

PART D: SCIENCE BASE

Section 1: Aiming To Meet Recommended Intakes of Nutrients

This section addresses five major questions related to achieving recommended intakes of nutrients and special considerations:

1. What nutrients are most likely to be consumed in amounts low enough to be of concern?
2. What dietary pattern is associated with achieving recommended nutrient intakes?
3. What factors related to diet or physical activity may help or hinder achieving recommended nutrient intakes?
4. How can the flexibility of the food pattern be increased?
5. Are special nutrient recommendations needed for certain subgroups?

The search strategies used to find the scientific evidence related to each of these questions appear in Part D, “Methodology.” See Appendix G-3 for tables summarizing the findings related to Questions 3, 4, and 5.

NUTRIENT INTAKE GOALS

At least 34 nutrients are needed for growth and normal body functioning. 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. Prospective epidemiological studies suggest that a healthy dietary pattern—one that provides recommended intakes of nutrients—reduces the risk of some common chronic diseases, including cardiovascular disease and some cancers (see Sections D3 to D8).

One premise of the Dietary Guidelines Advisory Committee (the Committee) is that the nutrients consumed should come primarily from foods. Many people understand the importance of good nutrition but believe that a daily vitamin 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 whole foods. 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 not shown that taking beta-carotene in pill form decreases the risk of cancer (Mannisto et al., 2004; Neuhouser et al., 2003). It is possible that beta-carotene and other nutrients are most beneficial to health when they are consumed in a natural form and in combination with each other, which occurs when a person consumes foods such as fruits, vegetables (including legumes), and whole grains. These foods contain not only the well-known vitamins and minerals that are often found in vitamin pills, but also hundreds of naturally occurring substances, including carotenoids, flavonoids and isoflavones, and protease

inhibitors that may protect against cancer, heart disease, and other chronic health conditions. The Institute of Medicine (IOM) report *Dietary Reference Intakes: Applications in Dietary Planning* (IOM, 2003) notes instances when fortified foods may be advantageous, including providing additional sources of certain 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.

Another basic premise of the Committee is that *Dietary Guidelines for Americans* should provide guidance in obtaining all the nutrients needed for growth and health. To this end, the Committee recommends that food guidance aim to achieve the most recent Recommended Dietary Allowances (RDAs), Adequate Intakes (AIs), and Acceptable Macronutrient Distribution Ranges (AMDRs) considering the individual's life stage, gender, and activity level (IOM, 1997, 1998, 2000a, 2001a, 2002, 2004). The Committee also recommends that the guidance consider the Tolerable Upper Intake Levels (ULs) (IOM, 1997, 1998, 2000a, 2001a, 2002, 2004). For convenience in this report, the term *Dietary Reference Intakes* (DRIs) is used to refer to the RDAs, AIs, AMDRs, and ULs—the reference intakes that are to be considered in diet planning.

The RDA for a nutrient is “the dietary intake level that is sufficient to meet the nutrient requirement of nearly all healthy individuals in a particular life stage and gender group” (IOM, 2003, p 24). The AI is a recommended intake value used when an RDA has not been set for a nutrient. The AI “is a value based on experimentally derived levels of intake or the mean nutrient intake by a group . . . of apparently healthy people” (IOM, 2003, pp 24–25).

The IOM recommends that RDAs or AIs be used to plan diets for individuals (IOM, 2003). The planning of food intake patterns, which was introduced in Part C, “Methodology,” is an example of this application. Both the AI and RDA are intended to serve as a goal for individual intake 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 RDA provides assurance that the probability of inadequate dietary intake of the nutrient will not exceed 2 to 3 percent (IOM, 2003).

The UL is the highest level of usual intake that is likely to pose no risk of adverse health effects for nearly all individuals in the age and gender group. Since consuming intakes below the UL minimizes risk to the individual, dietary guidelines for individuals should avoid exceeding the UL (IOM, 2003).

Table D1-1, which lists nutritional goals for the U.S. Department of Agriculture's (USDA's) daily food intake pattern, shows nutrient intake goals based on the current DRIs.

QUESTION 1: WHAT NUTRIENTS ARE MOST LIKELY TO BE CONSUMED BY THE GENERAL PUBLIC IN AMOUNTS LOW ENOUGH TO BE OF CONCERN?

Conclusion

Reported dietary intakes of the following nutrients are low enough to be of concern:

- For adults: vitamins A, C, and E, calcium, magnesium, potassium, and fiber
- For children: vitamin E, calcium, magnesium, potassium, and fiber.

Efforts are warranted to promote increased dietary intakes of vitamin E, potassium, and fiber regardless of age; increased intakes of vitamins A and C, calcium, and magnesium by adults; and increased intakes of calcium and magnesium by children age 9 years or older. Efforts are especially warranted to improve the dietary intakes of adolescent females.

Rationale

To reach this conclusion, the Committee examined data from reports that used methods recommended by the IOM for assessing the prevalence of inadequate nutrient intakes in a population (IOM, 2001b), supplemented by data from the Centers for Disease Control and Prevention and from the Agricultural Research Service.

Methods To Identify Shortfall Nutrients

If a group has a high prevalence of inadequate dietary intake of a nutrient, that nutrient is called a *shortfall* nutrient. Such nutrients are consumed in amounts low enough to be of concern. Although the RDA is intended to be used in planning diets, it is not appropriate to use it for identifying the proportion of a group whose usual intake of a nutrient is less than the requirement for that nutrient (IOM, 2003). When available, the Estimated Average Requirement (EAR) is the 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 (IOM, 2001).

The usual intake is the long-run average intake. If intake data are available for at least 2 days, statistical methods can be used to estimate usual intake as described by Guenther et al. (1997) and by Nusser et al. (1996). Because the requirement distribution for iron is skewed, the probability approach (NRC, 1986) is the recommended method to determine the adequacy of intake of that nutrient. For nutrients for which there is an AI rather than an EAR, usual intake distributions are examined, if available, and mean intakes are compared with the AI (IOM, 2001). If mean intake is above the AI, a low prevalence of inadequate intakes is likely.

Published data using the nutrient assessment methods recommended by the IOM (2001) are available for vitamin E (Maras et al., 2004) and for intakes by school children of 13 nutrients (Suitor and Gleason, 2002). Foote and co-workers (2004) used related methods to calculate the *probability of adequacy for individuals* on a single day for 15 nutrients.

Findings Regarding Shortfall Nutrients

As shown in Table D1-2, the probability of adequate dietary intake of six nutrients was less than 60 percent for the adult men and women. These nutrients include vitamins E, A, C, and folate¹, calcium, and magnesium. As shown in Table D1-3, mean intakes of potassium and fiber are far below the AI for all age groups. When mean intakes are below the AI for a nutrient, it cannot be assumed that the prevalence of inadequacy is low. Table D1-4 shows the results of an analysis of food intake data from the 1994–1996 *Continuing Survey of Food Intake by Individuals* for 2,692 children of school age (Suitor and Gleason, 2002). In contrast to Table D1-2, the values in this table represent *inadequacy* rather than adequacy. Nearly 80 percent of all the children had usual intakes of vitamin E that were below the EAR. The percentages of children with usual nutrient intakes below the EAR tended to increase by age group and were more pronounced for females than for males. For adults, reported folate and magnesium intakes tended to be below the EAR for sizable percentages of children. Suitor and Gleason (2002) present data for the usual distribution of calcium intake by children. Median calcium intake was well below the AI beginning at age 9 years. Shortfalls among children were most numerous and severe for females age 14 to 18 years (Suitor and Gleason, 2002).

Although the percentages of males and females with folate intakes below the EAR are reported to be very high (see Tables D1-2 and D1-4), these values no doubt overestimate the problem (Foote et al., 2004; Suitor and Gleason, 2002). The data were collected before the Food and Drug Administration required the fortification of enriched grains with folic acid, the synthetic form of folate. In addition, the folate values are reported in milligrams of total folate rather than in dietary folate equivalents—the units in which the RDAs are given. Shikany and co-workers (2004) examined the effect of folic acid fortification on folate intake by using pre- and post-fortification folate databases to estimate folate intake of 77 women in a clinical trial involving cigarette smokers. Mean folate intake assessed with the post-fortification database was 63 percent higher than intake assessed with the prefortification database. In this small nonrepresentative study, the proportion of subjects with folate intakes below the EAR decreased ($P < 0.0001$) from 75 percent before fortification to 40 percent after fortification. This study, although limited, suggests that folate may continue to be a nutrient of concern and that attention should be given to consuming foods that are rich sources of folate.

Advance data from National Health and Nutrition examination Survey (NHANES) 1999–2000 (Ervin et al., 2004), based on 1-day diet recalls, cover years when folic acid fortification of enriched grain products was in effect but folate intakes are reported in micrograms of folic acid rather than dietary folate equivalents. Although the age groups do not correspond exactly when comparing median intake with the EAR, it appears that reported median intakes by all males and children under age 12 exceeded the EAR, while intakes by females age 12 and older were still lower than the EAR. For example, median folate intakes of women age 20 to 59 years were 291 μg per day as compared to the EAR of 320 μg per day. It is not known to what extent reporting intakes in dietary folate equivalents would increase the estimated intake values. Recent nationwide data on the

¹ While the probability of adequacy for folate was found to be low, the data used were collected prior to the mandatory fortification of enriched grains with folate. See further discussion later in this section.

distribution of *usual* folate intake are not yet available to determine whether folate intake is of concern for adult women in particular or the public in general.

Nutrients That Pose Special Challenges

The Committee gives special attention to four shortfall nutrients below: vitamin E, calcium, potassium, and fiber. These four nutrients pose special challenges in developing dietary guidance to meet recommended food intakes, as explained later in this section. We address iron and vitamins B₁₂, D, and folate under Question 5, which deals with special populations. In addition, we present more detailed information about the nutrients water, sodium, potassium, and fiber in later sections of Part D. Low intakes of vitamins A, C, and magnesium tend to reflect low intakes of fruits and vegetables. The food pattern described below show that these nutrient requirements can be met by increasing the intake of fruits and vegetables. Tables D1-5a, D1-6a, and D1-7a list the best food sources of vitamin A, C, and magnesium per standard amount, respectively, from the Agricultural Research Service nutrient database, along with the number of calories for that standard amount. Tables D1-5b, D1-6b, and D1-7b list the major sources of these nutrients from American food consumption data.

The U.S. Department of Agriculture (USDA) (Fed. Reg. Notice, 2003) proposed a food intake pattern with the goal of meeting recommended intakes for all nutrients. The *basic food groups* used in this pattern and mentioned below are fruits, vegetables, grains, meat and beans, and milk. The proposed pattern has since been revised by USDA in collaboration with the Committee, to take into account the newly released IOM recommendations for potassium and sodium (IOM, 2004). Methods used in developing these patterns are summarized in Part C of this report. The revised food intake pattern meets nutritional recommendations for almost all nutrients, including most of the nutrients considered shortfall nutrients. Exceptions are vitamin E and potassium, as described below.

Vitamin E. As shown in Tables D1-2 and D1-4, and reported by Maras et al. (2004), vitamin E is a shortfall nutrient for nearly the entire population of U.S. adults and children. Although these data suggest widespread deficiency, there is no evidence of overt deficiency symptoms, i.e., sensory neuropathy and erythrocyte fragility, in the American population. Current intake levels likely are underestimated because of the underreporting of food intake on dietary surveys, especially related to the intake of fats and oils, and the limitations of nutrient databases with regard to the vitamin E content of foods (IOM, 2000a; Maras et al., 2004).

Most Americans do not typically consume foods that are especially rich in vitamin E on a daily basis. Table D1-8a lists the best food sources of vitamin E per standard amount from the Agricultural Research Service nutrient database along with the number of calories for that amount. Table D1-8b lists the major sources of vitamin E from American food consumption data. 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 United States.

The revised USDA food intake pattern includes increases in vitamin E content over current consumption but still provides only 50 to 90 percent of the RDA for vitamin E. The food composites used in modeling the food pattern are relatively low in vitamin E content, reflecting Americans' relatively low use of foods rich in vitamin E. As the calorie level of the food pattern increases, the pattern comes closer to providing the recommended intake of vitamin E.

Calcium. Milk and milk products are rich sources of calcium. Table D1-9a lists foods that provide at least 20 percent of the adult AI for calcium in standard amounts along with the number of calories provided by that serving size. Milk and milk products also are the major sources of calcium in U.S. diets (Table D1-9b), but calcium intake falls considerably short of the AI for most age groups beginning at age 9 years, especially for females. The revised USDA food pattern specifies 2 or 3 cups per day from the milk group, based on the calorie level of the pattern,² and meets the goals for calcium intake. The rationale for Question 4 below includes several tables that address ways to achieve recommended calcium intake. Part D, Section 5, "Selected Food Groups," addresses relationships of milk products with health.

Potassium. Potassium intake falls short of the AI for all age groups examined, but sources of potassium come from all the basic food groups. Table D1-10a lists the potassium content and calories for standard amounts of foods ranked by potassium content. For calorie levels at or above 1,600 kcal per day, the revised USDA food pattern provides more than 76 percent of the AI for potassium. For calorie levels less than 1,600 kcal per day, only 64 to 75 percent of the AIs would be met. As was the case for vitamin E, some of the food composites used in modeling the food pattern are relatively low in potassium content, reflecting Americans' relatively low use of some of the better potassium sources (see Table D1-10b for a list of major sources of potassium in American diets). The rationale for Question 2 below describes how this problem was addressed.

Fiber. As for potassium, fiber intakes fall short of the AIs for all age groups examined. Table D1-11a lists the fiber content and calories for standard amounts of foods ranked by fiber content. As can be seen in Table D1-11b, the major source of fiber in the U.S. diet is yeast bread; however, white bread, which is the most common form of yeast bread, does not appear in the list of foods that are among the best fiber sources. The large amount of white yeast breads consumed (as bread, rolls, buns, and pizza crust) causes this food to be a major fiber contributor to American diets. However, legumes, many vegetables and fruits, and whole grains are far better dietary fiber sources for a standard amount.

² In the food pattern with 1,000; 1,200; and 1,400 calories, which are targeted to children under 9 years of age, 2 cups from the milk group are recommended. In the food pattern with 1,600 calories and above, 3 cups from the milk group are recommended.

Table D1-12 identifies the functions of the shortfall nutrients that are listed above. Increasing one's intake of each of these nutrients to achieve recommended nutrient intakes can help promote health.

QUESTION 2: WHAT DIETARY PATTERNS ARE ASSOCIATED WITH ACHIEVING RECOMMENDED NUTRIENT INTAKES?

Conclusion

Two major aspects of the USDA dietary pattern contribute to meeting nutrient intake recommendations:

1. Consumption of foods from each of the basic food groups:
 - fruits
 - vegetables
 - grains
 - milk, yogurt, and cheese
 - meat, poultry, fish, dry beans, eggs, and nuts³
2. Consumption of a variety of food commodities within each of those food groups—since higher energy intake is strongly associated with greater variety and higher nutrient intake, attention also should be given to food group choices that maintain appropriate energy balance.

Rationale

This conclusion is supported by food pattern modeling conducted by USDA's Center for Nutrition Policy and Promotion (CNPP) and by one published study (Foote et al., 2004) that links survey data on food intake with data on nutrient intakes. It also is supported by information on nutrients provided by the basic food groups and their subgroups.

Food Pattern Modeling

The USDA method of food pattern modeling, which is described briefly in Part C, "Methodology," and in detail in "Notice of Availability of Proposed Food Guide Pyramid Daily Food Intake Patterns and Technical Support Data" (Fed. Reg. Notice, 2003), is a well-documented approach for developing food patterns (Welsh et al., 1993). The method is intended to develop the food pattern that meets the DRIs and that is as realistic and practical as possible (Fed. Reg. Notice, 2003). Food intake patterns were first developed using this method in the 1980s, and became the scientific basis for the Food Guide Pyramid. In 2003, a new pattern (developed using this same method) was proposed and submitted for public comment by USDA. Since then, USDA has slightly revised the proposed pattern to account for recent recommendations for potassium and sodium (IOM, 2004) and provided the Committee with the revised pattern. USDA states that it will use this report of the 2005 Dietary Guidelines Advisory Committee to finalize

³ Some patterns designed to meet nutrient intake recommendations divide this group into two groups: (1) meat, poultry, and fish and (2) seeds, dry peas and beans, and nuts.

a new food intake pattern and will then develop graphic and educational materials for the public based on these patterns.

In developing the new daily food pattern, the nutrient content of preliminary patterns was compared to the new nutritional goals. If the goals were not met at a given calorie level, amounts from food groups or subgroups that were higher in the nutrients in question were increased, and corresponding changes were made in other groups to maintain total calories at the goal level. The adjustments were made in an iterative manner, to bring the pattern closer to its nutritional goals.

Most of the nutritional goals for the USDA food intake pattern, as identified in the Federal Register Notice, were met by making relatively modest changes from the pattern used in the original Pyramid (Welsh et al., 1993) (see Appendix G-2 for a table of food patterns from the original Pyramid.) Changes included:

- Increasing the number of calorie levels from 3 (1,600; 2,200; 2,800) to 12 (every 200 calories from 1,000 to 3,200).
- Separation of discretionary fats into solid fats and oils and soft margarines, and a shift in the proportions recommended to 40 percent solid fats, 60 percent oils—The original Pyramid patterns did not distinguish among types of fats, and the proportions were therefore the estimated intake proportions of 58 percent solid fats, 42 percent oils.
- Increasing the amounts of vegetables for some calorie levels—To meet nutritional goals, the overall amounts of vegetables recommended were increased for several calorie levels.
- Change in the relative amounts of vegetable subgroups—The nutrient profiles of dark green vegetables and legumes were relatively high in the nutrients needed to meet unmet nutrient goals. Therefore, amounts of these vegetables were preferentially increased and amounts of the remaining vegetable subgroups (starchy, orange, and other vegetables) were held constant or decreased.
- Increase in the amount of whole grains, to one-half of the total amount in every pattern—Enriched grains were proportionately decreased. At least 3 oz of whole grains are provided for the calorie levels equal to and above 1600 kcal per day.

The Committee examined these data and noted the concern identified by USDA that the pattern provides only 50 to 75 percent of the RDA for vitamin E at all except the highest calorie levels. In contrast, the pattern provides well over 100 percent of the RDA for many of the nutrients.

The Committee also noted that the nutrient profiles use the lowest fat forms of each food in the food group and/or a form free of added sugars. Thus, the foods that make up the composite could be described as a nutrient dense version of the foods. Examples include nonfat milk, chicken without the skin, and ground beef with no more than 5 percent fat. Although this approach allows food pattern recommendations to provide individuals a way to meet their nutrient needs while avoiding the overconsumption of calories and of food components such as saturated fats, the Committee recognized that this key aspect of

the nutrient profiles could be overlooked easily and merits emphasis in nutrition education efforts.

In February 2004, the IOM released the report *Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate* (IOM, 2004). This report included new AIs for potassium—values that were more than two times as high as the potassium goals used in developing the food pattern published in the Federal Register Notice. Consequently, at the Committee's request, USDA made adjustments in the food intake pattern so that it would provide higher percentages of the AI for potassium. The adjustments required increasing milk or other milk products to 3 cups or the equivalent, increasing vegetables by 0.5 cups and increasing fruits by 0.5 cups, per day. To compensate for the calories provided by the increases in these three groups, the amounts of grains in the pattern were decreased by about 1 ounce equivalent, and added sugars and solid fats were decreased for some age and/or sex groups.

Tables D1-13 and D1-14 show the revised USDA food pattern that incorporates the new standards for potassium.⁴ The nutritional goals for this pattern, shown in Table D1-1, were based on the current Dietary Reference Intakes (IOM, 1997, 1998, 2000a, 2001a, 2002, 2004). The nutrient content that was assigned to a standard amount of food from each food group and subgroup appears in Table D1-15. The values in Table D1-15 were used in combination with the daily intake amount for each food group or subgroup to estimate the amounts of nutrients provided by the food intake pattern (Table D1-16).

The revised food intake pattern differs in important ways from food intake patterns that reflect usual food consumption by Americans. In particular, for many age groups and energy levels the pattern includes:

- **more** green vegetables, orange vegetables, legumes, fruits, whole grains, and milk
- **less** enriched grains, total fats (especially solid fats), and added sugars

As shown in Table D1-13, the food pattern includes suggested amounts to eat from each of the basic food groups: fruits, vegetables, grains, meat and beans (which includes meat, poultry, fish, dry beans, eggs, and nuts), and milk (which includes nonfat milk, yogurt, and cheese).

The food pattern also shows suggested amounts of oils to consume, because oils are major contributors of essential fatty acids and vitamin E. In addition, the pattern lists amounts of *discretionary calories* that can be accommodated within each calorie level. Table D1-14 provides more detail about discretionary calories and lists one way these calories can be split—between solid fats and added sugars. These solid fats and added sugars may be contained in selections made from the basic food groups. For example, the fats in low-fat or whole milk and in higher-fat meat products are counted as solid fats; and the sugars that are added in the processing of sweetened cereals, fruits canned in syrup, or cookies are counted as added sugars. Similarly, one needs to count solid fats (e.g., butter) or various sugars (e.g., syrup) that are added to foods. Discretionary

⁴ USDA has informed the Dietary Guidelines Advisory Committee that the *final* nutritional goals and food intake patterns will take into account all nutritional recommendations from this Committee.

calories may also be used to increase the amounts of nutrient-dense choices from any food group, such as increased amounts of fruits or vegetables. (See Section D-3, “Discretionary Calories,” for further information.)

Clearly, examination of Table D1-16 reveals that following the proposed pattern for one’s calorie level would promote reaching recommended intakes of almost all nutrients. The RDA or AI is reached or exceeded for nearly all nutrients at most calorie levels. Vitamin E remains the leading exception. By making careful selections from Table D1-8a, the vitamin E recommendations could be achieved while limiting total fat intake to 20 to 35 percent of energy. Potassium is another exception: at 2,000 calories or below, less than 90 percent of the AI for potassium is provided by the revised food pattern. Selecting fruits and vegetables that have relatively high potassium content helps to meet the AI for potassium. A number of these foods are listed in Table D1-10a.

Studies Linking Food Intake with Recommended Nutrient Intake

The only published study (Foote et al., 2004) that links food intake with current recommended nutrient intakes (IOM, IOM, 1997, 1998, 2000a, 2001a, 2002, 2004) used data on adults in the *Continuing Survey of Food Intakes by Individuals* (CSFII) 1994–1996. Foote and colleagues (2004) found high correlations among energy intake, intakes from the five food groups, and the variety of different food commodities consumed from the basic food groups. Food commodities represent different food types, such as beef, oranges, wheat, and milk. Different preparations of these foods would be counted as the same basic food commodity. For example, for variety within the grain group, rice, white bread, and oatmeal would count as different commodities, but white bread, pancakes, and English muffins would not be considered different commodities. The combination of energy, intakes from the five food groups, and dietary variety was a strong predictor of the mean probability of adequacy ($R^2 = .73$ for men and $.70$ for women). Dietary variety within the milk and grain groups was more strongly correlated with improved nutrient adequacy than was variety within the remaining food groups. However, this analysis does not include data on potassium or fiber intake.

A number of studies have been conducted to determine the extent to which Americans have followed the guidance provided by the Food Guide Pyramid and how this relates to their nutrient intake. For example, three studies compare food intakes from national surveys with the recommended number of servings of food from the original Pyramid food intake pattern (Cleveland et al., 2000; Krebs-Smith et al., 1997; Munoz et al., 1997). In most cases, the revised food intake pattern in Table D1-13 specifies more servings of fruits, vegetables, and whole grains than does the 1992 Pyramid food pattern.

Cleveland et al. (2000) analyzed food and nutrient intake by adults, using data from CSFII 1994–1996 that focused on whole grain intake. These investigators found that consumers of whole grains had significantly better vitamin and mineral profiles than nonconsumers. Whole grain consumers also were more likely to meet Pyramid recommendations for the grain, fruit, and milk groups. Only 17 percent of the population consumed at least 2 servings of whole grains per day.

Two early studies analyzed food and nutrient intake data from CSFII 1989–1991 using Pyramid recommendations based on energy. Krebs-Smith et al. (1997) reported that adults who met Pyramid recommendations for all food groups had mean vitamin and mineral intakes that exceeded 100 percent of the 1989 RDA (NRC, 1989) mean daily fiber intake of 22 g, and fat intake at the then recommended level of 30 percent of calories. In contrast, at least one nutrient intake shortfall was found for food group patterns that did not meet one or more of the Pyramid food group recommendations. Munoz et al. (1997) found comparable micronutrient results for children who met the Pyramid recommendations, and they reported a mean daily fiber intake of 19 g. The children’s fat intake averaged 35 percent of calories. In both studies, fewer than 5 percent of the population met all Pyramid recommendations.

Nutrients Provided by the Basic Food Groups and Their Subgroups

Basic Food Groups in the USDA Food Intake Pattern. Table D1-17 summarizes the nutrient contributions of each of the basic food groups and of subgroups for vegetables and grains. To prepare the table, the percent contribution from each food group to the total intake of a nutrient was calculated at each calorie level and then averaged across all calorie levels. The method used to develop this table appears in Appendix G-2 along with more detailed results. Since the amount of nutrients provided by each food group is estimated based on foods commonly consumed in the United States, the nutrient contributions of food groups to an individual’s diet could differ somewhat, depending on the foods selected from each group. The “Major Contribution” column identifies any nutrient provided by the food group in an amount greater than that provided by any of the other food groups.

Results of the analysis include the following:

- Each food group is the major contributor of at least one nutrient. In addition, each group makes substantial contributions of many other nutrients. Each vegetable subgroup provides at least one nutrient in an amount exceeding 10 percent of the total, even though the amount of food specified for each vegetable subgroup is relatively small.
- For a few nutrients, the food group that is the major contributor of a nutrient shifts from calorie level to calorie level within the USDA food pattern. For example, for potassium, the milk group is the major contributor at most calorie levels, but at higher calorie levels there are more fruit servings, thereby making the fruit group the major contributor of potassium.
- For a few nutrients, a single food group provides a majority of the overall amount in the food pattern. This is true for vitamin C, for which the fruit group provides about 67 percent of the total; calcium, for which the milk group provides about 67 percent; and linoleic and α -linolenic acids, for which oils and soft margarines provide about 59 percent and 53 percent, respectively. For all other nutrients, no single food group provides more than half of the total amount of the nutrient provided by the food pattern.
- Each food group provides a wide array of nutrients in substantial amounts, emphasizing the importance of including all food groups in the daily diet.

Health Effects of Dietary Patterns Similar to the USDA Food Intake Pattern

The revised USDA food intake pattern results from a modeling process that integrated nutrient recommendations from the IOM, as described above. Because the process did not include the preparation of actual menus, it is appropriate to confirm that Western style menus can be constructed that meet the new IOM's nutrient recommendations. It also is useful to document the health effects of dietary patterns similar to the revised USDA food intake pattern since one goal of using the pattern is to help reduce the risk of chronic disease. To this end, results from the Dietary Approaches to Stop Hypertension (DASH) trials (Appel et al., 1997; Sacks et al., 2001) are informative.

The first DASH trial was a randomized feeding study that tested the effects of three distinct dietary patterns on blood pressure. Participants were randomized to (1) a control diet, (2) a fruits and vegetables diet, or (3) a diet now termed the DASH diet. The control diet had a nutrient composition that is typical of that consumed by many Americans. Its potassium, magnesium, and calcium levels were relatively low, and its macronutrient profile and fiber content corresponded to average U.S. consumption. The fruits and vegetables diet was rich in potassium, magnesium, and fiber but otherwise similar to the control diet. The DASH diet emphasized fruits, vegetables, and low-fat dairy products; included whole grains, poultry, fish, and nuts; and was reduced in red meat, sweets, and beverages with added sugars. The DASH diet was rich in potassium, magnesium, calcium, and fiber, and was reduced in total fat, saturated fat, and cholesterol; it also was slightly increased in protein. A 7-day menu cycle at each of four kcal levels (1,600, 2,100, 2,600 and 3,100) was prepared using commonly available foods (Karanja et al., 1999). As displayed in Table D1-18, the nutrient profile of the DASH diet is nearly identical to that of USDA revised food pattern.

Among all participants, the DASH diet significantly lowered mean systolic blood pressure by 5.5 mmHg and mean diastolic blood pressure by 3.0 mmHg (net of control). The fruits and vegetables diet also significantly reduced blood pressure but to a lesser extent: it had about half of the effect of the DASH diet. In subgroup analyses, the DASH diet significantly lowered blood pressure in all major subgroups (men, women, blacks, non-blacks, hypertensives and non-hypertensives). In blacks, blood pressure reductions (systolic blood pressure/diastolic blood pressure) from the DASH diet (6.9/3.7 mmHg) were significantly greater than corresponding reductions in white participants (3.3/2.4 mmHg). The reductions in hypertensive individuals (11.6/5.3 mmHg) were striking and have obvious clinical relevance. In non-hypertensive individuals, corresponding net blood pressure reductions were 3.5/2.2 mmHg. Such blood pressure reductions, while smaller in magnitude, nonetheless have substantial public health relevance. In the DASH-Sodium trial, the DASH diet also lowered blood pressure at each of three sodium levels. In addition to blood pressure reduction, the DASH diet had beneficial effects on blood lipids (Obarzanek et al., 2001; Harsha et al., 2004) and on several biomarkers, including homocysteine (Appel et al., 2000) and markers of oxidative stress (Miller et al., 1998) and bone turnover (Lin et al., 2003).

It has been estimated that a population-wide reduction in BP of the magnitude observed in DASH could reduce stroke incidence by 27 percent and coronary heart disease (CHD) by 15 percent (Appel et al. 1997). Further reduction in CHD risk might be anticipated from changes in lipids and perhaps homocysteine. In observational epidemiological studies, dietary patterns similar to the DASH diet have been associated with a reduced risk of ischemic heart disease in men (Hu et al., 2000) and women (Fung et al., 2001).

Part D, Section 6, “Selected Food Groups,” addresses relationships of the following food groups to health: fruits, vegetables, whole grains, and milk products.

QUESTION 3: WHAT FACTORS RELATED TO DIET OR PHYSICAL ACTIVITY MAY HELP OR HINDER ACHIEVING RECOMMENDED NUTRIENT INTAKES

Conclusion

A sedentary lifestyle limits the amount of calories needed to maintain one’s weight. Careful food selection is needed to meet recommended nutrient intakes within this calorie limit. Diets that include foods with a high nutrient content relative to calories are helpful in achieving recommended nutrient intakes without excess calories. Diets that include a large proportion of foods or beverages that are high in calories but low in nutrients are unlikely to meet recommended intakes for micronutrients and fiber, especially for sedentary individuals.

Rationale

This conclusion is based on a review of data on the effects of physical activity on the total energy requirement from a combination of 26 clinical trials and review articles related to nutrient density and dietary diversity (see Appendix G-3), 12 of which are cited within the body of the text. It also is based on studies of the effects of intake of added sugars on nutrient intake, which are covered in detail under Question 4 in Section 5, “Carbohydrates”.

Physical Activity

The higher one’s physical activity level, the higher the energy requirement, and the easier it is to plan a food intake pattern that meets recommended nutrient intakes. This is apparent when one examines the percentages of recommended nutrient intakes (see Table D1-16) that are provided by the revised USDA food intake pattern. The food intake pattern at higher energy (calorie) levels results in intakes that are less likely to be below recommended nutrient intakes and more likely to exceed them. In addition, it allows more leeway for foods that contain added sugars and solid fats. As reported by Foote et al. (2004), energy intake is the strongest predictor of the mean probability of adequacy. Increasing one’s physical activity level is a healthy way to increase one’s energy requirement (see Section 2, “Energy,” for additional information about physical activity).

Nutrient Density

Nutrient-dense foods are those that provide substantial amounts vitamins and minerals and relatively fewer calories. Foods that are low in nutrient density are foods that supply

calories but relatively small amounts of micronutrients (sometimes none at all). In contrast, energy-dense, nutrient-poor foods supply relatively small amounts of vitamins and minerals with many calories. A number of epidemiological studies using data obtained from national surveys suggest that energy-dense, nutrient-poor foods may displace nutrient-dense foods, potentially reducing the consumption of foods from the five food groups to lower levels than recommended and limiting one's ability to achieve recommended nutrient intakes (Kant, 2000, 2003; Kant and Schatzkin, 1994). Increased intake of energy-dense, nutrient-poor foods was reported to result in increased total daily energy intake and smaller proportions of the population meeting the RDA for various nutrients. Respondents consuming a high proportion of energy-dense, nutrient-poor foods were more likely to report either no servings or less than the recommended number of servings of foods from the major food groups (Kant and Schatzkin, 1994). The strongest independent negative predictor of the reported number of foods of low nutrient density was the amount of nutrient-dense foods from the five major food groups (Kant and Graubard, 2003).

Dietary diversity among and within food groups was not related to total energy, fat, sugar, sodium, or cholesterol intake (Krebs-Smith et al., 1987), but individuals who consumed the greatest variety of foods (among the food groups, not within the food groups) had the most adequate nutrient intake (Kant et al., 1991).

Individuals consumed more total food when offered several different foods than when variety was more limited (Bellisle and Magnen, 1981; Pliner et al., 1980; Rolls et al., 1981a, 1981b, 1982; Spiegel and Stellar, 1990). In contrast, increased amounts of low-energy vegetables, prompted by high variety, have resulted in decreased energy intake and body fatness (McCory et al., 1999). The long-term effects of dietary variety on food intake and body weight are unknown.

Choosing foods that are rich sources of nutrients in short supply can be an effective way to put the concept of nutrient density into action. Using the food pattern in Table D1-13 that is appropriate for one's energy needs is one way to achieve a diet that meets recommended nutrient intakes.

Effects of Added Sugars on Vitamin and Mineral Intake

Added sugars are defined as sugars and syrups that are eaten separately at the table or added to foods during processing or preparation. As presented in detail in Section 5, "Carbohydrates," 19 papers show a decreased intake of at least 1 micronutrient with higher levels of added sugar intake. That section also provides evidence that small amounts of added sugars may have a beneficial effect on intake of vitamins and minerals, probably by improving the palatability of foods and beverages that might otherwise not be consumed.

QUESTION 4: HOW CAN THE FLEXIBILITY OF FOOD PATTERNS BE INCREASED?

Conclusion

By careful planning that considers the relative nutrient content of different foods, substitutions can be made to a food intake pattern to achieve recommended nutrient intakes.

Rationale

The Committee used empirical methods to identify ways to build flexibility into its recommendations for food guidance. In particular, the Committee asked USDA to use food pattern modeling or other nutrient analysis methods to identify ways to increase the flexibility of the proposed USDA food pattern while continuing to meet the nutritional goals. See Appendix G-2 for information about these analyses. Specific requests included identifying substitutions for refined grain products, legumes, and milk and milk products; comparing the nutrient contributions of fruits with fruit juices; and developing a lacto-ovo-vegetarian food pattern that met nutrient goals.

Legumes and Refined Grains

For individuals who choose not to eat legumes or refined grains, USDA staff prepared short lists of specific amounts of foods that could be substituted without substantially changing the nutrients or calories provided by a food pattern. For example, specified amounts of whole grains, dark green vegetables, and other vegetables could be substituted for a serving of legumes. More information appears in Part E and in Appendix G-2.

Milk and Milk Products

The milk group provides more than 70 percent of the calcium consumed by Americans. Other choices of dietary calcium are available (see Table D1-9a and Table D1-19) for those who choose not to consume the recommended quantities of milk products. Both calcium content and bioavailability should be considered when selecting dietary sources of calcium. Some plant foods have calcium that is well absorbed, but the large quantity of plant foods that would be needed to provide as much calcium as in a glass of milk may be unachievable for many. Many other calcium-fortified foods are available, but the percentage of calcium that can be absorbed is unavailable for many of them.

For individuals who avoid milk because of its lactose content, the most feasible way to obtain all the nutrients provided by dairy is to substitute lactose-reduced or low-lactose milk products (see Part E).

The inclusion of milk products in the proposed food pattern contributes important amounts of calcium, potassium, magnesium, and vitamin A (see Table D1-20). Moreover, low calcium intakes have been associated with low intakes of magnesium, riboflavin, vitamin B₆, vitamin B₁₂, and thiamin (Barger-Lux et al., 1992). Increased milk product intake was associated with increased intake of calcium, magnesium, potassium, zinc, iron, vitamin A, riboflavin, and folate by Americans over the age of two (Weinberg et al., 2004). Without milk products in the revised USDA food intake pattern, calcium intakes range from 321 to 965 mg per day less than recommended intakes (see Table D1-21). These calcium values are the amounts provided by 1.1 to 3.2 glasses of

milk. To meet recommended nutrient intakes, the food intake pattern that excludes milk would need to include a much larger amount of calcium-containing green vegetables and legumes than typically consumed by Americans.

Nondairy alternatives for calcium such as calcium-fortified orange juice or calcium-fortified soy products are listed in Table D1-19. This table considers only calcium and not the other nutrients provided by milk.

Fruits

The Committee also asked USDA to examine appropriate partitioning of the fruit group into fruit and juices. The question being addressed was, “How would guidance on the proportion of juice supplied by fruit juice affect the meeting of nutritional goals?” This question stemmed from a recent recommendation of the American Academy of Pediatrics (AAP) to limit fruit juice to no more than 4 to 6 ounces per day for children age 1 to 6 years, and to no more than 8 to 12 ounces per day for children age 7 to 18 years (AAP, 2001). Based on the fruit group analysis, the recommendation is to consume no more than one-third of the total recommended fruit group intake amount from fruit juice and the remainder from whole fruit (fresh, frozen, canned, dried). Increasing the proportion of fruit that is eaten in the form of whole fruit rather than juice is desirable to increase fiber intake, but it calls for more attention to consuming foods that are high in potassium. The fruit juices most commonly consumed by older children and adults provide more vitamin C, folate, and potassium in portions usually consumed than do the commonly eaten fruits. The recommended intake of fruits and juices achieve an optimal balance.

The Lacto-Ovo Vegetarian Food Pattern

The Committee also asked USDA to examine how substituting nuts, seeds, and legumes for the meat, poultry, and fish in the food pattern would affect the nutrient profile of the food group. The amount of eggs in the pattern was held constant. Although the nutrient profile of the egg, nut, seed, and legume group differed in some ways from the original “meat and beans group,” it still provided for a food pattern that met recommended nutrient intakes. The lacto-ovo-vegetarian pattern was higher in vitamin E, fiber, and folate than the original pattern. It was lower, although still at or above recommendations, in protein, many B vitamins, and zinc; and it was lower in cholesterol.

Nuts, Seeds, and Legumes in the Food Pattern

The Subcommittee considered the possibility of recommending that nuts, seeds, and legumes become a separate food group because they are rich sources of trace nutrients and rich in diverse phytochemicals. Some nuts are also rich in vitamin E, and nuts may promote satiety. However, the most commonly consumed types of nuts (i.e. peanuts) are not especially high in vitamin E, and the consumption of large amounts of nuts could lead to an excess intake of calories. Rather than creating a separate food group for nuts and seeds, the Committee decided to recommend selecting choices from a list of foods rich in vitamin E as a means to help individuals increase their intakes of that vitamin. It was suggested that modifying the USDA food model system to include a food group rich in vitamin E, such as nuts or seeds, could provide a food pattern that meets the RDA for vitamin E (King et al., 1978). The lacto-ovo vegetarian pattern developed by USDA

includes what is essentially a nut/seed/legume group that includes eggs, to replace all meat, poultry, and fish servings. The vitamin E in this pattern is 70 percent RDA at 1,800 kcal and 84 percent at 2,200 kcal. It does not reach 100 percent RDA until 2,800 calories.

QUESTION 5: ARE SPECIAL NUTRIENT RECOMMENDATIONS NEEDED FOR CERTAIN SUBGROUPS?

Conclusion

Special nutrient recommendations are warranted for the following subgroups and nutrients:

- Adolescent females and women of childbearing age—iron and folic acid
- Persons over age 50—vitamin B₁₂
- The elderly, persons with dark skin and persons exposed to insufficient UVB radiation—vitamin D

A conclusion specific to each group and nutrient follows, along with the rationale.

Women and Iron Conclusion

Substantial numbers of adolescent females and women of childbearing age have laboratory evidence of iron deficiency. Efforts are warranted to increase the dietary intake of iron-rich foods and of enhancers of iron absorption by these groups.

Women and Iron Rationale

Laboratory data from the *Third National Health and Nutrition Examination Survey* (1988–1994) indicate that iron deficiency (defined as having an abnormal value for at least two of three laboratory tests of iron status) affects 7.8 million adolescent females and women of childbearing age (age 12 to 49 years) (Looker et al., 1997). That is, 9 to 11 percent of nonpregnant women of childbearing age were iron deficient, and 2 to 5 percent of the women had iron deficiency anemia. These findings suggest the need to encourage this age group to increase dietary intake of iron-rich foods and of enhancers of iron absorption (meat and vitamin C). A list of sources of iron is provided in Table D1-22a and D1-22b.

Women and Folic Acid Conclusion

Since folic acid reduces the risk of the neural tube defects (NTD), called spinal bifida and anencephaly, daily intake of 400 µg of synthetic folic acid (from supplements or fortified food) is recommended for women who are capable of becoming pregnant and those in the first trimester of pregnancy.

Women and Folic Acid Rationale

The folic acid conclusion is based on the extensive review conducted by the IOM (IOM, 1998) and review of the two available reports on effects of folic acid fortification of enriched grain products. Based on its review of 7 population-based studies, 1 controlled metabolic study plus 1 additional piece of evidence, the IOM concluded, “the recommendation for women capable of becoming pregnant is to take 400 µg of folate from fortified foods and/or a supplement as well as food folate from a varied diet. It is not known whether the same level of protection could be achieved by using food that is naturally rich in folate” (IOM, 1998, p 12).

Since the relatively new folic acid fortification program to reduce the risk of NTDs could influence the need for obtaining folic acid from supplements, the Committee reviewed the two available reports on the effects of the fortification program. Evans et al. (2004) report that, post fortification, the percentage of high maternal serum alpha-fetoprotein values obtained during midtrimester of pregnancy decreased by 32 percent. The Centers for Disease Control and Prevention (CDC, 2004b) report that the incidence of spinal bifida and anencephaly decreased by 26 percent between the pre- and post-fortification periods (1995–1996 and 1999–2000), suggesting that the fortification of enriched grains has helped reduce risk. They note that the observed decrease in NTD-affected pregnancies is less than the estimate that was based on data from research trials.

Persons Over Age 50 and Vitamin B₁₂ Conclusion

A substantial proportion of individuals over age 50 may have reduced ability to absorb naturally occurring vitamin B₁₂ but not the crystalline form. Thus, all individuals over the age of 50 should be encouraged to meet their RDA for vitamin B₁₂ by eating foods fortified with vitamin B₁₂ such as fortified cereals, or by taking the crystalline form of vitamin B₁₂ supplements.

Persons Over Age 50 and Vitamin B₁₂ Rationale

This conclusion was supported by evidence from a systematic review conducted for the IOM (IOM, 1998) and by recent laboratory studies to screen for functional vitamin B₁₂ status, as summarized below, resulting in 11 studies.

According to the *National Health and Nutrition Examination Survey* in 1999–2000 for the U.S. population, mean daily vitamin B₁₂ intake was above the RDA for all ages and both sexes, and ranged from 2.9 to 5.1 µg (CDC, 2004a). For people age 40 to 59 and age 60 and above, the mean and standard deviation of vitamin B₁₂ intake were 5.1±0.37 and 4.5±0.25 µg/day, respectively. Data are not available regarding the amount of crystalline vitamin B₁₂ consumed from fortified foods and supplements by people over age 50.

Based on a systematic, extensive review of the literature, the IOM (1998) set the RDA for vitamin B₁₂ at 2.4 µg per day. However, since 10 to 30 percent of the older population may be unable to absorb naturally-occurring vitamin B₁₂, the IOM advised that persons age 50 and older should meet their RDA mainly by consuming foods fortified with vitamin B₁₂ or by taking vitamin B₁₂-containing supplements. This RDA was based on the amount needed to maintain the hematological status, as well as the normal serum vitamin B₁₂ level. Neurological manifestation of vitamin B₁₂ deficiency was not used to establish vitamin B₁₂ status since 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.

This conclusion was further supported by recent studies utilizing serum radioimmunoassays of vitamin B₁₂, combined with serum total homocysteine (tHcy) and methylmalonic acid (MMA) values, to screen for functional vitamin B₁₂ status. A low

serum vitamin B₁₂ value (< 300 pg/mL), high serum MMA value (> 0.4 μmol/L), and tHcy greater than 15.0 μmol/L would suggest vitamin B₁₂ deficiency. Using results from these three laboratory tests, Clarke and colleagues (2004) reported the prevalence rate of vitamin B₁₂ deficiency to be 1 in 20 among people age 65 to 74, and 1 in 10 among people age 75 and older. Additionally, various clinical trials (McKay et al., 2000), either among free-living or institutionalized elderly, demonstrated that either oral vitamin B₁₂ supplements alone or multivitamin/mineral supplements could improve vitamin B₁₂ status.

A screening procedure using serum radioimmunoassay of vitamin B₁₂ combined with serum tHcy and MMA has been recommended for all individuals over age 65 to detect vitamin B₁₂ deficiency (Dharmarajan et al., 2003; Klee, 2000).

Special Groups and Vitamin D Conclusion

The elderly, persons with dark skin, and persons exposed to insufficient UVB radiation are at risk of being unable to maintain vitamin D status. Persons in these high-risk groups may need substantially more than the 1997 AI for vitamin D from vitamin D-fortified foods and/or vitamin D supplements.

Vitamin D Rationale

The relationship of vitamin D to health was evaluated from a systematic review of the scientific literature, which produced 28 studies and 14 reviews—largely articles that were unavailable when the IOM conducted its review on which the AIs for vitamin D were based (IOM, 1997). Adequate vitamin D status, which depends on dietary intake and cutaneous synthesis, is important for optimal calcium absorption, and it can reduce the risk for bone loss.

The criterion used by the IOM for setting the AI was the normal concentration of serum 25-hydroxyvitamin D concentration, an indicator of vitamin D status. In the absence of consensus for optimal vitamin D status based on functional indicators, the IOM panel identified normal ranges for serum 25-hydroxyvitamin D. The normal range for various populations is broad with means of serum 25-hydroxyvitamin D ranging from 25 to 137.5 nmol/L. Newer information on the relationship of serum 25-hydroxyvitamin D to health, the relationship of vitamin D intake to serum 25-hydroxyvitamin D concentration, vitamin D status of the U.S. population, and safety of vitamin D intakes is summarized in a supplement of a National Institutes of Health conference held in October 2003 (NIH, 2004). Two functionally relevant measures indicate that optimal serum 25-hydroxyvitamin D may be as high as 80 nmol/L. Among postmenopausal women who lived in Omaha, Nebraska, and who were supplemented with vitamin D, calcium absorption efficiency increased with increasing serum 25-hydroxyvitamin D values up to 80 nmol/L (Heaney et al., 2003b). Serum parathyroid hormone, which stimulates bone resorption, decreases with increasing serum 25-hydroxyvitamin D values up to 80 nmol/L (Chapuy et al., 1997; Thomas et al., 1998). Serum 25-hydroxyvitamin D values are below 80 nmol/L for much of the population (Looker et al., 2002; see Table D1-23).

The elderly and individuals with dark skin are at a greater risk of low serum 25-hydroxyvitamin D concentrations (Holick 1985; Holick et al., 1989; Looker et al., 2002). Also at risk are those exposed to insufficient UVB radiation for the cutaneous production of vitamin D, e.g., housebound individuals. Serum 25-hydroxyvitamin D values increase with increasing oral vitamin D intake in both young and older subjects (Vieth et al., 2003). Further data are needed to determine if a serum 25-hydroxyvitamin D concentration of 80 nmol/L is sufficient to increase the efficiency of calcium absorption or to reduce PTH levels in the populations at risk.

For individuals within the high-risk groups, substantially higher daily intakes of vitamin D, i.e., 25 µg or 1000 IU of vitamin D, have been recommended to reach and maintain serum 25-hydroxyvitamin D values at 80 nmol/L (Heaney and Weaver, 2003; Holick, 2004). Applying the slope (0.7 nmol/L/microgram vitamin D) from the regression between vitamin D intake and change in serum 25-hydroxyvitamin D derived from a dose response study in men (Heaney et al., 2003b) to the mean serum 25-hydroxyvitamin D concentrations in the U.S. population shown in Table D1-23, one can estimate the additional vitamin D intake required to achieve and maintain a target vitamin D status. For example, women over age 80 with mean serum 25-hydroxyvitamin D values of 59.6 nmol/L might need to increase their vitamin D intakes by 29 µg or 1166 IU per day to achieve serum values of 80 nmol/L. Mean current consumption of vitamin D in females over age 71 participating in NHANES III was only 4.5 µg or 180 IU of vitamin D (Moore et al., 2004), an amount considerably below the 1997 AI of 600 IU. Dark skinned subgroups have lower vitamin D status than comparable fair-skinned subgroups, but the optimal vitamin D status and the ability of vitamin D intakes to increase serum 25-hydroxyvitamin D concentrations in various subgroups are not known.

A recent estimate of the vitamin D intakes of Americans surveyed in either NHANES III, 1988–1994, or the *Continuing Survey of Food Intakes by Individuals* (CSFII) 1994–1996, 1998, showed that the average reported intakes from food and supplements by all age and gender groups were below the 1997 IOM AI for vitamin D (Moore et al., 2004). Less than 10 percent of older adults (age 51 to 70) and only about 2 percent of the elderly (older than age 70) met the AI from food sources alone. Less than a third of the adolescent and adult women met the AI.

Fatty fish is the primary natural food source of vitamin D. Other good sources are all foods that have been vitamin D fortified: milk and some brands of margarine, ready-to-eat breakfast cereal, enriched rice and pasta, and fruit juices and drinks. Different kinds of vitamin D-fortified foods differ in the amounts of vitamin D they contain (Table D1-24). Vitamin D intakes of approximately 1000 IU per day can be achieved by consuming 3 cups of vitamin D fortified milk per day (300 IU) plus a supplement containing vitamin D (600 IU) plus 1 cup of vitamin D fortified orange juice (100 IU). Although this level of vitamin D intake exceeds the AI of 600 IU per day for an elderly person, there is no evidence that consuming this amount will have a detrimental effect on health. No signs of hypercalcemia or hypercalcuria were observed with healthy men and women who were given 4000 IU of vitamin D per day for 2 to 5 months (Vieth et al., 2001). For evaluation of vitamin D status, at-risk individuals should consult their physician.

SUMMARY

Meeting nutrient recommendations is a basic premise of dietary guidance for Americans, but controlling calorie intake also is important. Most Americans consume too little vitamin E, potassium, and fiber; and many consume too little vitamin A, vitamin C, calcium, and magnesium. To meet nutrient recommendations, the committee recommends that children and adults consume a variety of foods from each of the basic food groups (fruits; vegetables; grains; milk, yogurt, and cheese; and meat, poultry, fish, dry beans, eggs, and nuts). To meet nutrient recommendations while controlling calories, it helps to choose foods that are high in nutrient content but low to moderate in calories and to increase one's level of physical activity.

Additional nutrient recommendations are warranted for a few large subgroups of the population, as follows:

- Adolescents and females of childbearing age need extra iron and folic acid
- Persons over age 50 benefit from taking vitamin B₁₂ in its crystalline form from foods fortified with this vitamin or supplements that contain vitamin B₁₂
- The elderly, persons with dark skin, and persons exposed to insufficient UVB radiation need extra vitamin D from vitamin D-fortified foods and/or supplements that contain vitamin D.

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