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The DASH diet for high blood pressure: From clinical trial to dinner table

ABSTRACT

Three recent studies show that a diet rich in fruits, vegetables, whole grains, and lowfat dairy products and low in fat, refined carbohydrates, and sodium can lower blood pressure either alone or in combination with other lifestyle changes. These studies have greatly expanded our knowledge of nonpharmacologic interventions to prevent and manage hypertension. They also underscore the need for diet and lifestyle counseling in the primary care setting.

KEY POINTS

The DASH study demonstrated that blood pressure can be significantly reduced with a diet abundant in fruits, vegetables, complex carbohydrates, and lowfat dairy products.

The DASH and DASH-Sodium studies provide a scientific basis for a dietary sodium goal lower than currently recommended, and highlight the benefit of reducing sodium intake even for nonhypertensive persons.

The behavioral interventions used in the PREMIER study led to substantial weight loss, reduced sodium intake, and increased physical fitness.

Subjects who were hypertensive, African American, or older tended to experience the greatest reduction in blood pressure from the DASH diet and lifestyle changes.

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EATING RIGHT lowers blood pressure by about as much as any single antihypertensive drug—but will patients do it?

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Three recent randomized studies proved that a diet high in complex carbohydrates, fruits, vegetables, and lowfat dairy products and low in fat and sodium (not necessarily vegetarian and, on the other extreme, certainly not low-carbohydrate) lowers blood pressure effectively and quickly.

But studies are not like the real world. In two of the studies the patients had all of their food prepared for them, and in the third they underwent intensive counseling. How can physicians hope to convince and teach their patients to change their eating habits, given the time constraints of primary care?

Here, we summarize what we have learned about the impact of diet on blood pressure from three studies:

- Dietary Approaches to Stop Hypertension (DASH)[1]
- DASH-Sodium[2]
- PREMIER.[3]

We also provide practical advice to translate the results of these studies into clinical practice.

WHAT WE KNEW BEFORE DASH

Before DASH, the only nondrug options for managing high blood pressure were salt reduction, weight control, and moderation in alcohol consumption.[4]

These have limitations. Most people have trouble keeping weight off; as many as 95% of

people who lose weight gain it back within 5 years.[5] Similarly, efforts to reduce salt consumption are hampered by the wide availability of processed foods, the source of 70% to 80% of all salt consumed in the United States.[6] Furthermore, the role of sodium restriction in preventing and managing hypertension remained controversial.[7,8]

There was therefore a clear need to increase the number of nondrug options for people who are at risk for hypertension, but who do not meet the clinical definition of hypertension, and to provide alternative or adjunct therapy to those with hypertension.

Individual nutrients or whole diet?

Vegetarians and populations that routinely consume plant-based foods have lower blood pressure and do not experience the age-related rise in blood pressure seen in populations that consume meat-based diets.[9,10] Diets high in calcium and protein are also associated with lower blood pressure.[11,12]

The prevailing wisdom at the time the DASH study was designed was that individual nutrients were responsible for lowering blood pressure. Candidate nutrients included the minerals calcium, potassium, and magnesium and the macronutrients fat, fiber, and carbohydrates. But when these nutrients were tested individually—primarily through supplement use—blood pressure went down only modestly (< 3 mm Hg systolic and < 1 mm Hg diastolic) or not at all.[13–15] In contrast, lowfat, vegetarian diets lowered systolic blood pressure by 5 to 6 mm Hg.[10,11] These results strongly suggested that the beneficial effects seen in the observational studies were due to overall dietary patterns that included a variety of food components.

The DASH diet lowered blood pressure by 11/6 mm Hg in hypertensive subjects

THE DASH STUDY

The DASH study was organized and funded by the National Heart, Lung, and Blood Institute (NHLBI) to assess the impact of two diets on blood pressure.

How the DASH study was conducted

The DASH study included 459 adults (age 22 years or older) with systolic blood pressure lower than 160 mm Hg and diastolic pressure 80 to 95 mm Hg—prehypertension or stage 1 hypertension by the current classification system. None were taking antihypertensive medications.

About half of the participants were women, and 60% were African Americans, who bear a disproportionate burden of hypertension in the United States.

At baseline, 29% of participants had hypertension, and 27% were smokers.

Over 8 weeks, the participants were randomly assigned to one of three diet groups:

- **Control:** A diet similar to what many Americans consume, although somewhat lower in potassium, magnesium, and calcium.
- **Fruits and vegetables:** Similar to the control diet, but with more fruits and vegetables.
- **DASH:** A diet high in fruits, vegetables, lowfat dairy products, whole grains, poultry, fish, and nuts and low in fats, red meat, sweets, and sugar-containing beverages (TABLE 1). As a result, the diet is high in calcium, magnesium, potassium, and fiber. It is low in total fat, particularly saturated fat and cholesterol. Its 18% protein content is somewhat higher than the typical American diet, which is 15% protein.[16,17]

Participants received all their food and beverages in prepared meals and snacks for the 11 weeks of the study. They were asked to eat only the food provided and nothing else. Uneaten or nonstudy foods were recorded.

All three diets contained the same amount of sodium (3,000 mg/day), and participants were allowed 500 mg of discretionary sodium. Alcohol intake was limited to two drinks or fewer per day, and weight was intentionally held constant.

What we learned from the DASH study

The DASH diet lowered systolic blood pressure by an average of about 6 mm Hg and diastolic pressure by about 3 mm Hg. The diet that was merely higher than the typical American diet in fruits and vegetables also lowered blood pressure, but by a lesser amount: about 3 mm Hg systolic and 2 mm Hg diastolic.

For participants with stage 1 hypertension (blood pressure 140/90–159/99 mm Hg), the DASH plan was even more effective, reducing

TABLE 1

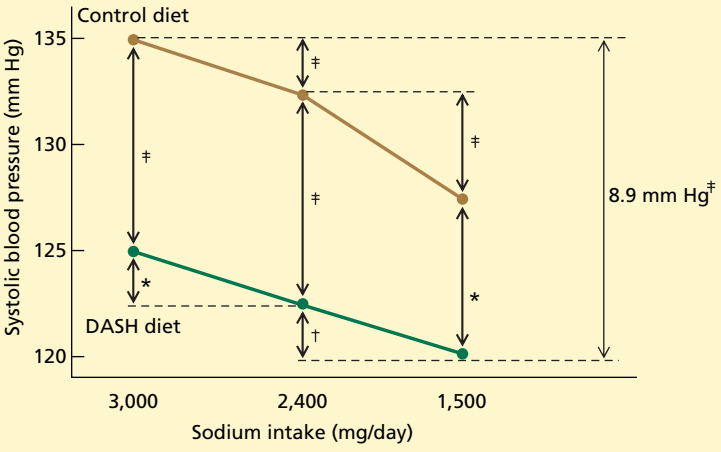
The DASH diet

FOOD GROUP	DAILY SERVINGS*	SERVING SIZES, EXAMPLES, AND SIGNIFICANCE
Grains, grain products	7–8	**Serving sizes:** 1 slice bread, 1 oz dry cereal,† 1/2 cup cooked rice, pasta, or cereal **Examples:** Whole wheat bread, English muffin, pita bread, bagel, cereals, grits, oatmeal, crackers, unsalted pretzels, popcorn **Significance:** Major sources of energy and fiber
Vegetables	4–5	**Serving sizes:** 1 cup raw leafy vegetable, 1/2 cup cooked vegetable, 6 oz vegetable juice **Examples:** Tomatoes, potatoes, carrots, green peas, squash, broccoli, turnip greens, collards, kale, spinach, artichokes, green beans, lima beans, sweet potatoes **Significance:** Rich sources of potassium, magnesium, and fiber
Fruits	4-5	**Serving sizes:** 6 oz fruit juice, 1 medium fruit, 1/4 cup dried fruit, 1/2 cup fresh, frozen, or canned fruit **Examples:** Apricots, bananas, dates, grapes, oranges, orange juice, grapefruit, grapefruit juice, mangoes, melons, peaches, pineapples, prunes, raisins, strawberries, tangerines **Significance:** Important sources of potassium, magnesium, and fiber
Lowfat or fat-free dairy	2–3	**Serving sizes:** 8 oz milk, 1 cup yogurt, 1 1/2 oz cheese **Examples:** Fat-free (skim) or lowfat (1%) milk, fat-free or lowfat buttermilk, fat-free or lowfat regular or frozen yogurt, lowfat and fat-free cheese **Significance:** Major sources of calcium and protein
Meats, poultry, and fish	2 or less	**Serving sizes:** 3 oz cooked meats, poultry, or fish **Note:** Select only lean meats; trim away visible fat; broil, roast, or boil, instead of frying; remove skin from poultry **Significance:** Rich sources of protein and magnesium
Nuts, seeds, and dry beans	4–5 per week	**Serving sizes:** 1/3 cup or 1 1/2 oz nuts, 2 Tbsp or 1/2 oz seeds, 1/2 cup cooked dry beans **Examples:** Almonds, filberts, mixed nuts, peanuts, walnuts, sunflower seeds, kidney beans, lentils, peas **Significance:** Rich sources of energy, magnesium, potassium, protein, and fiber
Fats and oils‡	2–3	**Serving sizes:** 1 tsp soft margarine, 1 Tbsp lowfat mayonnaise, 2 Tbsp light salad dressing, 1 tsp vegetable oil **Examples:** Soft margarine, lowfat mayonnaise, light salad dressing, vegetable oil (eg, olive, corn, canola, safflower) **Note:** DASH has 27% of calories as fat, including that in or added to foods
Sweets	5 per week	**Serving sizes:** 1 Tbsp sugar, 1 Tbsp jelly or jam, 1/2 oz jelly beans, 8 oz lemonade **Examples:** Maple syrup, sugar, jelly, jam, fruit-flavored gelatin, jelly beans, hard candy, fruit punch, sorbet, ices **Note:** Sweets should be low in fat

*The DASH eating plan is based on 2,000 calories a day. The number of daily servings in a food group may vary from those listed, depending on the patient's caloric needs. Patients should use this chart to help plan their menus or take it with them when they go to the store.
†Equals 1/2 to 1 1/4 cup, depending on cereal type. Check the product's nutrition label.
‡Fat content changes serving counts for fats and oils. For example, 1 Tbsp of regular salad dressing equals 1 serving, 1 Tbsp of lowfat dressing equals 1/2 serving, 1 Tbsp of a fat-free dressing equals 0 servings.

SOURCE: HTTP://WWW.NHLBI.NIH.GOV/HEALTH/PUBLIC/HEART/HBP/DASH/INDEX.HTM

DASH diet, low sodium intake both lower blood pressure



*$P < .05$; †$P < .01$; ‡$P < .001$

FIGURE 1. Reduction in systolic blood pressure in the DASH-Sodium study. Participants were randomized to a control diet or the DASH diet (see text and TABLE 1); within each group, each participant rotated through three sodium intake levels (3,000, 2,400, and 1,500 mg/day).

FROM SACKS FM, SVETKEY LP, VOLLMER WM, ET AL. EFFECTS ON BLOOD PRESSURE OF REDUCED DIETARY SODIUM AND THE DIETARY APPROACHES TO STOP HYPERTENSION (DASH) DIET. DASH-SODIUM COLLABORATIVE RESEARCH GROUP. N ENGL J MED 2001; 344:3–10.

systolic blood pressure by an average of 11 mm Hg and diastolic blood pressure by 6 mm Hg.[1,17] Moreover, the reductions in blood pressure happened quickly, within 2 weeks of starting the diet.

These dramatic results demonstrated that the DASH diet can lower blood pressure significantly, and prompted the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure to recommend the DASH diet to aid in blood pressure control.[18]

THE DASH-SODIUM STUDY

All three of the diets in the DASH study contained about 3,000 mg of sodium daily—roughly 20% below the US average for adults but still above the recommended intake of 2,400 mg per day.

Building on the DASH findings, investigators designed the DASH-Sodium study to answer key questions about the relationship between sodium intake, diet, and hypertension:

- What is the effect of reducing sodium in the context of a typical American diet and the DASH diet?
- What is the combined effect of the DASH diet and reducing sodium?
- To what extent does reducing sodium or following the DASH diet or both lower blood pressure in people without hypertension (a critical question for the primary prevention of hypertension)?

How the DASH-Sodium study was conducted

Like its predecessor, the DASH-Sodium study was a multicenter, randomized, outpatient feeding study. Participants were adults with prehypertension or stage 1 hypertension—120 to 159 mm Hg systolic and 80 to 95 mm Hg diastolic. They were randomized to two diet groups: the DASH diet and a control diet that approximated the average American fat intake (although, as in the original study, slightly lower in potassium, magnesium, and calcium).

Within each diet, participants received three different levels of sodium intake (3,000, 2,400, and 1,500 mg/day) in random order for 30 days, each in a crossover fashion. Thus, each person consumed all three sodium levels on his or her assigned diet, either DASH or control.

What we learned from the DASH-Sodium study

Reducing sodium intake lowered systolic and diastolic blood pressure significantly in both the control and DASH diet groups (FIGURE 1).[2,19] Key findings:

- The DASH diet lowered blood pressure at all levels of sodium intake.
- Lowering sodium intake to the currently recommended level (2,400 mg) effectively reduced blood pressure for all participants.
- Lowering sodium intake even further to 1,500 mg lowered blood pressure by twice as much.
- Lowering sodium intake to 1,500 mg/day in nonhypertensive subjects lowered blood

TABLE 2

The PREMIER study: Effects of dietary interventions at 6 months

OUTCOME	BASELINE	AT 6 MONTHS		
		ADVICE-ONLY GROUP	ESTABLISHED RECOMMENDATIONS GROUP	ESTABLISHED-PLUS-DASH GROUP
Percent with hypertension	37	26	17*	12†
Percent with optimal blood pressure	0	19	30†	35†

*$P < .01$ vs advice-only group; †$P < .001$ vs advice-only group

DATA FROM THE WRITING GROUP OF THE PREMIER COLLABORATIVE RESEARCH GROUP. EFFECTS OF COMPREHENSIVE LIFESTYLE MODIFICATION ON BLOOD PRESSURE CONTROL: MAIN RESULTS OF THE PREMIER CLINICAL TRIAL. JAMA 2003; 289:2083–2093.

pressure by 5.6/2.8 mm Hg on the control diet and by 1.7/1.1 mm Hg on the DASH diet.

- The effect of lower sodium intake and the DASH diet on blood pressure was substantially greater when combined. The combined effect of the DASH diet and lowering sodium intake to 1,500 mg was a reduction of 8.9/4.5 mm Hg (7.1/3.7 mm Hg in nonhypertensive subjects and 11.5/5.7 mm Hg in hypertensive subjects).

These findings have far-reaching implications. First, they provide a scientific basis for a dietary sodium goal lower than currently recommended. Second, they highlight the benefit of reducing sodium intake even in people without hypertension.

FURTHER QUESTIONS ABOUT THE DASH DIET IN DAILY LIFE

The two DASH studies conclusively demonstrated that diet can lower blood pressure. Both studies, however, were conducted in a highly controlled fashion. Participants were given all their food and beverages for the entire time they were in the study. The meals were prepared and tailored to optimize nutrient and calorie content for each participant. Thus, minimal effort was required of participants. Several key questions remained:

- What would happen if people attempted to follow the DASH eating plan on their own?
- Would the daily challenges of acquiring and preparing food result in a less-than-optimal compliance with the diet?
- Would this attenuate the effects of the diet on blood pressure?
- What would happen if the DASH diet was combined with established lifestyle changes known to lower blood pressure (ie, reduced sodium intake, increased physical activity, limited alcohol intake, and weight reduction in overweight persons)?

These questions were addressed in a third study called PREMIER.[3]

Blood pressure was lowered within 2 weeks of starting the DASH diet

THE PREMIER STUDY

PREMIER was also a multicenter, randomized study, but unlike in the DASH and DASH-Sodium studies, food was not provided. Instead, the participants, who had prehypertension or stage 1 hypertension, were randomly assigned to undergo one of three different interventions:

- **Advice-only** (the control intervention): a single education session, with printed handouts provided.
- **Established recommendations:** behavioral counseling based on established recommendations for the nonpharmacologic management of hypertension (ie, reduced sodium intake, increased physical activity, limited alcohol intake, and weight loss). Participants attended a total of 18 sessions with trained interventionists (typically registered dietitians) over 6 months.[3]
- **Established-plus-DASH:** 18 sessions

TABLE 3

Diet lowers blood pressure as much as drugs do

TREATMENT	REDUCTION (MM HG)
Hydrochlorothiazide (thiazide diuretic)*	11/5
Atenolol (beta-blocker)*	8/7
Captopril (angiotensin-converting enzyme inhibitor)*	6/5
Diltiazem (calcium channel blocker)*	10/9
Prazosin (alpha-1 blocker)*	9/6
DASH plus 1,500 mg sodium diet†	11/6

*When given as monotherapy to men with stage 1 hypertension in the Veterans Affairs Cooperative study[21]
†When applied to men and women with stage 1 hypertension in the Dietary Approaches to Stop Hypertension (DASH)-Sodium study[2,19]; see text and TABLE 1 for a description of the DASH diet

Diet lowered blood pressure the most in hypertensive, African-American, and older subjects

based on the established recommendations plus the DASH diet.

Goals for weight loss, physical activity, and sodium and alcohol reduction were the same in both the established-recommendation group and the established-plus-DASH group. Those in the established-plus-DASH group set additional goals related to fruits, vegetables, dairy, and fat consumption.

The main outcomes in PREMIER were blood pressure and hypertension status at 6 months.

What we learned from the PREMIER study

Both the established-recommendation group and the established-plus-DASH group lost substantial weight, reduced their sodium intake, and increased their physical fitness. Blood pressure and hypertensive status improved for all three groups (TABLE 2).

Hypertension was best controlled in the established-plus-DASH group, in which 77% of participants who started with stage 1 hypertension ended the study with blood pressure lower than 140/90 mm Hg.

The effects attributed to the DASH diet were less than in previous studies, however. In particular, the difference in blood pressure was not statistically significant between the established-plus-DASH group and the established-recommendation group. Furthermore, the advice-only group achieved changes that were better than any observed in control groups of similar studies.[3]

While participants made changes consistent with the DASH diet and other recommendations, they did not do so to the same extent as in the controlled-feeding studies. For example, those in the established-plus-DASH group increased their intake of fruits and vegetables to only 7.8 servings instead of the 9.6 servings in the DASH and DASH-Sodium studies. Therefore, they did not receive the same magnitude of benefit as in those studies. It is also plausible that participants found it more challenging to pay equal attention to each component of the intervention, resulting in the subadditive effects on blood pressure that we observed.

The larger-than-expected effect in the advice-only group is intriguing and unexplained. It is possible that even though their one-time counseling session was brief, the participants in this group were more motivated to make changes using the advice materials they were given. Furthermore, even though they did not attend weekly sessions, they still came to the clinics for measurements, and this contact with health care professionals may have had an effect on their lifestyle choices in the absence of active counseling.

Effects in subgroups

The DASH, DASH-Sodium, and PREMIER studies explored whether certain subgroups defined by lifestyle factors (eg, physical activity, alcohol use) and sociodemographic factors (eg, age, gender, race, income, education) responded differently to dietary patterns.

While all participants benefitted from the interventions in the PREMIER study, the greatest reductions in blood pressure were in hypertensive patients, African Americans, and older participants.[1,19,20]

IMPLICATIONS FOR PRACTICE

The DASH, DASH-Sodium, and PREMIER studies have far-reaching implications for clinical practice and public health. If we compare

the blood pressure-lowering effects of the five antihypertensive medications used in the Veterans Affairs Cooperative study,[21] and of the DASH and DASH-Sodium diets (TABLE 3), it would appear that the diets lower blood pressure as much as the drugs do, at least when the drugs are used as monotherapy. For patients with hypertension, then, the DASH diet and other lifestyle changes can be recommended as an adjunct to pharmacologic treatment of hypertension.

The greatest benefits of the DASH diet and other nonpharmacologic therapies may accrue to people with prehypertension—blood pressure 120–139/80–89 mm Hg. Although drug treatment for this group is rarely indicated, adults with prehypertension have a 2.5-fold (men) and 1.6-fold (women) higher risk of a cardiovascular event than adults with optimal blood pressure.[22] Efforts to reduce the risk of cardiovascular disease in this group are worthwhile.

LIFESTYLE COUNSELING IN THE OFFICE

Given the well-known difficulty of changing one's lifestyle, patients wishing to adopt the DASH diet and make other lifestyle changes are likely to need support, which physicians are in a unique position to provide. The average American visits his or her health care provider 3.1 times a year,[23] the highest level of contact between any professional and the general public.

When patients visit their physicians, they are receptive to suggestions to make lifestyle changes,[24,25] and brief patient-provider conversations increase the chances that patients will comply with recommendations to reduce disease risk.[26]

But how does one implement a counseling program in a busy primary care clinic, where there are competing demands and severe time constraints?

Three levels of counseling

The United States Preventive Services Task Force[27] defines three levels of counseling to change diet and lifestyle behavior:

- **Brief** sessions last about 5 minutes and are typically delivered during a medical visit. Patients have reported that they have changed their habits as a result, but the long-term effects are unknown.[28]
- **Medium-intensity face-to-face** sessions consist of two or three group or individual sessions lasting for 30 minutes or more and are delivered by dietitians or specially trained primary care physicians or nurses.
- **High-intensity** counseling, similar to that in the PREMIER, study includes multiple sessions over periods of up to 6 years. Such intense counseling has the greatest impact on reducing disease risk.[29]

Brief counseling

The key role of the physician in a brief counseling session is to suggest lifestyle change as a means of managing elevated blood pressure and to guide the patient to self-help materials to accomplish this task.

Linkage to resources can be as simple as providing the Internet address of the NHLBI from which to download the brochure "Following the DASH Diet," ie, **www.nhlbi.nih.gov/health/public/heart/hbp/dash/index.htm**. This brochure provides guidelines on how to follow the DASH diet, including the servings and food groups for the eating plan and the number of servings appropriate to the patient's caloric needs. Multiple printed copies can be obtained at nominal cost from the NHLBI. Also available is the book *The DASH Diet for Hypertension*, which includes menus and recipes.

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Additional support might include office charts that illustrate the DASH diet in terms of the kinds of foods one might actually eat (TABLE 1), and more details can be found on the NHLBI Web site. Other patient information about making lifestyle changes can be found in **Ten tips to help you control your high blood pressure** (page 754).

Medium-intensity counseling

Medium-intensity counseling still involves the physician in his or her other role as a motivator, but counseling might be delivered by a trained staff member who may be a physician, nurse, or dietitian.

Like the more intense counseling formats, medium-intensity counseling aims to change behavior by using the principles of motivation.

Staff members should be trained in motivation assessment and enhancement techniques, such as evaluating the client's stage of change (ie, not thinking about changing one's lifestyle, thinking about changing, or in the process of making changes—counseling is different in each stage).[30,31] They also should be trained in motivational interviewing, a directive, patient-centered technique intended to help patients explore and resolve their ambivalence to change—an important part of getting patients ready to change their behavior.

The five A's of counseling

Successful interventions use the "five A's" framework. These steps are:

- **Assess** the patient's eating behavior and readiness to change. Short dietary assessments and screening tests are available for this purpose. Also, assess other factors that might interfere with attempts to make lifestyle changes.
- **Advise:** Provide clear, specific advice tailored to the patient. Emphasize the value of making lifestyle changes in controlling blood pressure.
- **Agree:** Make sure that you and the patient agree on the most appropriate target behavior to focus on, and the best method to achieve this behavior. Typically, the patient chooses a dietary goal (eg, increase fruit and vegetables) and creates an action plan for achieving this goal (eg, have a piece of fruit for breakfast).
- **Assist** the patient as he or she attempts to make changes. This includes, but is not limited to, giving patients tools and skills to monitor themselves and overcome barriers to behavioral change. Nutrition education is also provided, including information about serving sizes and tips on how to shop for and prepare food.
- **Arrange:** Schedule follow-up contacts to provide ongoing support and advice, adjust lifestyle goals as needed, and refer for intensive counseling if needed.

This counseling algorithm, combined with efficient clinic flow, can facilitate counseling.[31] For example, the patient may complete the dietary and stage-of-change assessment in the waiting room. The goal that the patient may have set in previous visits can be flagged to provide a counseling cue for the provider, and materials (eg, food preparation tips) associated with that visit may be assembled ahead of time.

Intense counseling

Intense counseling of the kind delivered in the PREMIER study has the highest impact on disease risk, but is not feasible in the office setting. Nevertheless, the provider can again play a critical role in motivating patients and preparing them for intense counseling through referrals, as well as provide ongoing motivation and support during office visits.

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