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Maintenance of Dietary Behavior Change

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Reducing dietary fat, saturated fat, and sodium and increasing intakes of dietary fiber and fruits and vegetables are important for cardiopulmonary risk reduction. Behaviorally, these dietary changes are very challenging, and in different ways. Fewer than half of U.S. adults have diets meeting recommended intakes of these constituents, and many do not see a need to align their diets with recommendations. Various nutrition education and behavioral counseling approaches have been shown to facilitate changes in fat, fiber, sodium, and fruits and vegetables, but primarily in research settings and among the highly motivated. Practice-based and interdisciplinary studies are needed to refine strategies to effect long-term dietary changes, to differentiate behavioral issues for changes involving additions versus deletions from the diet, and to elucidate the roles of sensory, psychosocial, and contextual factors in adoption and maintenance.

Key words: cardiovascular diseases, diet, nutrition, intervention studies

The topic of dietary behavior change is broad and complex, yet it is an important element in any discussion of attempts to reduce cardiopulmonary risk. Changes may be needed for any or all of several dietary components, for example, food groups as carriers of potentially harmful or protective constituents, specific nutrients, or food constituents. Quantitative recommendations (e.g., increasing or decreasing fiber or fat intake) are linked to qualitative changes in the composition of the foods consumed as well as to changes in the relative proportions of various foods in the diet. Implementation of dietary behavior changes requires attention to a specific, recurring array of behaviors (i.e., food choices and food preparation practices) and their determinants, and depends on an understanding of the cumulative effects of these behaviors on adherence to an overall recommended eating pattern. Furthermore, unlike health-related habits that are optional features of one's lifestyle, food consumption is central to everyday survival. Thus, dietary interventions are undertaken with an element of ambivalence. On the one hand, survival, nutritional adequacy, and quality of life require preservation of appetite and enthusiasm about eating. On the other hand, there is a need to decrease consumption of certain types of foods that, even if culturally or psychologically beneficial, are thought to have adverse health consequences over the long term.

The literature on dietary modification for cardiopulmonary risk reduction converges around five categories: (a) reduced intake of dietary fat, (b) increased intake of dietary fiber, (c) increased intake of fruits and vegetables, (d) reduced intake of dietary sodium or salt, and (e) reduced prevalence of obesity. Obesity is addressed elsewhere in this issue. For the other four topics, we describe current recommendations and criteria for successful change and the populations to whom these recommendations are addressed. Then the available evidence for each category is summarized with respect to successful change and maintenance, lapse–relapse patterns, and obstacles to long-term maintenance. Interactions among changes in these dietary behaviors and between these behaviors and other lifestyle change recommendations, including weight reduction, are also discussed. We conclude with recommendations for future research directions.

The establishment and long-term maintenance of healthful dietary behavior from childhood onward and the interplay between the dietary practices of adults and children within the same households and communities are topics that deserve detailed consideration. For some dietary guidelines,

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implementation of behavior changes during childhood (over age 2) is a priority (U.S. Department of Agriculture [USDA]/ U.S. Department of Health and Human Services [DHHS], 1995). To narrow the scope of this article, however, we focus on adults.

Dietary Behavior Change Objectives and Criteria for Change

Current Recommendations

Successful change in diet and maintenance of these four changes is typically defined in relation to reported intake above (for fiber and fruits and vegetables) or below (for fat and sodium) recommended levels. Dietary guidance tends to target populations or subgroups rather than individuals (Rose, 1990), for whom optimal intake is more difficult to define. From a public health perspective, the goal of dietary guidance is to achieve optimal diet in the population as a whole, with the expectation that the number of people at risk will decline.

Consensus recommendations from various federal agencies and voluntary organizations provide guidance for the levels of fat, fiber, fruits and vegetables, and sodium considered healthful for adults in the U.S. population (American Cancer Society, 1996; Committee on Diet and Health [CDH]/National Research Council [NRC], 1989; Deckelbaum et al., 1999; Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure, 1997; Krauss et al., 1996; National Cholesterol Education Program, 1990; USDA/DHHS, 1995; see also Table 1).

Fat. Evidence relating dietary fat intake to health is well established, and most authorities agree that individuals in the general public should eat no more than 30% of daily energy from fat in order to reduce the risk of heart disease and cancer. Because dietary saturated fat increases blood cholesterol levels, which in turn increase cardiovascular disease (CVD) risk, some of the recommendations also target 10% or less of daily dietary intake from saturated fat. Several of the recommendations describe the benefits of plant rather than animal sources of dietary fat because animal sources have higher saturated fat. Individuals with previous heart disease or who have evidence of atherosclerosis are a special focus of dietary fat reduction advice, particularly about saturated fat, to prevent second occurrences or continued progression.

Fiber. The role of dietary fiber in reducing risk of CVD has received considerable research attention over the past 10 years. Fiber has been reported to influence lipid and glucose metabolism, improve weight control, and reduce hypertension, and has been reported to prevent colon cancer (Anderson, Smith, & Gustafson, 1994; Wolk et al., 1999). Intakes of 20–30 g per day, including both soluble and insoluble fiber, have been recommended (American Cancer Society, 1996; Butrum, Clifford, & Lanza, 1988; CDH/NRC, 1989; Krauss et al., 1996; Federation of American Societies for Experimental Biology [FASEB], Life Sciences Research Office [LSRO], 1995).

Fruits and vegetables. Advice to increase intake of fruits and vegetables is based on epidemiologic studies indicating that an eating pattern high in fruits and vegetables is protective against cancer and CVD (Appel et al., 1997; Deckelbaum et al., 1999; FASEB, LSRO, 1995). Recommendations for fruit and vegetable intake are expressed in numbers of daily servings (USDA/DHHS, 1995). This advice is most commonly recognized as the National Cancer Institute's 5 A Day campaign (Heimendinger, Van Dyn, Chapelsky, Forester, & Stables, 1996). The 1995 U.S. dietary guideline for fruits and vegetables recommends 3–5 servings of vegetables and vegetable juices and 2–4 servings of fruits and fruit juices each day, depending on level of caloric intake (USDA/DHHS, 1995). Somewhat higher fruit and vegetable consumption (9–12 servings per day) has been

Table 1
Current Dietary Recommendations for Intakes of Fat, Fiber, Fruits and Vegetables, and Sodium in the U.S. Population

Dietary component	Recommendation	Relevant population group(s)
Total fat	No more than 30% of kilocalories, e.g., 53 g of fat for a person consuming 1,600 kcal per day	General population and persons at high risk for cardiovascular disease
Saturated fat	Less than 10% of kilocalories	General population and persons at high risk for cardiovascular disease
Dietary fiber	20–30 g per day	General population and persons at high risk for cardiovascular disease
Fruits and vegetables	2–4 servings of fruits and fruit juices and 3–5 servings of vegetables and vegetable juices	General population
Sodium	Less than 2,400 mg (approximately 100 mmol) per day	Healthy, nonpregnant adults in the general population and persons with or at high risk of developing high blood pressure

Note. From American Cancer Society (1996); Committee on Diet and Health/National Research Council (1989); Joint National Committee on Detection, Evaluation and Treatment of High Blood Pressure (1997); Krauss et al. (1996); National Cholesterol Education Program (1990); U.S. Department of Agriculture/U.S. Department of Health and Human Services (1995); U.S. Department of Health and Human Services (1987).

shown to substantially reduce blood pressure (Appel et al., 1997).

Sodium. Sodium reduction recommendations for all healthy, nonpregnant adults are intended primarily to prevent and control hypertension (USDA/DHHS, 1995). Because hypertension is a major public health problem (Burt et al., 1995), primary prevention efforts are greatly needed. The 1995 U.S. dietary guidelines noted that moderate sodium reduction may also reduce osteoporosis (USDA/DHHS, 1995). Thus, populations with low calcium intake (e.g., African Americans) or at high risk of osteoporosis (e.g., thin older women [FASEB, LSRO, 1995]) may benefit most from dietary sodium reduction. Some dietary guidelines also suggest that reducing intake of certain highly salted foods may reduce the risk of gastric cancer (American Cancer Society, 1996).

Methodological Issues in Assessing Successful Change

Quantitative dietary intake variables used to assess changes in fat, fiber, or sodium may be expressed as nutrients or as foods, with certain foods either directly targeted by name (e.g., fruits and vegetables) or indicated by nutrient intake (highly salted foods, high fiber foods, etc.). Semiquantitative or -qualitative behavioral variables are also used to assess dietary changes. For example, questions about frequency of adding fat or salt to foods or of removing fat (trimming meat) or sodium (rinsing canned vegetables) during preparation may be able to differentiate among people with markedly different levels of fat or salt intake. However, such data may capture only a subset of dietary behaviors and might be misleading about overall dietary pattern.

Accurate estimation of diet requires a complete and unbiased assessment of foods consumed and a comprehensive database of the nutrient content of foods. Factors that limit measurement of dietary change include daily variability, memory bias, social desirability, lack of objective biochemical markers, differences in food preparation techniques, and use of composite dishes. Because dietary intake varies considerably from day to day, the definition of successful change includes successful maintenance; that is, transient differences in intake are not considered noteworthy. Short-term success may be defined as evidence of consistent change for a period of a few weeks or months. Long-term success usually refers to a period of at least 6 months to 1 or more years. Actual long-term success in dietary change is difficult to document, however, because it requires repeated or summary objective measures of dietary intake or markers of dietary intake that reflect an extended time period. Some biochemical markers of dietary intake reflect long-term intake, whereas others do not; however, nondietary factors can also influence biological markers (Margetts & Nelson, 1997). Dietary reports and many biological markers may be biased by changes in adherence as the time of data collection approaches.

In summary, several dietary constituents with implications for cardiopulmonary health have levels of consumption recommended by one or more health policy bodies. These levels can be quantified reasonably well, and they represent standards to meet at the population or aggregate level.

Adherence to Current Dietary Recommendations in the U.S. Population

Percentage of the Population Meeting Recommended Intake Levels

Data from cross-sectional, population-based surveys conducted during the past decade are consistent with the inference that many individuals still do not perceive a need to change their diets. These data may also reflect limited success among those attempting to maintain healthful diets.

Fat. Figure 1 shows the distribution of fat intake among U.S. adults across three levels of percentage of kilocalories, by sex and poverty level as ascertained during 1989–1991. Overall, only about 25% of the population consumed fat at the recommended level of less than 30% of kilocalories. Almost half consumed between 30% and 40%, and about one quarter reported consuming more than 40% of their kilocalories as fat. The distribution of fat intake was similar for those who were near the poverty level and those well above it, and for African Americans and Whites (ethnic breakdown not shown; FASEB, LSRO, 1995). Figure 1 suggests that more women consume fat at the recommended level than do men.

Fiber. Median intakes for adults for two age groups and three sex–ethnic groups from the first round of the Third National Health and Nutrition Examination Survey (NHANES III, 1988–1991 [FASEB, LSRO, 1995]) are shown in Figure 2. As shown, median intake ranged from around 10 to around 20 g of fiber per day; it was highest in younger men and was higher in men than in women in both age groups. Within each age group, Mexican American men had the highest fiber intake; within age and sex groups, African Americans had the lowest fiber intake.

Fruits and vegetables. Telephone survey data on the distribution of fruit and vegetable consumption among a representative sample of 2,811 U.S. adults are shown in Figure 3 (FASEB, LSRO, 1995). The percentage consuming the recommended 5 or more servings per day was higher among women than men and increased with age. However, even in the oldest group of women, only 35% met the recommendation. The median number of servings of fruits and vegetables in this sample was 3.4.

The Five A Day baseline survey (Subar et al., 1995) found that vegetables were consumed more often than fruits, although this was not true for African American and Hispanic respondents when fruits and citrus juices were combined. USDA survey data have clearly indicated that inadequate fruit consumption is more of a problem than inadequate vegetable consumption, particularly among adolescents, men, Blacks or African Americans, and low-income adults. For example, in the USDA Continuing Survey of Food Intakes of Individuals (CSFII) for 1989–1991 (FASEB, LSRO, 1995, p. 109), whereas 95% or more of Black men and women ages 20 and over reported consuming some type of vegetable during a 3-day period,

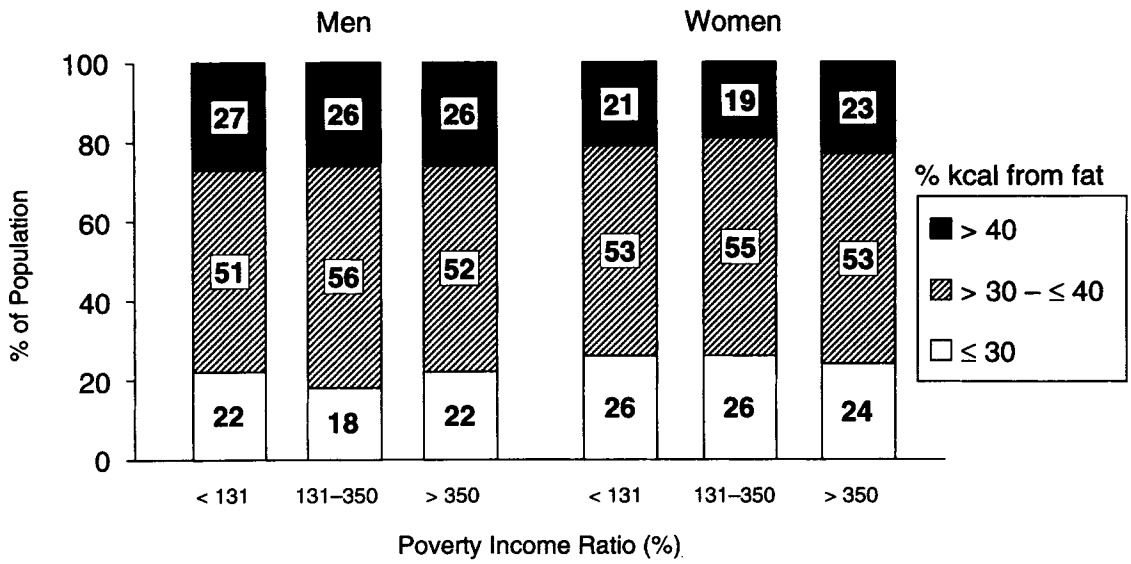

Figure 1. Percent distribution of dietary fat as a percentage of total kilocalories, by income category, for U.S. men and women ages 20 years and over. The income variable is expressed as a percentage of the poverty threshold, adjusted for inflation. Data are from the U.S. Department of Agriculture Continuing Survey of Food Intakes by Individuals, 1989–1991 (Federation of American Societies for Experimental Biology, Life Sciences Research Office, 1995).

the percentages reporting any fruit or fruit juice consumption during the 3 days were 60% for Black men, 69% for White men, 69% for Black women, and 77% for White women. When examined by income level, the percentage reporting some type of vegetable consumption during the 3 days was 95% or more even within the lowest income group, whereas only 54% of men and 66% of women with incomes less than 131% of the poverty line reported consuming fruit or fruit juice, and only 72% of men and 80% of women with incomes greater than 350% of the poverty line reported this (see FASEB, LSRO, 1995, p. ES-14 or pp. 109 and 111).

Selected CSFII data accounting for fruit and vegetable intakes from all sources and based on the serving sizes described in dietary guidelines are shown in Table 2, broken down by ethnicity (Krebs-Smith et al., 1995). The difference in the current status of fruit versus vegetable intake is clear in these data. Although nearly one third of the overall population met the minimum 5 A Day criterion, this proportion dropped to only 12% when specific targets for fruit intake and vegetable intake were included.

Sodium. Neither of two types of available data on sodium consumption provides a satisfactory indication of

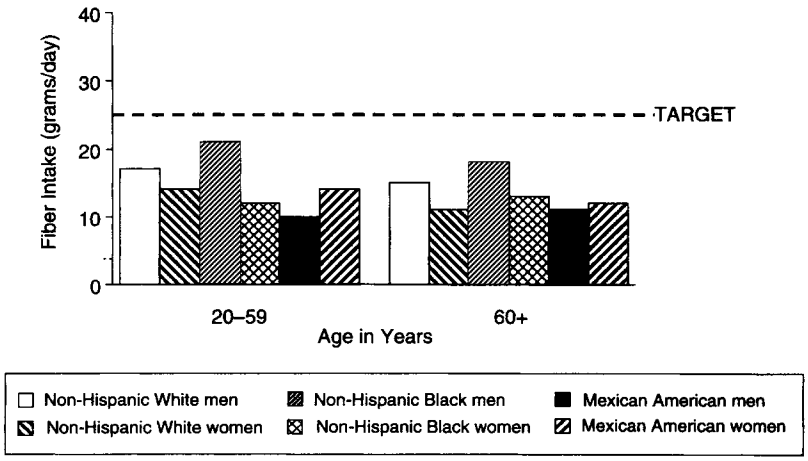

Figure 2. Median dietary fiber intake among non-Hispanic Whites, non-Hispanic Blacks, and Mexican Americans, by sex and ethnicity. Target line approximates recommended level of fiber intake. Data are from the National Health and Nutrition Examination Survey, 1988–1991 (Federation of American Societies for Experimental Biology, Life Sciences Research Office, 1995).

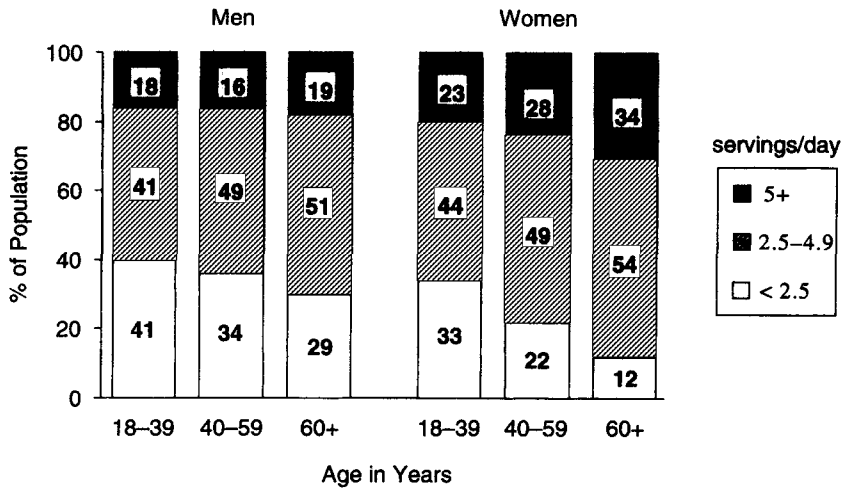

Figure 3. Percent distribution of daily servings of fruits and vegetables for U.S. men and women ages 18 years and over. Data are from the Department of Health and Human Services Baseline Survey of the 5 A Day for Better Health Program, 1991 (Federation of American Societies for Experimental Biology, Life Sciences Research Office, 1995).

the percentage of U.S. adults meeting the recommended guideline of 2,400 mg or less per day. Figure 4 shows that fewer than 20% of men and women add salt to their food on a regular basis. However, it is now well established that most consumed sodium comes from processed or prepared food (Mattes & Donnelly, 1991). Figure 5 shows the median intake of sodium as a percentage of the recommended level based on 24-hr recall data from the first phase of NHANES III. These data underestimate levels of total sodium intake because they do not account for salt added at the table. Still, median sodium intake levels were well above 2,400 mg for several sex–age groups and were close to 2,400 mg for others; thus, at least half of the population was consuming more than 2,400 mg of sodium per day.

Figure 5 also shows that average reported sodium intake is lower in women than men and declines with age. This is related in part to the positive association of sodium intake with total calorie intake (Subar, Krebs-Smith, Cook, & Kahle, 1998). The ethnic differences in Figure 5 are difficult to interpret since the 24-hr recall did not account for discretionary salt or salt-containing flavorings; use of salt as a flavoring varies in ethnic cuisines (Kittler & Sucher, 1998).

Attempts to Change Dietary Intake

Whether individuals are attempting to change various aspects of their diets can be assessed by questionnaires that address key target behaviors (e.g., consumption of low-fat foods, avoidance of high-fat foods), the overall dietary objective (e.g., attempting to lower fat intake), or even the targeted risk factor (e.g., following dietary advice to lower your blood pressure or blood cholesterol). Even data on professional advice to change diet can be useful in assessing patterns of dietary change attempts in certain subpopulations, such as those with high blood pressure. Along the same lines, data on awareness of dietary recommendations

Table 2
Percentage of U.S. Adults Consuming Various Amounts of Fruits and Vegetables During a 3-Day Period, by Ethnicity

Ethnic group	<1 serving of fruits/day	<1 serving of vegetables/day	≥5 servings of fruits or vegetables/day	≥2 servings of fruits and 3 servings of vegetables/day
All persons 20 years or older (n = 8,181)	54.3	8.2	32.1	12.2
Non-Hispanic White (n = 6,311)	53.7	7.6	32.9	12.9
Non-Hispanic Black (n = 967)	61.0	12.2	25.8	8.3
Hispanic (n = 676)	56.4	9.3	29.9	9.3
Other (n = 227)	40.7	5.0	41.0	13.7

Note. Data are from "U.S. Adults' Fruit and Vegetable Intakes, 1989 to 1991: A Revised Baseline for the Healthy People 2000 Objective," by S. M. Krebs-Smith, A. Cook, A. F. Subar, L. Cleveland, and S. Friday, 1995, *American Journal of Public Health, 85,* p. 1626, Table 2. Copyright 1995 by the American Public Health Association.

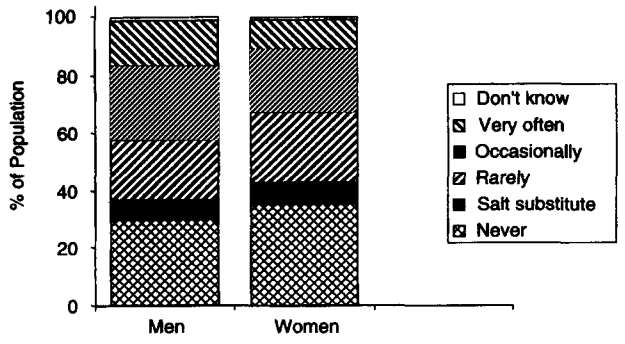

Figure 4. Responses to the question, "How often do you add salt to your food at the table?" among U.S. men and women ages 20 and over. Data are from the U.S. Department of Agriculture Continuing Survey of Food Intakes by Individuals, 1989–1991 (Federation of American Societies for Experimental Biology, Life Sciences Research Office, 1995).

Table 3
Percentage of Primary Meal Planners and Preparers (n = 4,331) Assigning High Importance to Dietary Guidance on Selected Topics

Meal planner	Total fat	Saturated fat	Fiber	Fruits and vegetables	Salt, sodium
Aware of health problems related with not following the guidance					
All	66.4	72.1	65.5	48.3	63.8
Men	62.9	68.2	52.5	36.0	60.1
Women	67.3	73.1	68.5	51.1	64.7
Not aware of health problems related with not following the guidance					
All	52.3	57.7	61.0	43.0	51.4
Men	46.2	48.1	56.7	25.9	38.6
Women	54.2	60.1	62.1	47.5	55.9

Note. Data are from the USDA Diet and Health Knowledge Survey and Continuing Survey of Food Intakes of Individuals, 1989–1991 (FASEB, LSRO, 1995).

or perceptions that dietary changes are needed can suggest the minimum percentage of the population involved in dietary change attempts. Finally, readiness to make changes (Curry, Kristal, & Bowen, 1992; Prochaska et al., 1994) is an additional indicator of the proportion interested in changing dietary habits.

Perhaps the most uniformly collected data reflecting the percentage of people attempting to change their fat, fiber, fruit and vegetable, and salt intake are from the 1989–1991 USDA Diet Health and Knowledge Survey for primary meal planners and preparers (USDA/DHHS, 1995). With the exception of fruits and vegetables, about one half to two thirds of respondents assigned high importance to following dietary guidance—that is, on fat, fiber, and salt (see Table 3). Women and individuals who were aware of health problems deemed diet to be more important. The importance assigned to consuming more fruits and vegetables was lower than for guidance in the other areas. A race- and sex-specific analysis of data for primary meal planners and preparers from the same survey indicated that Black women were more likely than White men and women to perceive their diets as too high in fat, saturated fat, and salt, and too low in fiber. Black men were as likely as Black women to consider their diets too high in fat and were more likely than White men and women to think their diets should be lower in salt, but they were the least likely to perceive their diets as too high in saturated fat or too low in fiber (from FASEB, LSRO, 1995, Table 8–7, p. 226).

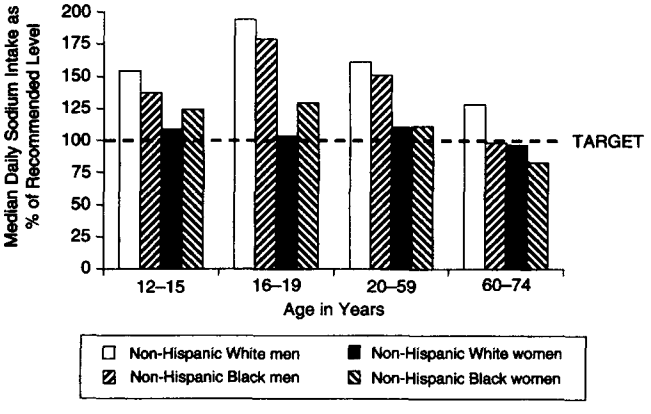

Figure 5. Median daily sodium intake among U.S. non-Hispanic Whites and non-Hispanic Blacks, by sex and age group, expressed as a percentage of the recommended upper limit of 2,400 mg per day. For subgroups with median sodium intake below the target line, at least 50% of reported sodium intakes are within the recommended range. Estimates do not include table salt. Data are from the National Health and Nutrition Examination Survey, 1988–1991 (Federation of American Societies for Experimental Biology, Life Sciences Research Office, 1995).

Trends in the proportion of people who report that they are following a sodium- or cholesterol-lowering diet (which would include reductions in total fat, saturated fat, and cholesterol) have been reported for the period between 1982 and 1990 (Interagency Board for Nutrition Monitoring and Related Research, 1993, Charts 74 and 75). On the basis of Food Marketing Survey data, Evans, Cohen, Kumanyika, Cutler, and Roccella (1996) suggested that the proportion of individuals who were very or somewhat concerned about the sodium content of foods increased from 20% to 30% between 1986 and 1990, and then declined to 18% in 1994. A similar U-shaped trend was observed for the cholesterol content of foods, whereas those concerned about the fat content of food increased from 17% to 59%. According to Burt et al. (1995), the proportion of those with hypertension who attempted to reduce sodium intake was considerably higher than in the general population. These trends suggest that continued surveillance and monitoring of subgroups is important to obtain optimal dietary adherence in the population.

Indirect evidence that a substantial proportion of those who might benefit from changing their dietary fat, saturated fat, or fiber intake do not perceive a need to do so was provided by an analysis from the USDA surveys. Among those whose reported diets (average of 3-day intakes) were above 30% fat kilocalories, only 57% thought their fat intake should be lower. Only 46% of those who reported diets that had 10% or more kilocalories from saturated fat thought

their diets were too high in saturated fat. For fiber, 54% whose diets contained less than 20 g thought their fiber intake should be higher (FASEB, LSRO, 1995, Table 8-9, p. 228).

Curry et al. (1992) conducted a population-based assessment of readiness to change low-fat dietary behaviors in the state of Washington. They found that approximately 25% of adult participants were not interested in making changes, whereas approximately 55% reported they had made substantial changes to their dietary fat consumption. These findings have been replicated (Prochaska et al., 1994) and indicate that interventions must consider the needs of individuals at different stages of readiness for change.

Taken together, these data illustrate several key points. First, many individuals in the U.S. population are making attempts to have more healthful dietary patterns. Proportions of people reporting attempts to change range from 25% to 60%, depending on the dietary constituent under study. These efforts, perhaps, have resulted in sizeable proportions of individuals in the United States who are currently meeting the dietary guidelines for at least one of the targeted components. Again, prevalence estimates for consumption at or better than any set of guidelines range from 12% to 30%, depending on the target.

Progress in Making Dietary Changes

The need to increase the proportion of the population attempting to follow dietary guidance is clear. At the population level, trends in mean dietary intake can be used to estimate progress in changing the American diet.

Fat. Evidence that fat intake in the U.S. population has decreased from the mid-1960s has been frequently cited as an example of progress in dietary change (Daily Dietary Fat and Total Food-Energy Intakes, 1994; Enns, Goldman, & Cook, 1997; Norris et al., 1997). For example, an analysis of National Health Interview Survey (NHIS) data for 1987 and 1992 (based on a 60-item food frequency questionnaire) reported a drop from about 38% to 36% of kilocalories as fat and suggested that Black Americans (whose fat intakes were highest) decreased their fat intakes the least and Hispanics (who already had the lowest fat intakes) decreased theirs the most (Norris et al., 1997) during this 5-year period. The USDA estimates that, among 19- to 50-year-old men in the U.S. population, average fat intake decreased from about 135 g per day in 1965 to about 100 g per day in 1995 and from about 80 to less than 65 g per day over the same time period for women (Center for Nutrition Policy and Promotion, 1998). Most of the decrease in fat intake was in saturated fat derived from animal products.

Fiber. Data on trends in fiber intake are difficult to identify. Norris et al. (1997) reported that there was no appreciable increase in fiber consumption between 1987 and 1992. Fiber intake of Mexican Americans from 1982–1991 appears to have increased for both men (17.4 to 20.6 g/per day) and women (10.9 to 14.2 g/day; FASEB, LSRO, 1995, Tables 6-18 and 6-19). Whether this is an artifact of trends in ascertainment of fiber intake is uncertain.

Fruits and vegetables. The NHIS data did not indicate an increase in reported fruit and vegetable consumption between 1987 and 1992, in spite of the promotion of increased fruit and vegetable consumption during that time frame (Norris et al., 1997). Enns et al. (1997) also reported no appreciable change in either the amount of vegetables in grams or the percentage of adults 20 years and older who consumed vegetables over a 17-year period, based on their analysis of data for 1 day of dietary recall in USDA surveys conducted in 1977–1978 and in 1994–1995. Overall consumption of fruits and fruit juices remained constant during this period, although proportions of men or women consuming certain types of fruit increased (e.g., the percentage of women eating bananas doubled). There was also an overall small increase in grams of fruit and fruit juices consumed; this was more pronounced in men than in women.

Sodium. NHANES dietary data actually suggest an increase in the intake of sodium from 1971–1974 to 1988–1991 (FASEB, LSRO, 1995). Whether this is merely an artifact of increasingly better ascertainment (e.g., better probing for overall food intake or for sodium-related descriptors of food items, or updating of the nutrient database over time) is not known. Nonetheless, this finding suggests either a decrease in efforts to lower sodium intake or a decrease in success. For example, sodium intake may have increased with increased reliance on convenience foods and restaurant meals (Lin, Guthrie, & Frazão, 1999).

To summarize, evidence for change over time is mixed, depending on specific nutrients. For fat, the population levels do appear to be slowly dropping, but for fiber and fruits and vegetables the evidence indicates little or no change in recent years. Decreases in sodium consumption have not been seen.

Adoption and Maintenance of Dietary Changes in Clinical and Community Trials

Dietary Change Strategies

Dietary changes involve decreasing or avoiding certain foods, beverages, or constituents of foods or beverages (e.g., fat or salt) as well as increasing consumption of certain foods (e.g., fiber or fruits and vegetables). Complementary strategies are often required, for example, eating fruit rather than a salty snack food between meals. Learning to avoid fat or salt involves nutrition education to recognize what types of foods these are likely to occur in, to learn to interpret food labels, and to learn food preparation techniques to lower fat and sodium content. Interventions to add foods may involve less education (especially for fruits and vegetables, which are easy to identify) but nevertheless still involve teaching people to recognize and incorporate certain foods (e.g., those high in fiber) into everyday eating patterns.

Strategies that help people make permanent changes in their eating habits have usually involved social learning theory and behavior modification approaches. The group and individual counseling methods based on these approaches that have been found effective in calorie reduction for weight control have been adapted for use in studies of fat

and sodium reduction (McCann & Bovbjerg, 1998; Bowen et al., 1994; Lasser et al., 1995). Usually, numerous strategies are included as part of a "tool kit" from which interventionists and participants can select in order to find the approach that works best for a particular person. Self-monitoring (e.g., keeping food intake diaries), at least for an initial period, is considered essential when the objective is to decrease consumption of nutrients that are often "hidden" in foods (e.g., to lower salt or fat intake) because it allows the individual to estimate the amounts of the targeted nutrients in each portion of food. Self-monitoring of fat and salt in packaged foods has been greatly facilitated by the Nutrition Facts panel that now appears on food labels, because both sodium and fat content must be listed. However, an individual's ability to self-monitor fat and salt intake may have decreased during recent years because of the pattern of eating away from home more frequently (Lin et al., 1999), because restaurant foods usually do not have nutrition labeling. Point systems, exchanges, and other simpler ways of scoring the relative content of dietary fat and salt have been used in some studies and community programs, especially when the target population has had limited literacy skills or limited time. These systems are less demanding but also inherently less accurate than food diaries with quantitative estimation, but the monitoring itself may serve as a behavioral prompt for adherence.

Another behavioral strategy used in dietary change studies includes providing feedback on progress (e.g., from nutritionist comments on food diaries) and results of urinalysis (e.g., for sodium content) or levels of other biochemical markers when an analyte of blood, urine, or other tissue (e.g., adipose tissue biopsy) that reflects short- or long-term dietary intake can be identified (Bates, Thurnham, Bingham, Margetts, & Nelson, 1997). However, the ability to monitor fat and salt intake objectively is limited compared with the ability to monitor body weight. Monitoring additions of servings of foods (e.g., fruits and vegetables) is conceptually and practically simpler than keeping track of total fat and salt intake.

The ability to maintain large changes in dietary composition requires permanent adoption of an entirely new or modified eating pattern. It may be possible to overcome difficulties and add complexity to dietary patterns for a short time, but a variety of individual preferences, family variables, demographic, and lifestyle factors influence the desire and ability to sustain changes in day-to-day food selection, preparation, and consumption patterns. For example, purchasing power, neighborhood of residence, and the amount of discretionary time influence the ability to obtain or prepare reduced-fat or reduced-sodium foods. In addition, sociocultural variables, which include trends in food marketing and catering, determine the context in which dietary behavior changes must be maintained. Thus, gradual changes in the fat or sodium contained in packaged foods or cafeteria or restaurant foods could influence an individual's intake upward or downward, without any change in the pattern of consuming these foods.

Success of Long-Term Dietary Behavior Changes Among Participants in Randomized Clinical Trials

Data on maintenance of dietary changes for up to 6 years are available from individual randomized trials. However, application of these studies to the general population is not always appropriate (Horwitz & Horwitz, 1993; Hollis et al., 1995; Barnard et al., 1995; Brunner et al., 1997). That is, participants in randomized trials are often highly selected on health characteristics and are often more highly motivated than individuals or patients in the reference population (Horwitz & Horwitz, 1993; Hollis et al., 1995; Barnard, Akhtar, & Nicholson, 1995). They are also offered expert nutrition and behavioral counseling at the beginning of and often throughout the entire study period. Furthermore, analyses of follow-up data from some of these studies are severely biased by inclusion of only those who remain in the program.

Fat intake. Studies of dietary fat reduction are more numerous than studies of sodium reduction or of increases in fruit and vegetable or fiber intake. An overview of dietary fat reduction studies is provided in two recent systematic reviews (Barnard et al., 1995; Brunner et al., 1997). Barnard et al. (1995) compared the fat intake reductions achieved with the stated dietary change goals and also compared the final level of fat reduction among studies with different characteristics. The main conclusions of this review were that studies with the strictest goals, that is, the most drastic reductions in fat intake, met with the greatest success. The meaning of this finding was complicated by the fact that participants in the studies with the strictest goals were more highly selected in terms of their health characteristics and motivations than those in other studies. Nevertheless, the authors noted that setting less stringent objectives, although intended to render the diets more acceptable by minimizing the level of change needed, may actually discourage people from making sufficient changes. Other program characteristics that appeared to predict success were frequent monitoring, initial residential treatment, prescription of vegetarian regimens or meatless meals, family involvement, use of prepackaged meals, and focus on people with symptomatic heart or vascular disease. The inclusion of support groups as such did not seem to make a difference in the level of fat reduction achieved, although the specific content or dynamics of the support groups was not taken into account in this analysis. Long- and short-term success were relatively similar in these trials. For example, the 18 studies of 1 year or longer reported a final mean fat intake of 29% of kilocalories, compared with 28% of kilocalories for the 21 shorter studies. Thirteen of the longer studies (i.e., >1 year) stated specific fat reduction goals, and 6 studies (46%) met these goals. Seventeen of the shorter studies had stated specific goals; 9 (53%) met these goals.

Brunner et al. (1997) performed a meta-analysis of several randomized, controlled dietary intervention trials, including 10 reports from trials of dietary fat reduction in diverse populations. Trials were grouped by the duration of follow-up (3–6 months or 9–18 months) and the number of contacts (2–3, 5–9, or 10–32). All of the shorter trials

showed a significant decrease in the percentage of kilocalories from fat, and this did not appear to differ according to participants' cardiovascular risk status. However, unlike the studies reviewed by Barnard et al. (1995), none of these trials studied patients with symptomatic CVD. Effect sizes appeared to be larger with a higher level of contact and with longer duration. However, as the authors pointed out, this finding is confounded by differences in the study populations and their motivations for dietary change. The trials with more contacts and longer duration were, with one exception, with women at high risk of breast cancer. One of these longer, breast cancer trials (Schapira, Lyman, Kumar, & Baile, 1991) achieved no significant reduction in percentage of energy from fat at 12 months in intervention participants compared with controls. Because the results of that trial showed 28% of energy from fat in controls and 29% of energy from fat in intervention participants, it may indicate success in both groups. That is, highly motivated controls succeeded in reducing their intake without benefit of the intervention. The other, longer trial, a worksite intervention, reported a very small reduction in fat intake. When studies with serum cholesterol measurements were used to evaluate longer term reductions in dietary fat intake, the effect observed in longer trials was somewhat smaller than the effect in shorter trials. Among both the short- and long-term trials, the net effects appeared to be greater in those with a greater number of intervention contacts.

Low-intensity interventions can have meaningful, though small, effects on samples that are recruited without intensive screening. Beresford et al. (1992) conducted a randomized controlled trial involving 242 patients in two primary care clinics in Chapel Hill, North Carolina. Self-help materials appropriate for an eighth-grade reading level were developed and printed in folders with card inserts of graded sizes. The key features of the materials were the emphasis on giving the patient control over his or her own diet, providing individuals with more than one way to both monitor and change their fat and fiber habits, and giving some alternative menu suggestions. The materials were introduced to the participants in the intervention group at the end of the clinic visit by a study nurse. Approximately 33% of the participants were Black, and 47% had received less than 12 years of education. The estimated reduction in fat, measured by a food frequency questionnaire, was 3.8 g larger for the intervention than the control group. Individuals who had some responsibility for meal preparation had even larger reductions of fat intake, 6.9 g (95% confidence interval = 0.6–13.2).

The Eating Patterns Study (Beresford et al., 1997) evaluated a low-intensity intervention that was effective in reducing fat intake at both 3 months and 1 year. This study randomized physician practices within 6 primary care clinics to intervention or no-intervention conditions. The intervention consisted of a standardized, brief introduction of *Help Yourself*, a self-help booklet, to patients by a physician, with a follow-up letter from the physician 2 weeks later. The booklet included self-assessment questionnaires and goal-setting forms, with behaviorally oriented advice about eating low-fat and high-fiber foods. The Eating Patterns Study enrolled 2,111 patients, of whom approximately 90% were White, and approximately three quarters had at least some college education. Fat and fiber changes were assessed at 3 months and 1 year through a food frequency questionnaire (FFQ) and through a food habits questionnaire, both administered by telephone. At both 3 months and 1 year, both groups reduced their fat intake. The changes in fat and fiber scores were significantly larger in the intervention group, adjusting for baseline value, age, and gender. A similar pattern was reflected in the percentage of energy from fat as assessed by the FFQ. The 1-year results (n = 1,816 participants) indicated that the adjusted mean differential change between intervention and controls, adjusted for clinic and practice effects, baseline value, age, and gender, was −1.20 ($p < .01$) for percentage of energy from fat, −0.04 ($p < .01$) for fat intake behavior score, 0.32 for fiber (g/1000 kcal; *ns*), and 0.04 ($p < .05$) for the fiber intake behavior score. Three participant variables appeared to increase the efficacy of the *Help Yourself* intervention: change in percent calories from fat was greater among intervention subjects with food responsibility (shopping, preparation), who were in the action or maintenance stage of readiness for dietary change, and who used of the self-help booklet provided.

The Multiple Risk Factor Intervention Trial (MRFIT) used a variety of educational and behavioral strategies to facilitate dietary changes among men at high risk of CVD, with individualized approaches (Dolecek, Stamler, Caggiula, Tillotson, & Buzzard, 1997). Van Horn, Dolecek, Grandits, and Skweres (1997) analyzed characteristics of MRFIT participants who were best able to adhere to the targeted dietary changes. Three different measures were used to assess adherence—food record ratings, nutritionist's evaluation, and serum cholesterol level—and results sometimes varied across the three measures. Approximately one half adhered well during the initial year or two of follow-up and almost one half adhered well throughout the study. Dietary fat reduction achieved and maintained at 6 years was better in older than in younger men, White, or Asian men, compared with Black men, those taking high blood pressure medications at baseline, nondrinkers, those with less stress in their lives, and those who ate fewer meals per day away from home. Educational attainment and coronary-prone behavior did not predict adherence by any measure. Marital status was only predictive of serum cholesterol, and being on a special diet at baseline was only predictive of adherence when measured by food record ratings. Smoking was related to having poorer overall adherence, particularly in the subgroups of smokers who were overweight or had high blood pressure.

Kristal et al. (1992) reported on the fat intake behavior changes of middle-aged and older women at high risk of breast cancer who were randomized to an intensive fat-lowering intervention in the Women's Health Trial. The intervention program consisted of an 18-month period of nutritionist-led group counseling sessions that emphasized nutrition information and behavioral skills relative to a low-fat diet. Goals were to achieve a diet with 20% or less of kilocalories as fat, with an increase in complex carbohydrates. Behaviors involving substitutions of manufactured

low-fat foods for high-fat foods were relatively well maintained, whereas avoidance behaviors (avoiding the use of sauces and fats at the table or in recipes, avoiding desserts, and eliminating meat from some meals) were not well maintained 12 months after the end of an 18-month intervention study. More burdensome strategies (label reading, self-monitoring) were also not retained. Adherence to low-fat eating at dinner was less than at breakfast, particularly over the long term. However, women who had the largest reductions in fat intake were those who were able to reduce the use of fat as a flavoring and in cooking (Burrows, Henry, Bowen, & Henderson, 1993), indicating that fat as a taste or flavor was important.

Taken together, these studies indicate that fat consumption can be changed in participants who are screened and recruited into large, intensive, behavior-changing projects. These projects often have intensive dietary goals and participants who are motivated to make the changes in dietary behavior required. Smaller changes are possible with less intensive, community-based intervention projects.

Fiber intake. The fiber intervention literature includes several different categories of intervention, each with its own strengths and limitations (Glore et al., 1994; Humble, 1997; Schneeman & Tinker, 1995). These include: (a) quantitative approaches, in which participants were counseled to increase daily total grams of fiber intake from various sources; (b) approaches in which a specific food was prescribed—for example, advice to consume one or more servings of a specific cereal, vegetable, or fruit, on a daily basis; (c) fiber supplement studies involving fiber powder, pills, gels, drinks, and so forth, intended to isolate the source of fiber or to offer a double-blind alternative within a usual or fat-modified diet; (d) interventions in which increased fiber intake was one of several objectives—for example, a low-fat plus high-fiber diet or an overall dietary pattern approach involving a high-fiber intake. Generally, interventions have simply prescribed amounts or types of total dietary fiber or supplements or frequency of fiber-rich foods with or without placebo controls (i.e., wheat cereal for oats). Use of foods and even placebo controls for treatment foods has been emphasized (Ritenbaugh, 1993). Pectin, guar gum, and psyllium supplements have been successful in lowering total cholesterol and low-density lipoprotein cholesterol without changing other aspects of the diet.

Chlebowski & Grosvenor (1994) pointed out that increases in dietary fiber as a result of interventions to lower fat intake are not automatic; however, excellent long-term adherence to dietary fiber change has been reported among breast cancer patients (Chlebowski & Grosvenor) and patients at high risk of colon cancer (Lanza et al., 1996). Strategies to increase motivation for adherence in these studies include self-monitoring of adherence, group support, and frequent contact with study staff.

One of the most recent and best documented behaviorally oriented studies involving fiber intervention was reported by Pierce et al. (1997). Mean increases of 6.4 g fiber/1,000 kcal fiber, along with significant increases in vegetables and fruit and decreased fat, among breast cancer patients were achieved largely through telephone counseling. The authors stated that social–cognitive theory (Bandura, 1977) was applied to enhance participant motivation and to self-regulate and maintain those changes. Three phases of intervention were applied. First, a brief, intensive intervention was introduced to encourage women to quickly achieve the study goals while the counselor monitored eating behavior. The second phase was less intense and aimed toward self-empowerment of participants to make changes relevant to their lifestyles and to monitor their own adherence. The third phase was described as maintenance aimed at preventing relapse, including cooking classes that were offered monthly. Using this approach, adherence was successfully maintained for 12 months of follow-up. The investigators also developed an adherence score based on the study intervention goals (i.e., fruit, vegetables, fiber, etc.) to better reflect the overall dietary pattern rather than concentrating on only one factor. Adherence was objectively documented using nutrient biomarkers sensitive to changes in the intake of carotenoid-containing fruits and vegetables (e.g., serum β-carotene, α-carotene, and lutein). The authors concluded that telephone counseling can be an effective intervention method as part of this overall program, at least in rigorously selected, presumably highly motivated, patients.

In summary, most data pertaining to changes in dietary fiber intake reflect studies among middle-aged women or men, usually well educated and motivated because of their disease or high-risk status. Data are insufficient to characterize potential differences in adherence based on ethnicity, gender, or socioeconomic factors. In general, approaches that have offered the participant choices in dietary fiber intake appear to yield good long-term adherence. However, it is difficult to tease out factors related to short- versus long-term dietary fiber changes, because the short- and long-term studies may involve very different types of study designs, food choices, and palatability, and result in different frequencies of GI distress or other negative side effects. Therefore, more data are needed to document the results of interventions to change fiber consumption.

Fruit and vegetable intake. At least two randomized trials of increasing fruit and vegetable consumption for individuals have resulted in measurable and sustained increases. Le Marchand et al. (1993) randomized participants at high risk for cancer to consume more fruits and vegetables to increase their micronutrient consumption. He found changes in both behavioral and biomarker indicators of fruit and vegetable consumption. Women in the Women's Health Trial increased their consumption of fruit by about one serving per day for the duration of the trial (Burrows et al., 1993).

Whereas most of the interventions relating to dietary fat, sodium, and fiber intake have been in clinical studies, most studies of how to increase fruit and vegetable consumption as such (i.e., as opposed to as a means for reducing fat or sodium consumption or increasing fiber intake) have been in community or worksite settings. Specifically, the 5 A Day program sponsored by the National Cancer Institute has sponsored several research programs to identify successful intervention strategies to increase fruit and vegetable intake. Havas et al. (1995) have described nine such projects that

were funded in 1993. The Maryland Women, Infants, and Children (WIC) 5 A Day program was designed to increase fruit and vegetable consumption among pregnant women, breastfeeding women, postpartum women, and the mothers of infants and young children receiving services at several sites of the Special Supplemental Food program for WIC in Baltimore and other areas of Maryland. A program in 10 counties in North Carolina was designed around the use of lay health advisors to motivate and facilitate fruit and vegetable consumption among members of Black churches. A worksite program in Seattle, Washington, included both individual-level interventions, based on the stage of change concept, and strategies related to company policies involving cafeteria foods, vending machines, and availability of nutrition resources, and workplace events to promote increased consumption of fruits and vegetables. A Massachusetts worksite project included a family intervention in one test condition. An Arizona worksite program targeted predominantly male, Hispanic employees in job classifications such as custodian, sanitation, food service, heavy equipment operation, and physical plant maintenance—a population not traditionally reached by worksite wellness programs—and involved training individuals recruited from the target population to work as peer educators within their social networks. Four other projects—in Minnesota, Louisiana, Georgia, and Alabama—were designed to reach elementary or high school children, or elementary school children and their families. Most of the 5 A Day projects' results are not published; the two published studies are described below.

Results of the Maryland WIC 5 A Day program (Havas et al., 1998) indicate a significant effect of the program 1 year after completion of the intervention. Mean daily consumption of fruits and vegetables was assessed with a seven-item questionnaire at 2 months after the last intervention session and then again 1 year later. At the survey taken shortly after the intervention, both intervention and control participants had increased their consumption; the increase in intervention versus control participants was significantly larger at 2 months (0.56 versus 0.13 servings, $p = .002$). Increases in fruit and vegetable consumption were greater in women who were White, under 30 years of age, married, high school graduates, nonsmokers, and unemployed. Participants who were in the preaction stage of change increased their consumption of fruits and vegetables more than those in the action or maintenance stages. The 1-year follow-up data indicated that both intervention and control participants had increased their fruit and vegetable consumption by an additional 0.27 serving. The difference between intervention and control participants in overall change (e.g., baseline to the 1-year follow-up survey) remained statistically significant ($p = .004$).

A multifocal, 2-year worksite intervention described by Sorensen et al. (1998) reported differences in effects on dietary fiber and fruit and vegetable intake by worker job classification. The intervention, which targeted reduction of dietary fat and increases in dietary fiber and fruit and vegetable intake, was based on a socioecological model that integrated several worksite strategies, including planning and implementation of programs jointly by worker–management teams, environmental changes that included increased availability of healthy foods, and health education programs to facilitate individual behavior changes. Other factors targeted in addition to diet were tobacco control and occupational hazards.

The intervention was effective in increasing fruit and vegetable consumption (i.e., an increase of 0.23 serving per day in intervention sites versus 0.10 serving per day in control sites), as assessed with two questionnaire items. Workers classified as professional or managerial increased their fruit and vegetable consumption more than other workers. Changes (increases) in fiber intake were larger in intervention versus control participants only among workers in the skilled and unskilled labor categories; the opposite effect was observed in office workers and professional and managerial workers.

The few clinical studies available indicate that motivated individuals can make large increases in fruit and vegetable consumption. The few community-based studies conducted indicate that interventions to change fruit and vegetable consumption can have small effects over a large number of individuals. Again, much more research is needed to address this issue.

Sodium intake. Evidence of the effects of interventions on dietary sodium reduction comes exclusively from trials of hypertension treatment or prevention. There have been several with durations of up to 4 years, all targeting a reduction in intake of about 30% to 50% and typically involving an intensive intervention followed by an extended period of follow-up with less intervention (Appel et al., 1995; Brunner et al., 1997; Elmer, Grimm, Flack, & Laing, 1991; Evans et al., 1996; Kumanyika et al., 1993; Lasser et al., 1995). Some of these trials evaluated sodium reduction as a single-focus intervention, whereas others combined sodium reduction with weight reduction or other lifestyle changes. Intervention approaches in these trials included group and individual counseling on how to identify and lower the sodium content of the diet on a meal-by-meal or food-group basis, taste-testing foods with reduced sodium content and alternative flavors, self-monitoring and other behavioral modification strategies, shopping guides, and adherence enhancement through provision of feedback on food diaries and on sodium excretion in urine samples (Elmer et al., 1991; Kumanyika et al., 1993; Lasser et al., 1995).

Elmer et al. (1991), in reviewing several of these trials, reported that the percentage decrease in sodium, assessed from mmol sodium excreted per 24 hr or per 8 hr, was 13% to 47% at 12 months. Elmer et al. (1991) noted that in three of the trials in which some or all participants were followed for longer than 12 months, final or overall reductions were the same or greater than the 12-month effects.

The Trials of Hypertension Prevention, Phase I (TOHP I) reported a net percentage reduction (vs. usual-care controls) in sodium intake at 18 months of 30%, reflecting relatively little change from that observed initially at 6 months (Kumanyika et al., 1993). Averaged over the 18 months of follow-up, approximately 40% of participants in the TOHP I

sodium intervention achieved the targeted level of sodium intake (<80 mmol per 24 hr). In a similar but larger and longer second phase of the TOHP (TOHP II), which was confined to overweight adults with high-normal blood pressure, the reported net sodium reductions from baseline at 6, 18, and 36 months, respectively, were 50, 43, and 40 mmol/24 hr in the group that received sodium reduction alone; and 37, 29, and 24 mmol/24 hr in those receiving a combined sodium and weight reduction intervention (TOHP Collaborative Research Group, 1997).

Brunner et al. (1997) concluded that longer term results for sodium reduction were relatively good. The summary effect estimated for sodium reduction was somewhat larger at 9–18 months (based on TOHP) than at 3–6 months. Taken together these studies suggest that interventions involving intensive counseling and extended support can achieve and maintain substantial sodium reductions of relatively long duration in motivated participants. The possibility that follow-up measures in intervention group participants reflect good adherence only during the period immediately prior to the sample collection cannot be ruled out. However, several of these studies also show parallel patterns of decreases in blood pressure that suggest sustained adherence to sodium reduction throughout follow-up (i.e., blood pressure reductions presumably reflect chronic sodium effects). With respect to predictors of adherence, the TOHP I data indicated better adherence in White than in Black participants (Kumanyika et al., 1993). Gender-specific results for sodium reduction in TOHP I also highlight the relative advantage for women in achieving sodium reduction goals, because sodium intake tends to be expressed as an absolute level (e.g., less than 80 or 100 mmol/day). Sodium intake was correlated with caloric intake. Hence, women, who consume fewer calories, will achieve targeted levels of intake when consuming diets that have the same sodium density (i.e., per 1,000 kcal) as men.

Interactions Among Different Types of Dietary and Lifestyle Changes

The four dietary behavior change foci discussed here are highly interrelated with each other and with other recommended lifestyle changes (e.g., smoking, weight reduction, increasing physical activity). Fruits and vegetables are sources of fiber and help to lower fat intake when they are substituted for high-fat foods (e.g., snacks, desserts, breakfast foods) and are not prepared with high-fat sauces or flavorings. Fat reduction is commonly used to reduce weight and will facilitate weight reduction if the substitutions made for high-fat foods do not contain equivalent kilocalories. Low-fat products may be formulated with sufficient sugar to replace or exceed the calories removed from fat, and this has been noted as a possible contributor to the increase in obesity in the United States during a period when fat avoidance was at its peak, as indicated by a population-wide decline in serum cholesterol levels (Sempos, Cleeman, & Carroll, 1993; Sempos et al., 1989). Increasing fiber intake, through increased consumption of fruits and vegetables as well as of other fiber-containing foods, is also very compatible with weight-loss regimens because many high-fiber foods are low in both calories and fat. In addition, high-fiber foods are filling and may decrease meal size.

Conclusions and Recommendations

Dietary survey data indicate that we are far from the targeted levels for all four dietary changes that are recommended for reduction of cardiopulmonary risk. Survey data indicate a relatively high awareness of fat and salt issues related to health, although the level of awareness varies over time and the proportion of individuals attempting to modify their diets for health reasons seems to be less than those who are aware of the issue.

These four dietary changes are generally compatible with each other and with other recommended lifestyle changes. Some combinations of these changes, such as reducing fat and increasing fiber intake, or increasing fiber intake and increasing fruits and vegetables, might occur together naturally, whereas other combinations, such as sodium reduction and increased fiber consumption, may require special effort. Changes involving removal of dietary constituents, for example, fat and sodium, are more complex because they involve significant knowledge of foods in order to recognize which ones to avoid or modify, and it may be difficult to maintain a reduction of both fat and sodium because of a combination of availability, cost, and preferences. Increasing fruit and vegetable and fiber consumption is simpler conceptually but may be difficult to implement (Drewnowski, 1997).

Overall, these data give the impression that qualitative dietary changes, once learned, are more likely to be maintained than the reduced calorie intake that might be needed to maintain a lower weight. However, the level of difficulty involved in making such changes may deter individuals who are not highly motivated. Studies with highly motivated individuals have shown that it is clearly possible to achieve and maintain demanding dietary changes for several years. Fat and salt intake have been much better studied than fiber and fruit and vegetable intake, but none of these four aspects of eating patterns has been well studied under the conditions that can be generalized to population-based samples.

We close with a list of research priorities for the field. This list is not exhaustive but highlights critical questions that arose from our review and working group discussions.

1. Research is needed on interventions that enhance maintenance of dietary change. Such intervention studies should:

(a) use designs that compare the effects of different types of maintenance interventions and the timing of their implementation. For example, participants could be randomized to different maintenance strategies derived from conceptual models such as stages of change (Prochaska & DiClemente, 1983), relapse prevention (Marlatt & Gordon, 1980), and motivational interviewing (Miller, 1996).

(b) define and test specific, concrete approaches to dietary change and maintenance (e.g., adding vs. subtracting dietary elements). Examples of this type of approach include the work by Epstein and colleagues (Lappalainen & Epstein,

1990; Smith & Epstein, 1991; Epstein, Bulik, Perkins, Caggiula, & Rodefer, 1991; Epstein, Smith, Vara, & Rodefer, 1991) applying behavioral economics to food choice, activity choice, and smoking.

(c) explore Person × Treatment interactions and define which interventions work with different subgroups of the population.

(d) explore the use of individually tailored and algorithm-based methods. For example, an unexplored question is whether change and maintenance are affected by individuals' perceptions that an intervention is tailored to them.

(e) test participant-chosen approaches.

(f) test whether multifactorial approaches that combine a number of intervention nutrients or behavior patterns are more effective for change and maintenance than intervening on a single nutrient or behavior. Studies should test how best to combine intervention targets.

2. Research is needed on sensory and taste preferences and dietary maintenance to determine the following:

(a) How does an individual's maintenance of a dietary change (e.g., reduced fat or sodium diet) affect preferences for that diet?

(b) How do changes in preference affect relapse, and how many times does it take for a lapse in dietary habits to translate into preference for the original diet?

(c) How long does it take to change preferences for different dietary components, and are the effects (e.g., duration) of changing preferences different for different dietary components?

(d) What are the primary determinants and maintenance patterns of dietary preferences (e.g., availability or choice of foods, social norms or culture, costs, individuals' responses to different foods)?

3. Descriptive research is needed to:

(a) characterize the behavioral and psychosocial factors associated with lapse–relapse behavior relevant to dietary change and maintenance.

(b) assess the meaning of individuals' responses to different foods so that maintenance interventions can use this information.

(c) investigate how the context in which dietary behaviors are learned (e.g., home, office, neighborhood) and factors associated with the context of learning can improve maintenance of dietary behavior change.

4. More practice-based research, using registries, such as the National Weight Control Registry (Klem, Wing, McGuire, Seagle, & Hill, 1997), should be conducted and existing clinical and research networks be used, to conduct research on behavior change and maintenance.

5. Interdisciplinary efforts are needed in this area, with cross-fertilization of ideas from a variety of social science disciplines. Theoretical constructs and methods from different areas of social science, such as social and experimental psychology, anthropology, sociology, which can be used to guide research at the applied and clinical level, should be applied to advance knowledge of health behavior change and maintenance.

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