intakes above adequate intake
Potassium	<3
Dietary fiber	4
Vitamin K	27
Vitamin D*	31
Calcium*	36
Phosphorus*	95

Figure D2.16. Distribution of usual daily intakes of vitamin D, in micrograms, in comparison to Adequate Intake (AI) levels, by age/sex group

Bars show, from left to right, usual vitamin D intakes at the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles. Horizontal line shows the AI level for each age/sex group.



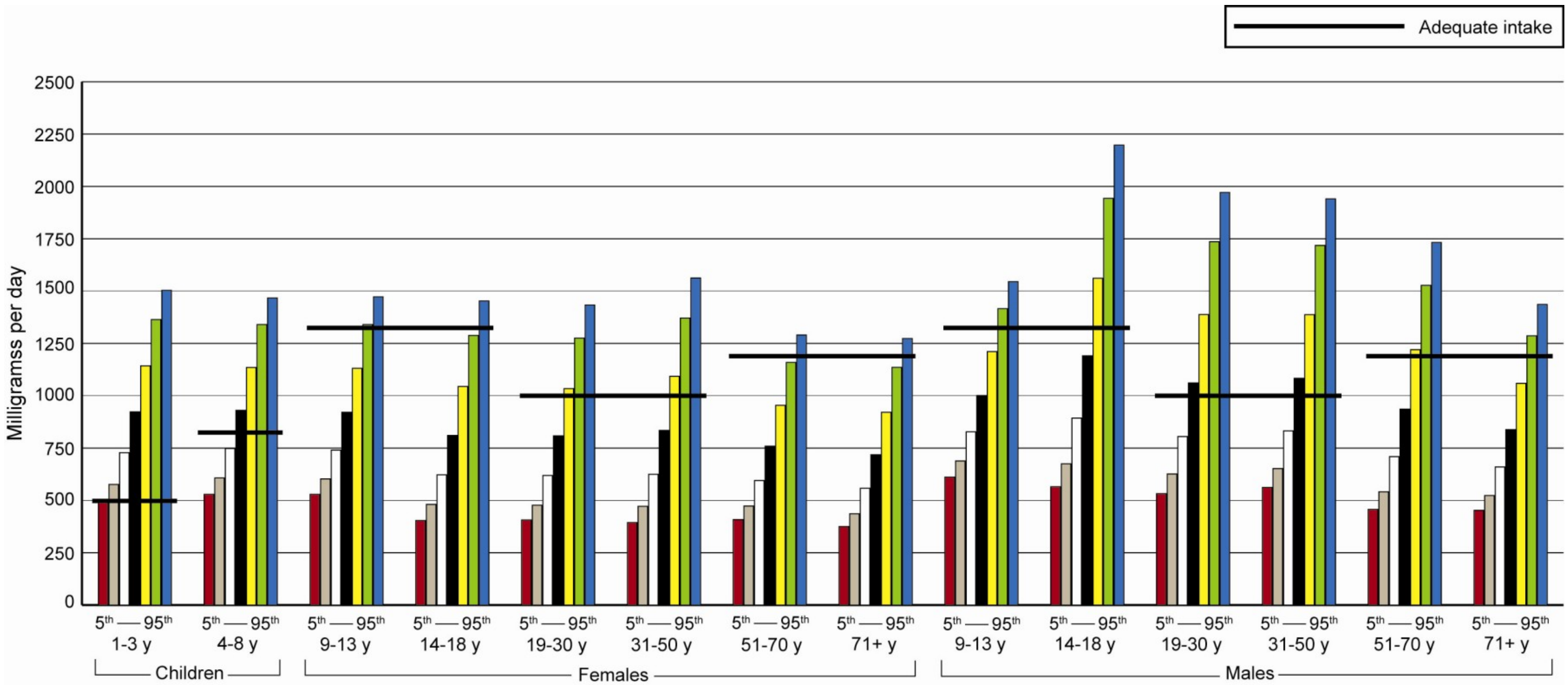
Source: Moshfegh, Alanna; Goldman, Joseph; Ahuja, Jaspreet; Rhodes, Donna; and LaComb, Randy. 2009. *What We Eat in America*, NHANES 2005-2006: Usual Nutrient Intakes from Food and Water Compared to 1997 Dietary Reference Intakes for Vitamin D,Calcium, Phosphorus, and Magnesium. U.S. Department of Agriculture, Agricultural Research Service.

Figure D2.16. Data points. All values are in micrograms.

Age/sex group	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Adequate intake
Children, 1 to 3 years	2.4	3.1	4.6	6.6	9.0	11.4	13.0	5
Children, 4 to 8 years	2.3	2.9	4.0	5.6	7.4	9.3	10.4	5
Females, 9 to 13 years	1.5	2.0	3.1	4.8	7.0	9.4	11.1	5
Females, 14 to 18 years	1.1	1.4	2.1	3.3	5.0	6.9	8.4	5
Females, 19 to 30 years	0.8	1.1	1.8	3.0	4.7	6.9	8.6	5
Females, 31 to 50 years	0.9	1.3	2.1	3.6	5.7	8.5	10.7	5
Females, 51 to 70 years	1.3	1.6	2.3	3.4	4.9	6.7	8.0	10
Females, 71+ years	1.3	1.7	2.6	3.9	5.8	7.8	9.2	15
Males, 9 to 13 years	2.1	2.6	3.7	5.2	7.2	9.3	10.7	5
Males, 14 to 18 years	1.3	1.8	3.0	5.0	8.1	11.7	14.3	5
Males, 19 to 30 years	1.3	1.7	2.6	4.2	6.5	9.5	11.7	5
Males, 31 to 50 years	1.5	1.9	2.9	4.6	7.0	10.0	12.1	5
Males, 51 to 70 years	1.5	1.9	2.9	4.5	6.6	9.1	10.9	10
Males, 71+ years	2.1	2.6	3.6	5.1	7.1	9.2	10.7	15

Figure D2-17. Distribution of usual daily intakes of calcium, in milligrams, in comparison to Adequate Intake (AI) levels, by age/sex group

Bars show, from left to right, usual calcium intakes at the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles. Horizontal line shows AI level for each age/sex group.



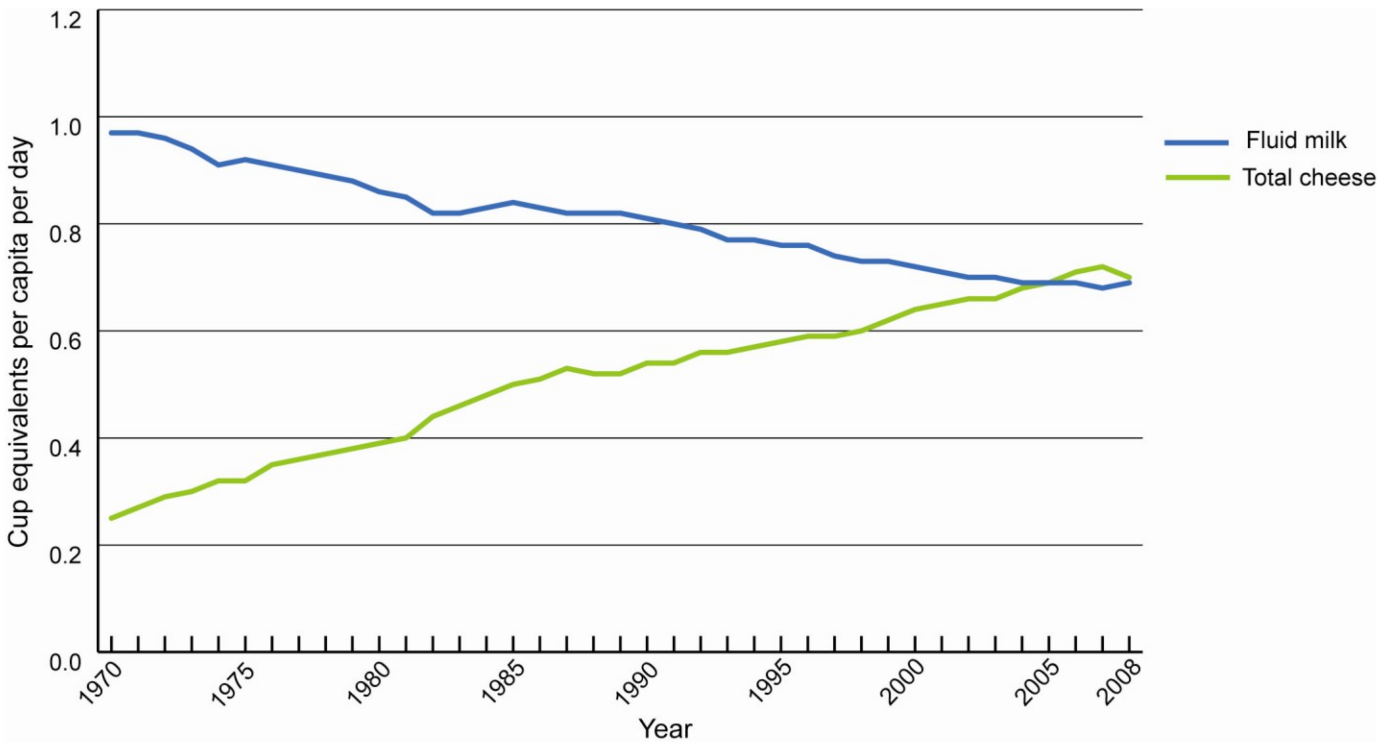
Source: Moshfegh, Alanna; Goldman, Joseph; Ahuja, Jaspreet; Rhodes, Donna; and LaComb, Randy. 2009. *What We Eat in America*, NHANES 2005-2006: Usual Nutrient Intakes from Food and Water Compared to 1997 Dietary Reference Intakes for Vitamin D, Calcium, Phosphorus, and Magnesium. U.S. Department of Agriculture, Agricultural Research Service.

Figure D2.17. Data points. All values are in milligrams.

Age/sex group	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Adequate intake
Children, 1 to 3 years	494	576	728	923	1143	1364	1503	500
Children, 4 to 8 years	529	607	748	930	1135	1340	1467	800
Females, 9 to 13 years	529	603	740	921	1131	1340	1472	1300
Females, 14 to 18 years	404	481	622	810	1044	1288	1453	1300
Females, 19 to 30 years	406	477	619	808	1034	1275	1433	1000
Females, 31 to 50 years	394	472	625	834	1093	1371	1562	1000
Females, 51 to 70 years	408	473	595	759	954	1159	1290	1200
Females, 71+ years	375	436	558	718	921	1136	1273	1200
Males, 9 to 13 years	611	688	828	1001	1211	1416	1545	1300
Males, 14 to 18 years	565	675	893	1191	1561	1943	2197	1300
Males, 19 to 30 years	532	626	805	1061	1388	1736	1971	1000
Males, 31 to 50 years	562	652	832	1083	1387	1718	1940	1000
Males, 51 to 70 years	457	541	709	936	1220	1527	1732	1200
Males, 71+ years	452	523	660	838	1059	1286	1436	1200

Figure D2.18. Relative proportions of fluid milk and cheese available for consumption over time

Graph shows loss adjusted availability of fluid milk and cheese in cup equivalents per capita per day.



Source: Economic Research Service (ERS), U.S. Department of Agriculture (USDA). Food Availability (Per Capita) Data System. http://www.ers.usda.gov/Data/FoodConsumption.

Figure D2.18. Data points.

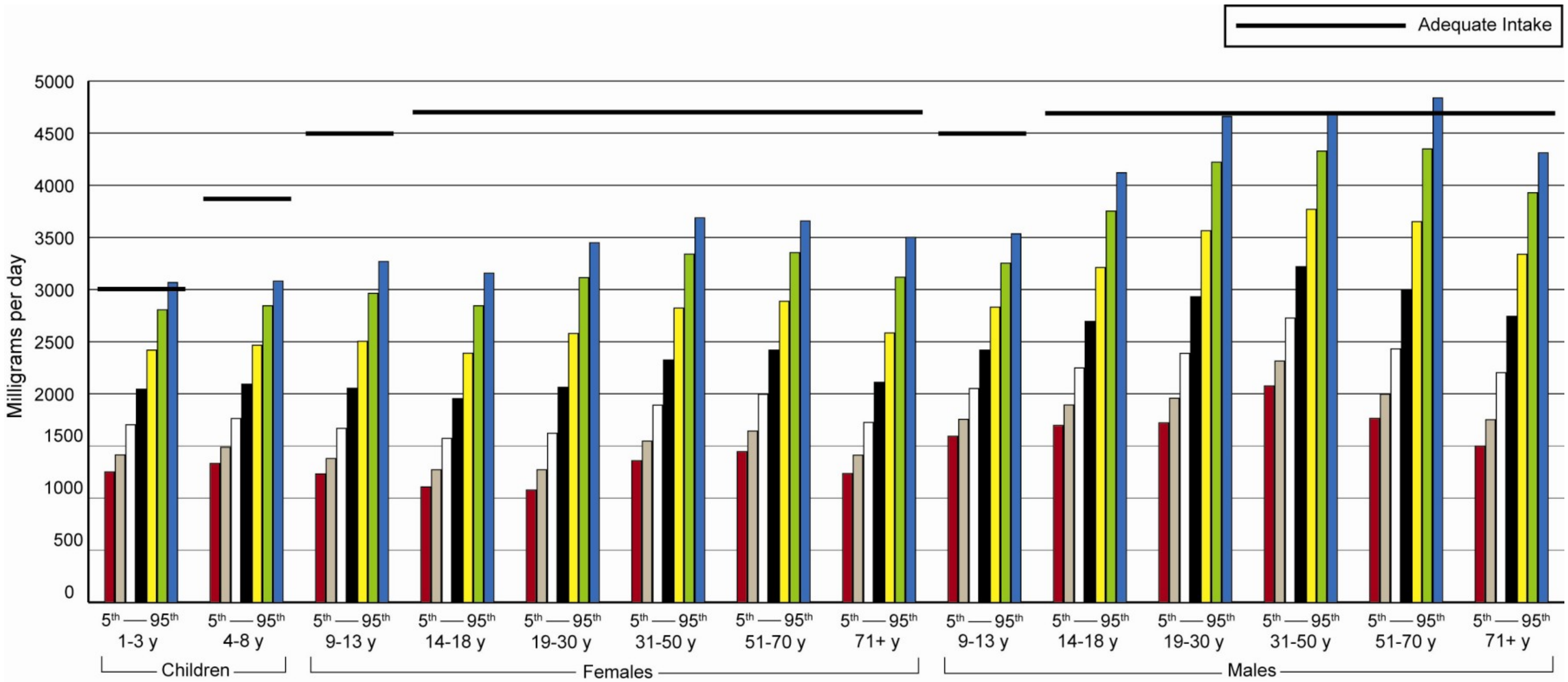
Year	Fluid milk	Total cheese
1970	0.97	0.25
1971	0.97	0.27
1972	0.96	0.29
1973	0.94	0.30
1974	0.91	0.32
1975	0.92	0.32
1976	0.91	0.35
1977	0.90	0.36
1978	0.89	0.37
1979	0.88	0.38
1980	0.86	0.39
1981	0.85	0.40
1982	0.82	0.44
1983	0.82	0.46
1984	0.83	0.48
1985	0.84	0.50
1986	0.83	0.51
1987	0.82	0.53
1988	0.82	0.52
1989	0.82	0.52

Figure D2.18. Data points continued.

Year	Fluid milk	Total cheese
1990	0.81	0.54
1992	0.80	0.54
1992	0.79	0.56
1993	0.77	0.56
1994	0.77	0.57
1995	0.76	0.58
1996	0.76	0.59
1997	0.74	0.59
1998	0.73	0.60
1999	0.73	0.62
2000	0.72	0.64
2001	0.71	0.65
2002	0.70	0.66
2003	0.70	0.66
2004	0.69	0.68
2005	0.69	0.69
2006	0.69	0.71
2007	0.68	0.72
2008	0.69	0.70

Figure D2.19. Distribution of usual daily intakes of potassium, in milligrams, in comparison to Adequate Intake (AI) levels, by age/sex group

Bars show, from left to right, usual potassium intakes at the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles. Horizontal line shows AI level for each age/sex group.



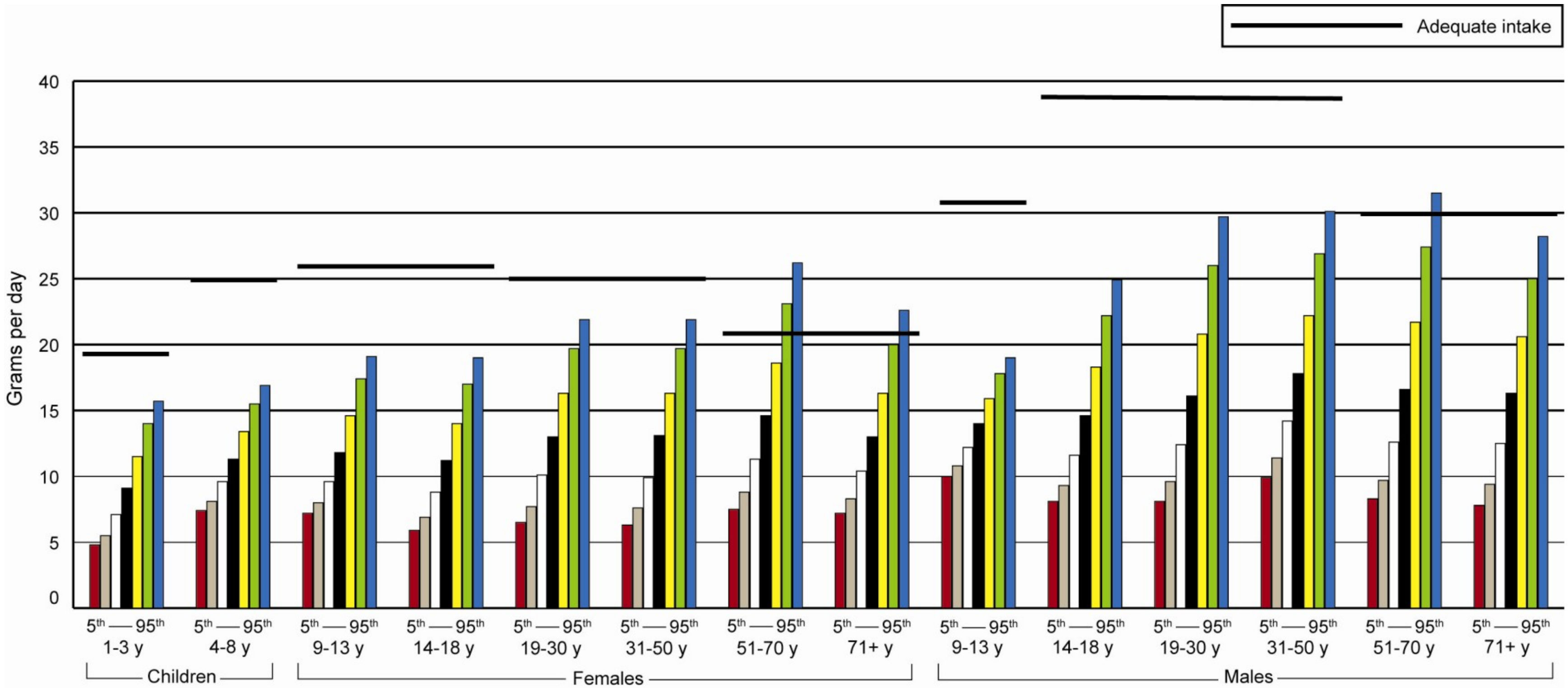
Source: Moshfegh, Alanna; Goldman, Joseph; and Cleveland, Linda. 2005. *What We Eat in America*, NHANES 2001-2002: Usual Nutrient Intakes from Food Compared to Dietary Reference Intakes. U.S. Department of Agriculture, Agricultural Research Service.

Figure D2.19. Data points. All values are in milligrams.

Age/sex group	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Adequate intake
Children, 1 to 3 years	1251	1414	1703	2044	2419	2806	3067	3000
Children, 4 to 8 years	1332	1487	1763	2092	2466	2845	3081	3800
Females, 9 to 13 years	1231	1379	1669	2054	2503	2964	3268	4500
Females, 14 to 18 years	1107	1271	1573	1954	2389	2845	3157	4700
Females, 19 to 30 years	1077	1271	1622	2063	2579	3114	3449	4700
Females, 31 to 50 years	1358	1547	1892	2324	2822	3340	3688	4700
Females, 51 to 70 years	1446	1643	1995	2419	2887	3354	3657	4700
Females, 71+ years	1235	1411	1726	2111	2584	3118	3501	4700
Males, 9 to 13 years	1593	1755	2051	2419	2831	3253	3535	4500
Males, 14 to 18 years	1697	1893	2248	2694	3211	3752	4121	4700
Males, 19 to 30 years	1722	1958	2388	2932	3564	4221	4660	4700
Males, 31 to 50 years	2076	2314	2726	3219	3769	4328	4692	4700
Males, 51 to 70 years	1764	1995	2431	2994	3651	4349	4837	4700
Males, 71+ years	1499	1752	2202	2743	3338	3929	4311	4700

Figure D2.20. Distribution of usual daily intakes of dietary fiber, in grams, in comparison to Adequate Intake (AI) levels, by age/sex group

Bars show, from left to right, usual dietary fiber intakes at the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles. Horizontal line shows AI level for each age/sex group.



Source: Dietary Fiber (g): Usual Intakes from Food and Water, 2003-2006, Compared to Adequate Intakes. Food Surveys Research Group, Agricultural Research Service, USDA. What We Eat in America, NHANES 2003-2006. Website: http://www.ars.usda.gov/Services/docs.htm?docid=18349. Updated April 1, 2010. Accessed April 22, 2010.

Figure D2.20. Data points. All values are in grams.

Age/sex group	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Adequate intake
Children, 1 to 3 years	4.8	5.5	7.1	9.1	11.5	14.0	15.7	19
Children, 4 to 8 years	7.4	8.1	9.6	11.3	13.4	15.5	16.9	25
Females, 9 to 13 years	7.2	8.0	9.6	11.8	14.6	17.4	19.1	26
Females, 14 to 18 years	5.9	6.9	8.8	11.2	14.0	17.0	19.0	26
Females, 19 to 30 years	6.5	7.7	10.1	13.0	16.3	19.7	21.9	25
Females, 31 to 50 years	6.3	7.6	9.9	13.1	16.3	19.7	21.9	25
Females, 51 to 70 years	7.5	8.8	11.3	14.6	18.6	23.1	26.2	21
Females, 71+ years	7.2	8.3	10.4	13.0	16.3	20.0	22.6	21
Males, 9 to 13 years	10.0	10.8	12.2	14	15.9	17.8	19	31
Males, 14 to 18 years	8.1	9.3	11.6	14.6	18.3	22.2	24.9	38
Males, 19 to 30 years	8.1	9.6	12.4	16.1	20.8	26.0	29.7	38
Males, 31 to 50 years	9.9	11.4	14.2	17.8	22.2	26.9	30.1	38
Males, 51 to 70 years	8.3	9.7	12.6	16.6	21.7	27.4	31.5	30
Males, 71+ years	7.8	9.4	12.5	16.3	20.6	25.0	28.2	30