Diet quality and major chronic disease risk in men and women: moving toward improved dietary guidance[1–3]

Marjorie L McCullough, Diane Feskanich, Meir J Stampfer, Edward L Giovannucci, Eric B Rimm, Frank B Hu, Donna Spiegelman, David J Hunter, Graham A Colditz, and Walter C Willett

ABSTRACT

Background: Adherence to the Dietary Guidelines for Americans, measured with the US Department of Agriculture Healthy Eating Index (HEI), was associated with only a small reduction in major chronic disease risk. Research suggests that greater reductions in risk are possible with more specific guidance.

Objective: We evaluated whether 2 alternate measures of diet quality, the Alternate Healthy Eating Index (AHEI) and the Recommended Food Score (RFS), would predict chronic disease risk reduction more effectively than did the HEI.

Design: A total of 38 615 men from the Health Professional's Follow-up Study and 67 271 women from the Nurses' Health Study completed dietary questionnaires. Major chronic disease was defined as the initial occurrence of cardiovascular disease (CVD), cancer, or nontraumatic death during 8–12 y of follow-up.

Results: High AHEI scores were associated with significant reductions in risk of major chronic disease in men [multivariate relative risk (RR): 0.80; 95% CI: 0.71, 0.91] and in women (RR: 0.89; 95% CI: 0.82, 0.96) when comparing the highest and lowest quintiles. Reductions in risk were particularly strong for CVD in men (RR: 0.61; 95% CI: 0.49, 0.75) and in women (RR: 0.72; 95% CI: 0.60, 0.86). In men but not in women, the RFS predicted risk of major chronic disease (RR: 0.93; 95% CI: 0.83, 1.04) and CVD (RR: 0.77; 95% CI: 0.64, 0.93).

Conclusions: The AHEI predicted chronic disease risk better than did the RFS (or the HEI, in our previous research) primarily because of a strong inverse association with CVD. Dietary guidelines can be improved by providing more specific and comprehensive advice. *Am J Clin Nutr* 2002;76:1261–71.

KEY WORDS Diet, nutrition, diet patterns, Healthy Eating Index, Recommended Food Score, cardiovascular disease, cancer, chronic disease, disease prevention, men, women

INTRODUCTION

Cardiovascular disease (CVD) and cancer account for nearly two-thirds of all deaths in the United States (1). In addition to smoking and physical inactivity, diet is thought to play a major role in the development of these diseases (2, 3). Traditional eating patterns of various cultures around the world have been associated with reduced risk for chronic diseases (4, 5). However, little is known about the combined effect of multiple recommended dietary behaviors on overall chronic disease risk. Also, little is known about the ideal combination of dietary factors or the best way to assess adherence to dietary recommendations in a population.

Several organizations in the United States have issued dietary recommendations aimed at chronic disease prevention (2, 3, 6–9), and investigators have begun to evaluate their effects on disease risk and mortality (10–12). The most prominent dietary recommendations, the Dietary Guidelines for Americans and the food guide pyramid, represent the cornerstone of federal nutrition policy (13). Researchers at the US Department of Agriculture created the Healthy Eating Index (HEI) to measure adherence to these guidelines (14). Using a dietary score developed on the basis of the HEI, we reported recently that better adherence was associated with only a small reduction in risk of major chronic disease (fatal or nonfatal CVD or cancer, or nontraumatic death) (11, 12). Moderate inverse associations between the HEI score and disease risk were found for CVD, but we observed no reduction in cancer risk with higher HEI scores (11, 12). Several components of the Dietary Guidelines for Americans focus on lowering total serum cholesterol, so some reduction of CVD risk would be expected with better adherence (15, 16). However, a dietary index that includes additional protective factors related to development of CVD (17–19) (eg, factors that lower homocysteine concentrations, decrease LDL oxidation, reduce platelet aggregation, or improve the ratio of total to HDL cholesterol) may predict risk more accurately. Less is known about specific aspects of diet that may help reduce cancer risk (20). Nevertheless, an index that takes into account risk factors for certain cancers (eg, intakes of red meat and folic acid), in addition to increased fruit and vegetable intakes, may also predict lower cancer risk.

In an attempt to improve the original HEI, we created a 9-component Alternate Healthy Eating Index (AHEI); it is designed to target food choices and macronutrient sources associated with reduced chronic disease risk (4, 5, 21–24). Recently, Kant et al

[1] From the American Cancer Society, Atlanta (MLM); the Departments of Nutrition (MJS, ELG, EBR, FBH, DJH, GAC, and WCW), Epidemiology (MJS, ELG, EBR, DS, DJH, and WCW), and Biostatistics (DS), Harvard School of Public Health, Boston; and the Channing Laboratory, Department of Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston (DF, MJS, ELG, EBR, DJH, GAC, and WCW).

[2] Supported by research grants HL 35464 and CA87969 from the National Institutes of Health.

[3] Address reprint requests to ML McCullough, Epidemiology and Surveillance Research, American Cancer Society, 1599 Clifton Road, NE, Atlanta, GA 30329. E-mail: mmccullo@cancer.org.

Received November 16, 2001.

Accepted for publication January 16, 2002.

(10) reported that the Recommended Food Score (RFS), the sum of recommended foods consumed at least weekly, predicted a 30% lower risk of death in a cohort of >40 000 women. The RFS is a simple summary of healthy foods listed on the dietary questionnaire, and thus it would be an efficient way to assess diet quality in populations. To determine whether either of these alternative scores (AHEI or RFS) represents an improvement over the original HEI score for predicting major chronic disease risk, we assessed their predictive ability in the large populations of men and women that we had studied previously.

SUBJECTS AND METHODS

Study populations

We analyzed data collected from 2 large cohorts. In 1986, 51 529 men aged 40–75 y enrolled in The Health Professional's Follow-up Study (HPFS), a prospective investigation of dietary etiologies of heart disease and cancer (12). In 1976, 121 700 female nurses aged 30–55 y enrolled in the Nurses' Health Study (NHS) (11). In 1984, 81 757 of these women completed an extensive food-frequency questionnaire (FFQ). Participants with previously diagnosed heart disease, cancer, or chronic renal failure were excluded at baseline so that the follow-up would begin with healthy cohorts and because these conditions may have led to recent alterations in diet. Men and women who did not respond to the baseline FFQ or who reported an implausible dietary intake were also excluded. The final analytic cohorts included 38 615 men and 67 271 women. At baseline, participants provided information on age, weight, height, smoking, physical activity, and family history of CVD and cancer. Every 2 y, we sent follow-up questionnaires to obtain up-to-date information on risk factors and to identify newly diagnosed diseases; most of the dietary information was updated every 4 y.

This study was approved by the committees for the protection of human subjects at the Harvard School of Public Health and the Brigham and Women's Hospital. Participants were provided with a written description of the study, and return of the questionnaire was deemed to indicate consent.

Dietary assessment

Dietary intake data were collected from men in 1986 and 1990 and from women in 1984, 1986, and 1990. The instrument used was a semi-quantitative FFQ containing ≈130 questions (which varied slightly from year to year) and accounting for >90% of the intake of most nutrients (25). For each item, a common serving size of the food or beverage was specified (eg, 1/2 cup carrots or 2 slices of bacon) and participants were asked how often, on average, they consumed this amount during the previous year. They selected from 9 possible frequency responses ranging from "never or less than once per month" to "6 or more times per day." We also collected information on types of fats and oils used in cooking, brands of cold cereal typically consumed, and brands and frequency of consumption for multivitamin supplements. We computed nutrient intakes by multiplying the consumption frequency for each food by its nutrient content (for specified portions) and then summing nutrient contributions from all foods. Nutrient values were obtained from the Harvard University Food Composition Database, which was derived from US Department of Agriculture sources (26, 27) and supplemented with information from food manufacturers and published research. The validity and reliability of this FFQ in terms of nutrient and food consumption have been documented in detail (25, 28–32).

The Alternate Healthy Eating Index

We calculated an AHEI score from each completed FFQ. The AHEI incorporates several aspects of the original HEI (14), and therefore some components correspond to existing dietary guidelines (eg, to increase fruit and vegetable intakes). The AHEI also provides quantitative scoring for qualitative dietary guidance (eg, choose more fish, poultry, and whole grains, and if you drink alcohol, do so in moderation). AHEI variables were chosen and scoring decisions were made a priori, on the basis of discussions with nutrition researchers. We sought to capture specific dietary patterns and eating behaviors that have been associated consistently with lower risk for chronic disease in clinical and epidemiologic investigations.

As shown in **Table 1**, 8 of the 9 components (eg, vegetables, *trans* fat) of the AHEI each contributed 0–10 points to the total score; a score of 10 indicates that the recommendations were fully met, whereas a score of 0 represents the least healthy dietary behavior. Intermediate intakes were scored proportionately between 0 and 10. The multivitamin component was dichotomous, contributing either 2.5 points (for nonuse) or 7.5 points (for use). All component scores were summed to obtain a total AHEI score ranging from 2.5 (worst) to 87.5 (best). The rationale for including each component and the criteria for assigning the minimum and maximum scores are described in Table 1.

To calculate an AHEI score from each completed FFQ, food items listed on the FFQ were assigned to their appropriate food groups (using the serving sizes identified on the FFQ). Values for *trans* fat, the ratio of polyunsaturated to saturated fatty acids (P:S), and cereal fiber were calculated from our nutrient database.

The Recommended Food Score

The RFS was originally developed by Kant et al (10); they used a 62-item FFQ that included 23 different recommended foods. Participants received 1 point for each of the recommended foods that they consumed at least weekly. Points were then summed to obtain a score ranging from 0 to 23. Consistent with Kant et al (10), we calculated the RFS by summing the recommended foods on our FFQs that were consumed at least weekly. Because our dietary questionnaire was longer, the highest possible RFS score ranged from 49 to 56 in the different years of the HPFS and NHS. In **Appendix A**, the recommended foods that contributed to the RFS score are listed for each follow-up FFQ in the NHS and HPFS.

Outcome ascertainment

The primary endpoint for this study, major chronic disease, was defined as the initial occurrence of CVD or cancer or non-trauma-related death. We also examined the associations of the scores with CVD and cancer risk separately.

For this study, CVD was defined as fatal or nonfatal myocardial infarction, fatal or nonfatal stroke, or sudden death. We asked all men and women who reported incident myocardial infarction or stroke on their biennial questionnaires to confirm the report and to provide permission for review of their medical records. Study physicians, who were blinded to risk factor status, reviewed the records and confirmed the diagnosis of myocardial infarction by using World Health Organization criteria (69). Strokes were confirmed if characterized by a typical neurologic defect of sudden or rapid onset, lasting ≥24 h and attributable to a cerebrovascular event (70). Sudden death was defined as death occurring within 1 h of the onset of symptoms in a person with no previous serious

TABLE 1
Alternate Healthy Eating Index (AHEI) scoring method and total scores at baseline for men and women[1]

Component	Criteria for minimum score of 0[2]	Criteria for maximum score of 10[2]	AHEI scores for men in 1986	AHEI scores for women in 1984	Rationale for including each component
Vegetables (servings/d)	0	5	6.1 ± 2.6[3]	5.6 ± 2.4	Vegetable consumption has been associated with reduced chronic disease risk (3, 33, 34). All vegetables on the FFQ were included, except potatoes (including French fries) because they have not been associated with reduced chronic disease risk in epidemiologic studies (35–37) and have a high glycemic index (38). We considered 5 servings of vegetables/d as ideal, reflecting the upper range of current dietary guidelines and consistent with intervention studies of intermediate CVD risk factors (33).
Fruit (servings/d)	0	4	5.5 ± 2.9	5.1 ± 2.7	Fruit consumption has been associated with reductions in CVD (33, 39) and cancer risk (3, 35). We considered 4 servings/d to be ideal, consistent with the upper range of current dietary guidelines.
Nuts and soy protein (servings/d)	0	1	4.7 ± 3.4	2.8 ± 3.0	Nuts and vegetable protein (eg, tofu) are 2 important sources of protein in vegetarian diets, and have been associated with lower rates of CVD (40, 41); their relation to cancer is inconclusive (42). A combined average of 1 serving/d was considered ideal.
Ratio of white to red meat	0	4	3.7 ± 3.2	3.2 ± 2.7	White meat was defined as poultry or fish, whereas beef, pork, lamb, and processed meats were considered red meat. Fish and poultry have been associated with lower rates of CHD and cancer (43, 44) and their intermediate markers of health status (45), whereas consumption of red meat, in particular processed meats (46), has been associated with increased risk of certain cancers (47–49). Gram quantities were summed and used in calculating the ratio. An ideal score of 10 was given for ratios ≥4:1. This value was chosen arbitrarily but is practical and consistent with patterns in healthy populations. Vegetarians (<0.5% of men and women), and those consuming red meat <2 times/mo were given a score of 10.
Cereal fiber (g/d)	0	15	4.5 ± 2.2	3.4 ± 1.8	Fiber from grain sources has been associated with reduced risk of CHD (50–52) and stroke (53); the association with cancer risk is less clear (54, 55). We considered 15 g cereal fiber/d as ideal on the basis of epidemiologic studies and the distribution in our cohorts.
trans Fat (% of energy)	≥4	≤0.5	7.8 ± 1.4	6.0 ± 1.7	*trans* Isomers of fatty acids, formed by partial hydrogenation of vegetable oils to produce margarines and vegetable shortening, raise serum LDL concentrations, lower HDL concentrations (56), and are associated with CHD (57, 58). We considered a *trans* fatty acid intake of ≤0.5% of total energy to be ideal, whereas ≥4% was assigned the lowest score.
P:S	≤0.1	≥1	5.2 ± 2.0	5.0 ± 1.8	A higher P:S has generally been associated with lower CHD risk (17), although n−3 and n−6 polyunsaturated fatty acids have different metabolic effects (19) and individual saturated fatty acids differ in their ability to raise serum total or LDL cholesterol (59). We considered a P:S ≥ 1 to be ideal. A ratio ≤0.1 was least optimal.
Duration of multivitamin use[4]	<5 y	≥5 y	3.7 ± 2.2	3.4 ± 1.9	Multivitamins provide folate, vitamin B-6, and other nutrients. In several studies, long-term folate intakes most feasible with supplement use have been associated with reduction in risk of both CHD and cancer (60–62). This is the only variable of the index that is not continuous. To avoid overweighting the score from this component, we gave participants who had used multivitamins for ≥5 y a score of 7.5 (best) and gave all others a score of 2.5.
Alcohol (servings/d)[5]	Men: 0 or >3.5 Women: 0 or >2.5	Men: 1.5–2.5 Women: 0.5–1.5	3.8 ± 3.2	3.9 ± 4.1	We defined moderate alcohol consumption of 1.5–2.5 drinks/d as ideal for men and 0.5–1.5 drinks/d as ideal for women on the basis of the substantially lower risk of CVD associated with moderate intake (23, 63–66). Although higher intakes may be related to even lower rates of CVD, high intakes are associated with increased cancer rates (67, 68) and have other health and social implications such as alcoholism and alcohol-related injuries.
Total score (range)	2.5	87.5	45.0 ± 11.1 (8.8–86.0)	38.4 ± 10.3 (9.8–83.6)	

[1] FFQ, food-frequency questionnaire; CVD, cardiovascular disease; CHD, coronary heart disease; P:S, ratio of polyunsaturated to saturated fatty acids.
[2] Intermediate intakes were scored proportionately between 0 and 10.
[3] $\bar{x}$ ± SD.
[4] For multivitamins, the minimum score was 2.5 and the maximum score was 7.5.
[5] Beer, wine, and liquor.

illness, if no more plausible cause than coronary heart disease could be found. Incident cases of nonfatal myocardial infarction and nonfatal stroke also included events which required hospitalization but for which the hospital records could not be obtained.

Study physicians confirmed the cancer diagnoses on the basis of a blinded review of the medical records. Of the confirmed cases, 10–15% were not confirmed on the basis of medical records, but rather because of other evidence (eg, death certificates). We included all confirmed cancers except nonmelanoma skin cancer and low-grade, organ-confined prostate cancer (stage A or B and Gleason grade < 7) because of the relatively low mortality from these highly prevalent lesions.

We included deaths, except those resulting from external causes (eg, injuries and suicides), in the composite major chronic disease endpoint. Deaths were reported by next of kin, coworkers, or postal authorities or were ascertained by searching the National Death Index for participants who did not respond (71). Nonresponding participants were assumed to be alive if they were not listed in the National Death Index. We attempted to confirm each cause of death, including fatal myocardial infarction, stroke, and cancer, by reviewing medical records or autopsy reports.

Statistical analyses

Each participant contributed follow-up time lasting from the return of his or her baseline questionnaire until the date of CVD, cancer, or death, or until February 1, 1994 for men or June 1, 1996 for women. During the course of the study, confirmed cases were excluded from subsequent follow-up; thus, the cohort at risk included only those free of disease at the beginning of each 2-y follow-up interval. For the major chronic disease endpoint, each person could contribute only one diagnosed CVD, cancer, or other-cause-of-death endpoint to the analysis (whichever came first). Overall follow-up, on the basis of eligible person years, was > 95% complete for both men and women.

Quintiles of the AHEI score and RFS were defined by using a cumulative average scoring method (72). This method optimizes the use of repeated dietary questionnaires. For example, in men, the 1986 AHEI score was used to predict outcomes between 1986 and 1990, and an average of the 1986 and 1990 AHEI scores was related to outcomes between 1990 and 1994. If no questionnaire was completed in 1990, the 1986 AHEI score was carried forward. We did not update dietary data for participants who had a new diagnosis of angina, hypercholesterolemia, diabetes, or hypertension because potential changes in diet as a result of these diagnoses may confound the association between diet and disease.

We calculated relative risk (RR) as the incidence rate of major chronic disease among participants in each quintile of the diet quality scores divided by the incidence rate for those in the lowest quintile, adjusted for age. To adjust simultaneously for several risk factors, we used pooled logistic regression (73), which accounts for changes in covariates over time and has been shown to provide a close approximation to Cox proportional hazard analysis (74). A trend test was computed by using the median values for quintiles modeled as a single continuous variable.

In the multivariate models, we included covariates that are known to be major determinants of health. These included age, leisure-time physical activity (in metabolic equivalents), cigarette smoking, body mass index (in kg/m^2), total energy intake, and in women, postmenopausal hormone use. The same baseline exclusions were used for each outcome (ie, major chronic disease, CVD, and cancer), and the same covariates were included in the final models. However, there were several exceptions: hypercholesterolemia and hypertension were included as covariates only in the CVD and major chronic disease models, vitamin E was included only in the CVD models, and multivitamin use was included only in the CVD model for the RFS analysis (the AHEI score already included multivitamin use). All reported *P* values are two-sided. Statistical analyses were performed with SAS, version 6.12 (SAS Institute Inc, Cary, NC).

RESULTS

During the period 1986–1994, we documented 3119 major chronic disease endpoints in men, including 1092 CVD events, 1661 cancers, and 366 deaths not resulting from CVD or cancer. In women, 7077 chronic disease endpoints occurred from 1984 to 1996; these included 1365 CVD events, 5216 cancers, and 496 deaths not resulting from CVD or cancer.

Mean AHEI scores at baseline for men and women are shown in Table 1. The mean baseline score for men was 45.0 ± 11.1 (range: 8.8–86.0). Women had a slightly lower mean score of 38.4 ± 10.3 (range: 9.8–83.6). The mean baseline RFS was 17.7 ± 7.3 (range: 0–51) for men and 17.3 ± 6.9 (range: 0–47) for women.

Tables 2 and **3** show age-standardized characteristics of the men and women at baseline according to AHEI and RFS quintiles. Both scores were associated with healthy lifestyle behaviors in men and women. Participants with higher scores were less likely to smoke, were slightly older, and exercised more. Those with higher AHEI and RFS scores also reported higher energy intakes, most likely in part because of greater physical activity. Dietary variables that contributed to the AHEI score increased or decreased in the expected direction with increasing AHEI quintile. We observed similar qualitative findings across RFS quintiles, although the ranges of these dietary factors between the higher and lower RFS quintiles were not as large as for the AHEI score. Alcohol intake, multivitamin use, body mass index, and P:S did not vary appreciably according to RFS quintile.

The associations of both the AHEI score and RFS with risk of major chronic disease, CVD, and cancer in men are shown in **Table 4**. After adjusting for age only, men in the highest AHEI quintile had a RR of 0.70 for major chronic disease (95% CI: 0.63, 0.79) compared with men in the lowest quintile. Controlling for smoking and other known risk factors in a multivariate adjusted analysis attenuated the association, but a moderate inverse relation with overall major chronic disease risk remained (RR = 0.80; 95% CI: 0.71, 0.91; $P < 0.001$). The RFS also predicted disease in age-adjusted analyses (for highest quintile compared with lowest quintile: RR = 0.79; 95% CI: 0.71, 0.88; $P < 0.001$). However, controlling for other risk factors and confounders in the multivariate adjusted analysis attenuated the relationship (RR = 0.93; 95% CI: 0.83, 1.04; $P = 0.02$).

Both the AHEI score and RFS were more strongly associated with risk of CVD than with risk of cancer. After adjusting for other risk factors in the multivariate adjusted analysis, men in the highest quintile of AHEI scores had a 39% lower risk of CVD than did men in the lowest quintile (RR = 0.61; 95% CI: 0.49, 0.75), whereas men in the highest quintile of RFS had a 23% reduction in CVD risk (RR = 0.77; 95% CI: 0.64, 0.93). Neither score predicted cancer risk, after multivariate adjustment. Results were similar when body mass index was not included in the model. We did not examine other causes of death separately, because this smaller category was comprised largely of respiratory disease, for which important dietary associations have not been established.

TABLE 2
Age-standardized baseline characteristics of men in the Health Professional's Follow-up Study according to Alternate Healthy Eating Index (AHEI) score and Recommended Food Score (RFS) quintiles[1]

	AHEI quintile					RFS quintile				
	1	2	3	4	5	1	2	3	4	5
Median score	31 (8.8–35.2)[2]	38.5 (35.3–41.5)	44.4 (41.6–47.4)	50.1 (47.5–54.5)	59.9 (54.6–86.0)	9 (0–11)	14 (12–15)	17 (16–19)	21 (20–23)	27 (24–51)
Age (y)	51.8[3]	52.4	53.0	53.4	54.0	53.9	54.7	54.8	55.1	55.2
BMI (in kg/m^2)	25.9	25.7	25.5	25.3	24.8	25.6	25.6	25.4	25.4	25.4
Total energy (kcal)	1696	1887	2016	2132	2280	1672	1872	2002	2109	2335
Current smoker (%)	16	12	9	7	5	16	12	9	8	6
Physical activity (METs/d)[4]	14	17	19	23	29	16	18	20	22	26
Vegetables (servings/d)	1.9	2.5	3.2	3.8	4.9	1.8	2.6	3.2	3.8	5.0
Fruit (servings/d)	1.2	1.8	2.3	2.8	3.7	1.3	1.8	2.3	2.8	3.6
Nuts and tofu (servings/d)	0.2	0.3	0.6	0.8	1.1	0.4	0.5	0.6	0.7	0.8
White meat:dark meat	0.7	1.1	1.7	2.5	5.6	1.4	1.8	2.2	2.7	3.3
Cereal fiber (g/d)	5.0	6.1	6.9	7.6	9.0	5.3	6.4	7.0	7.5	8.3
Alcohol (servings/d)	0.7	0.9	0.9	0.9	1.0	0.9	0.9	0.9	0.9	0.8
P:S	0.3	0.4	0.5	0.5	0.7	0.4	0.4	0.5	0.5	0.5
trans Fat (% of energy)	1.6	1.4	1.3	1.1	0.9	1.4	1.3	1.3	1.2	1.1
Multivitamin use for >5 y (%)	9	17	23	31	45	21	24	24	25	28

[1] Values are directly age standardized to the distribution of the 38 615 men eligible for the analyses. All *P* values for trends across quintiles are <0.001. P:S, ratio of polyunsaturated to saturated fatty acids.
[2] Range in parentheses.
[3] $\bar{x}$.
[4] Metabolic equivalents (METs) are defined for each type of physical activity as a multiple of the MET of sitting quietly for 1 h.

The associations of both the AHEI score and RFS with risk of major chronic disease, CVD, and cancer in women are shown in **Table 5**. Overall, the findings were weaker than those for men. The AHEI score predicted a weak but significant reduction in major chronic disease risk in our multivariate models (RR = 0.89; 95% CI: 0.82, 0.96; $P = 0.008$). AHEI scores in the highest quintile compared with the lowest quintile were associated with a 28% lower risk of CVD in women (RR = 0.72; 95% CI: 0.60, 0.86; $P < 0.001$). As with men, we observed no significant associations between AHEI score and cancer risk. All models evaluating the RFS in women were nonsignificant after multivariate adjustment.

Because alcohol consumption is associated with increased risk of injury-related death, we conducted the AHEI analyses in men and women with traumatic deaths included in the major chronic disease outcome. We also determined the AHEI score excluding

TABLE 3
Age-standardized baseline characteristics of women in the Nurses' Health Study according to Alternate Healthy Eating Index (AHEI) score and Recommended Food Score (RFS) quintiles[1]

	AHEI quintile					RFS quintile				
	1	2	3	4	5	1	2	3	4	5
Median score	25.4 (9.8–29.3)[2]	32.3 (29.4–35.0)	37.7 (35.1–40.4)	43.5 (40.5–47.0)	52.3 (47.1–83.6)	9 (0–11)	14 (12–15)	17 (16–18)	21 (19–23)	27 (24–47)
Age (y)	49.4[3]	49.9	50.4	51.1	51.8	49.5	50.1	50.5	50.9	51.5
BMI (in kg/m^2)	25.3	25.0	24.9	24.6	24.0	24.7	24.8	24.9	25.0	25.0
Total energy (kcal)	1538	1704	1745	1897	2041	1447	1633	1748	1860	2069
Current smoker (%)	31	25	22	19	16	34	26	23	19	18
Physical activity (METs/d)[4]	10	12	14	16	20	10.9	12.5	14.0	15.3	18.7
Vegetables (servings/d)	2.0	2.7	3.1	3.7	4.6	1.7	2.4	2.9	3.4	4.4
Fruit (servings/d)	1.3	1.9	2.3	2.8	3.5	1.1	1.7	2.1	2.5	3.4
Nuts and tofu (servings/d)	0.1	0.2	0.3	0.4	0.7	0.2	0.3	0.3	0.3	0.4
White meat:dark meat	0.7	1.1	1.5	2.0	3.1	1.1	1.3	1.4	1.6	1.9
Cereal fiber (g/d)	4.1	4.9	5.4	6.0	6.6	4.1	4.8	5.2	5.6	6.4
Alcohol (servings/d)	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.5	0.5
P:S	0.4	0.4	0.5	0.5	0.6	0.5	0.5	0.6	0.6	0.6
trans Fat (% energy)	2.2	2.0	1.9	1.7	1.5	2.1	2.0	1.9	1.9	1.7
Multivitamin use for >5 y (%)	13	17	19	22	27	16	18	18	19	22

[1] Values are directly age standardized to the distribution of the 67 271 women eligible for the analyses. All *P* values for trends across quintiles are <0.001. P:S, ratio of polyunsaturated to saturated fatty acids.
[2] Range in parentheses.
[3] $\bar{x}$.
[4] Metabolic equivalents (METs) are defined for each type of physical activity as a multiple of the MET of sitting quietly for 1 h.

TABLE 4
Relative risk (RR) and 95% CIs of major chronic disease, cardiovascular disease (CVD), and cancer in men according to Alternate Healthy Eating Index (AHEI) scores and Recommended Food Scores (RFS)

	Quintiles of index scores					
	1	2	3	4	5	*P* for trend[1]
Major chronic disease[2]						
AHEI						
n	704	672	634	568	541	
Age-adjusted RR	1.0	0.91 (0.82, 1.01)	0.83 (0.74, 0.92)	0.72 (0.65, 0.81)	0.70 (0.63, 0.79)	<0.001
Multivariate-adjusted RR[3]	1.0	0.96 (0.86, 1.07)	0.88 (0.79, 0.99)	0.79 (0.71, 0.89)	0.80 (0.71, 0.91)	<0.001
RFS						
n	712	665	615	510	617	
Age-adjusted RR	1.0	0.90 (0.81, 1.00)	0.78 (0.70, 0.87)	0.74 (0.66, 0.83)	0.79 (0.71, 0.88)	<0.001
Multivariate-adjusted RR[3]	1.0	0.97 (0.87, 1.07)	0.88 (0.79, 0.97)	0.83 (0.75, 0.93)	0.93 (0.83, 1.04)	0.016
CVD[4]						
AHEI						
n	298	246	233	197	165	
Age-adjusted RR	1.0	0.80 (0.68, 0.95)	0.73 (0.61, 0.87)	0.61 (0.51, 0.73)	0.52 (0.43, 0.63)	<0.001
Multivariate-adjusted RR[3]	1.0	0.85 (0.71, 1.00)	0.79 (0.66, 0.95)	0.67 (0.56, 0.81)	0.61 (0.49, 0.75)	<0.001
RFS						
n	282	247	228	171	211	
Age-adjusted RR	1.0	0.85 (0.72, 1.01)	0.75 (0.63, 0.89)	0.64 (0.53, 0.78)	0.69 (0.58, 0.83)	<0.001
Multivariate-adjusted RR[3]	1.0	0.88 (0.73, 1.02)	0.80 (0.68, 0.94)	0.69 (0.58, 0.83)	0.77 (0.64, 0.93)	<0.001
Cancer[5]						
AHEI						
n	328	367	343	321	337	
Age-adjusted RR	1.0	1.08 (0.93, 1.25)	0.97 (0.83, 1.13)	0.88 (0.76, 1.03)	0.95 (0.81, 1.10)	0.12
Multivariate-adjusted RR[3]	1.0	1.10 (0.94, 1.28)	0.99 (0.85, 1.16)	0.94 (0.80, 1.10)	1.03 (0.87, 1.22)	0.66
RFS						
n	347	362	334	295	358	
Age-adjusted RR	1.0	1.01 (0.87, 1.17)	0.88 (0.76, 1.02)	0.89 (0.76, 1.04)	0.95 (0.82, 1.10)	0.29
Multivariate-adjusted RR[3]	1.0	1.05 (0.92, 1.20)	0.95 (0.84, 1.09)	0.95 (0.83, 1.10)	1.08 (0.94, 1.25)	0.79

[1] Test for trend over quintiles of index scores with use of the median value per quintile.
[2] Defined as CVD (n = 1092), cancer (n = 1661), or death (n = 366), whichever came first.
[3] Adjusted for age (5-y categories), smoking (never, past, 1–14 cigarettes/d, 15–24 cigarettes/d, >25 cigarettes/d), time period, body mass index (quintiles), physical activity (6 categories of metabolic equivalents), total energy intake (quintiles), and, in all except the cancer models, history of hypertension or hypercholesterolemia at baseline. The CVD models include vitamin E and multivitamin supplement use for RFS and vitamin E for AHEI.
[4] Defined as fatal or nonfatal myocardial infarction or stroke or sudden death.
[5] Defined as all cancers except nonmalignant skin cancers and nonaggressive prostate cancers.

the alcohol component because many people do not consume alcohol. These changes had no significant effect on the association between the AHEI score and risk of major chronic disease (data not shown). In men, the inverse association between AHEI score and CVD risk was not as strong without alcohol in the analyses (RR = 0.64; 95% CI: 0.52, 0.79), but in women the association was unchanged (RR = 0.71; 95% CI: 0.59, 0.85).

In a further analysis, we included the original HEI score and the AHEI score or RFS simultaneously as continuous terms in the multivariate model for major chronic disease. When the HEI and AHEI scores were included in the same model, the AHEI score was significantly related to lower risk of major chronic disease (P = 0.005 for men and P = 0.01 for women), whereas the HEI score was not. In men, when the HEI and RFS were included in the same model, the RFS was not associated with risk but the HEI score was related to significantly lower risk. In women, neither the HEI score nor the RFS was significantly associated with risk when they were both included in the analysis. When all 3 scores were included simultaneously, the AHEI was significantly associated with reduction in major chronic disease risk in both men and women, whereas the other 2 scores were not.

DISCUSSION

In these 2 large prospective cohorts, men and women whose diets matched the AHEI goals most closely had a 20% and 11% lower risk of major chronic disease, respectively. This overall relation was mostly attributable to a strong reduction in CVD risk: men and women scoring highest on the AHEI had a 39% and 28% lower risk of CVD compared with those with lowest scores. The association of the RFS with all outcomes was weaker and was generally similar to our previous findings with the original HEI. Neither the AHEI nor the RFS predicted cancer risk in men or women.

In several European and US cohorts (10–12, 75), adherence to the dietary guidelines has been more strongly related to coronary heart disease mortality than to cancer mortality, even when those guidelines are directed toward lowering cancer risk (76). Because associations with mortality endpoints could reflect the effects of diet on survival after diagnosis, in addition to disease incidence, the implications about the role of diet in disease prevention are less clear. Also, associations of diet with mortality could be confounded by differences in practices related to diagnosis, choice of treatment, and compliance with treatment that are typically not

TABLE 5
Relative risk (RR) and 95% CIs of major chronic disease, cardiovascular disease (CVD), and cancer in women according to Alternate Healthy Eating Index (AHEI) scores and Recommended Food Scores (RFS)

	Quintiles of index scores					
	1	2	3	4	5	*P* for trend[1]
Major chronic disease[2]						
AHEI						
n	1483	1429	1361	1437	1367	
Age-adjusted RR	1.0	0.92 (0.85, 0.99)	0.85 (0.79, 0.92)	0.86 (0.80, 0.92)	0.78 (0.72, 0.84)	<0.001
Multivariate-adjusted RR[3]	1.0	0.97 (0.90, 1.04)	0.92 (0.85, 0.99)	0.95 (0.88, 1.02)	0.89 (0.82, 0.96)	0.009
RFS						
n	1549	1385	1356	1389	1398	
Age-adjusted RR	1.0	0.89 (0.83, 0.96)	0.89 (0.83, 0.96)	0.90 (0.84, 0.97)	0.84 (0.78, 0.91)	<0.001
Multivariate-adjusted RR[3]	1.0	0.95 (0.88, 1.03)	0.98 (0.90, 1.05)	1.02 (0.94, 1.10)	0.98 (0.90, 1.06)	0.89
CVD[4]						
AHEI						
n	356	322	267	251	231	
Age-adjusted RR	1.0	0.85 (0.73, 0.98)	0.67 (0.58, 0.79)	0.59 (0.50, 0.69)	0.52 (0.44, 0.61)	<0.001
Multivariate-adjusted RR[3]	1.0	0.95 (0.82, 1.11)	0.80 (0.68, 0.94)	0.75 (0.63, 0.89)	0.72 (0.60, 0.86)	<0.001
RFS						
n	343	292	249	281	262	
Age-adjusted RR	1.0	0.84 (0.72, 0.98)	0.71 (0.60, 0.84)	0.79 (0.68, 0.93)	0.68 (0.58, 0.80)	<0.001
Multivariate-adjusted RR[3]	1.0	0.95 (0.81, 1.12)	0.85 (0.72, 1.01)	1.02 (0.86, 1.20)	0.90 (0.75, 1.08)	0.45
Cancer[5]						
AHEI						
n	1040	1009	1036	1104	1087	
Age, adjusted RR	1.0	0.93 (0.86, 1.02)	0.94 (0.86, 1.02)	0.96 (0.88, 1.05)	0.91 (0.83, 0.99)	0.11
Multivariate-adjusted RR[3]	1.0	0.95 (0.87, 1.04)	0.97 (0.89, 1.06)	1.00 (0.92, 1.10)	0.97 (0.88, 1.06)	0.92
RFS						
n	1102	999	1054	1053	1068	
Age-adjusted RR	1.0	0.91 (0.84, 0.99)	0.98 (0.90, 1.07)	0.97 (0.89, 1.06)	0.92 (0.85, 1.01)	0.28
Multivariate-adjusted RR[3]	1.0	0.94 (0.86, 1.03)	1.03 (0.95, 1.13)	1.04 (0.95, 1.13)	1.00 (0.92, 1.11)	0.39

[1] Test for trend over quintiles of index scores with use of the median value per quintile.
[2] Defined as CVD (n = 1365), cancer (n = 5216), or death (n = 496), whichever came first.
[3] Adjusted for age (5-y categories), smoking (never, past, 1–14 cigarettes/d, 15–24 cigarettes/d, >25 cigarettes/d), time period, body mass index (quintiles), physical activity (6 categories of metabolic equivalents), total energy intake (quintiles), postmenopausal hormone use, and, in all except the cancer models, history of hypertension or hypercholesterolemia at baseline. The CVD models include vitamin E and multivitamin supplement use for RFS and vitamin E for AHEI.
[4] Defined as fatal or nonfatal myocardial infarction or stroke or sudden death.
[5] Defined as all cancers except nonmalignant skin cancers and in-situ breast cancers.

measured. This might explain why the RFS more strongly predicted total mortality in a cohort of women (10) than incident chronic disease in our cohorts of men and women.

Our results are directly comparable to our earlier analyses using the original HEI (a measure of adherence to the Dietary Guidelines for Americans), in which we studied the same populations during the same follow-up period. The AHEI was nearly twice as predictive of overall chronic disease risk as was the HEI, in which the overall risk was 11% lower among men and 3% lower among women in the highest quintile compared with the lowest quintile (11, 12). Most of the additional reduction in risk in the current study resulted from reduction in risk of CVD. Therefore, capturing dietary choices (eg, white versus red meat), fat quality (P:S, *trans* fat intake), and other behaviors (multivitamin use) predicted improved health outcome. Because some components of the AHEI were already known to be protective in this cohort (40, 50, 65), the revisions might be viewed as post hoc and should be tested in one or more independent study populations. However, associations between components of the AHEI and chronic disease have been observed in other epidemiologic studies and have a strong biological justification. Moreover, we used arbitrary scales primarily developed on the basis of external criteria and we avoided the use of regression coefficients derived from this population in creating the index.

All AHEI diet components have putative protective associations with CVD, but only about half have been associated with cancer reduction (eg, fruit intake, vegetable intake, white meat:dark meat, and multivitamin use). Therefore, it was not surprising that the score was more predictive of CVD risk than cancer risk. Moreover, the CVD outcome is more homogenous than is the cancer outcome, because the dietary factors associated with different cancer sites vary substantially. Although it may not be appropriate from an etiologic standpoint to pool all cancers together, it is useful to examine such overall relations from a public health perspective.

The relation of the RFS with chronic disease risk is heavily weighted toward reported fruit and vegetable intakes; these foods comprise 65% of the recommended foods in the study of Kant et al (10) and 75% in our study. Our findings suggest that including additional dietary behaviors may improve the ability of the RFS to predict incident disease.

The men and women in these cohorts are well educated and of relatively homogenous socioeconomic status. Most of the participants are white. This homogeneity has the advantage of reducing confounding

by variables related to socioeconomic status that are difficult to control. Intakes of protective dietary factors, such as antioxidants, in this population may be sufficient, and therefore higher consumption (from fruit and vegetables) might not reduce risk further (77). For some major cancers, death rates vary by race and socioeconomic status, although it is unclear how much of this is related to differences in access to health care and screening. Associations with cancer might be stronger in a population that is less well educated or of lower socioeconomic status. However, the strong associations found for CVD indicate that even within this well educated population, the diets of many men and women are far from optimal.

When assessing dietary intakes, measurement error generally leads to underestimation of associations. The relations of the AHEI score and RFS with protection against CVD may be even stronger than the results indicate, and a modest, underlying association with cancer could have been obscured. We did not incorporate information on cooking practices, such as doneness of meat, which could capture exposure to carcinogenic heterocyclic amines (78). Although cruciferous vegetables and plant foods high in certain antioxidants may be particularly related to protection from different types of cancer (77, 79, 80), we chose to be consistent with more general recommendations for fruit and vegetable intakes. Pooling all vegetables together in this way may mask subtle and interactive protective effects of specific plant foods against certain cancers, and thus may limit our ability to detect associations. Moreover, temporal relations between dietary intake and risk of cancer are much less clear than are such relations for CVD (17).

Prostate cancer is the major cancer diagnosed in the Health Professionals' Follow-up Study (≈25% of cancers in this analysis, which included only aggressive prostate cancer). Prostate cancer is known to be a slowly progressing disease (42). Several studies suggest that diet is a key factor in its etiology, and particular aspects of diet may play a role in the later stages of prostate cancer progression (42, 79, 81–84). Other than red meat, none of the dietary factors found to be predictive of prostate cancer in the initial analyses in this cohort (eg, calcium, tomato sauces, or fructose) are emphasized in the AHEI score. Likewise, breast cancer accounts for 40% of the cancers in women, and few dietary factors have been found to strongly predict reduced risk.

In summary, the dietary pattern represented by the AHEI predicted lower incidence of major chronic disease in men and women and was related to important reductions in CVD risk. These associations are stronger than our earlier findings with the original HEI and suggest that simple improvements to the dietary guidelines may reduce the risk of major chronic disease. Although the Dietary Guidelines for Americans were updated recently with some improvements (85), the HEI and the food guide pyramid currently remain unchanged. The weaker findings associated with the RFS suggest that diet quality scores, and dietary guidelines in general, will need to include both messages to consume more of certain foods (eg, fruit, vegetables, and whole grains) and messages aimed at the quality of nutrient sources (eg, consume more unsaturated than saturated or *trans* fats and eat more white meat than red meat). Because the populations we studied are relatively health-conscious, and some components of the AHEI were known to predict lower risk of certain chronic diseases in these cohorts, future studies should test the AHEI in other populations to assess its ability to predict major chronic disease risk. In addition, further research is needed to clarify the associations between dietary patterns and overall cancer risk reduction.

REFERENCES

1. Centers for Disease Control and Prevention. Chronic diseases and their risk factors: the nation's leading causes of death. Atlanta: Centers for Disease Control and Prevention, 1999.
2. National Research Council. Diet and health: implications for reducing chronic disease risk. Washington, DC: National Academy Press, 1989.
3. World Cancer Research Fund and American Institute for Cancer Research. Food, nutrition and the prevention of cancer: a global perspective. Washington, DC: American Institute for Cancer Research, 1997.
4. Willett WC, Sacks F, Trichopoulou A, et al. Mediterranean diet pyramid: a cultural model for healthy eating. Am J Clin Nutr 1995; 61(suppl):1402S–6S.
5. Willett WC. Diet and health: what should we eat? Science 1994;264:532–7.
6. US Department of Agriculture. The food guide pyramid. Hyattsville, MD: Human Nutrition Information Service, 1992. (Publication HG252.)
7. US Department of Health and Human Services, US Department of Agriculture. Dietary guidelines for Americans. 4th ed. Washington, DC: US Government Printing Office, 1995.
8. Byers T, Nestle M, McTiernan A, et al. American Cancer Society guidelines on nutrition and physical activity for cancer prevention: reducing the risk of cancer with healthy food choices and physical activity. CA Cancer J Clin 2002;52:92–119.
9. Krauss RM, Deckelbaum RJ, Ernst N, et al. Dietary guidelines for healthy American adults. A statement for health professionals from the Nutrition Committee, American Heart Association. Circulation 1996;94:1795–1800.
10. Kant AK, Schatzkin A, Graubard BI, Schairer C. A prospective study of diet quality and mortality in women. JAMA 2000;283:2109–15.
11. McCullough M, Feskanich D, Stampfer M, et al. Adherence to the Dietary Guidelines for Americans and risk of major chronic disease in women. Am J Clin Nutr 2000;72:1214–22.
12. McCullough M, Feskanich D, Rimm E, et al. Adherence to the Dietary Guidelines for Americans and risk of major chornic disease in men. Am J Clin Nutr 2000;72:1223–31.
13. Kennedy E, Meyers L, Layden W. The 1995 Dietary Guidelines for Americans: an overview. J Am Diet Assoc 1996;96:234–7.
14. Kennedy ET, Ohls J, Carlson S, Fleming K. The Healthy Eating Index: design and applications. J Am Diet Assoc 1995;95:1103–8.
15. Shekelle RB, Shryock AM, Paul O, et al. Diet, serum cholesterol, and death from coronary heart disease: The Western Electric Study. N Engl J Med 1981;304:65–70.
16. Verschuren WM, Jacobs DR, Bloemberg BP, et al. Serum total cholesterol and long-term coronary heart disease mortality in different cultures. Twenty-five-year follow-up of the Seven Countries Study. JAMA 1995;274:131–6.
17. Willett WC. Nutritional epidemiology. New York: Oxford University Press, 1990.
18. Ross R. Atherosclerosis—an inflammatory disease. N Engl J Med 1999;340:115–26.
19. Ulbricht TLV, Southgate DAT. Coronary heart disease: seven dietary factors. Lancet 1991;338:985–92.
20. Willett WC, Trichopoulos D. Nutrition and cancer: a summary of the evidence. Cancer Causes Control 1996;7:178–80.
21. Kushi LH, Lenart EB, Willett WC. Health implications of Mediterranean diets in light of contemporary knowledge. 1. Plant foods and dairy products. Am J Clin Nutr 1995;61(suppl):1407S–15S.
22. Kushi LH, Lenart EB, Willett WC. Health implications of Mediterranean diets in light of contemporary knowledge. 2. Meat, wine, fats and oils. Am J Clin Nutr 1995;61(suppl):1416S–27S.
23. Renaud S, de Lorgeril M. Wine, alcohol, platelets, and the French paradox for coronary disease. Lancet 1992;339:1523–6.
24. de Lorgeril M, Renaud S, Mamelle N, et al. Mediterranean alpha-linolenic acid-rich diet in secondary prevention of coronary heart disease. Lancet 1994;343:1454–9.
25. Rimm EB, Giovannucci EL, Stampfer MJ, Colditz GA, Litin LB,

Willett WC. Reproducibility and validity of an expanded self-administered semiquantitative food frequency questionnaire among male health professionals. Am J Epidemiol 1992;135:1114–26.
26. Adams CF. Nutritive value of American foods. Agriculture handbook no. 456. Washington, DC: US Government Printing Office, 1975.
27. Consumer and Food Economic Institute. Composition of foods. Agriculture handbook no. 8. Washington, DC: US Government Printing Office, 1989.
28. Willett WC, Sampson L, Stampfer MJ, et al. Reproducibility and validity of a semiquantitative food frequency questionnaire. Am J Epidemiol 1985;122:51–65.
29. Feskanich D, Rimm EB, Giovannucci EL, et al. Reproducibility and validity of food intake measurements from a semiquantitative food frequency questionnaire. J Am Diet Assoc 1993;93:790–6.
30. Giovannucci E, Colditz G, Stampfer MJ, et al. The assessment of alcohol consumption by a simple self-administered questionnaire. Am J Epidemiol 1991;133:810–7.
31. Salvini S, Hunter DJ, Sampson L, et al. Food-based validation of a dietary questionnaire: the effects of week-to-week variation in food consumption. Int J Epidemiol 1989;18:858–67.
32. Michaud DS, Giovannucci EL, Ascherio A, et al. Associations of plasma carotenoid concentrations and dietary intake of specific carotenoids in samples of two prospective cohort studies using a new carotenoid database. Cancer Epidemiol Biomarkers Prev 1998;7:283–90.
33. Appel LJ, Moore TJ, Obarzanek E, et al. A clinical trial of the effects of dietary patterns on blood pressure. N Engl J Med 1997;336:1117–24.
34. Gramenzi A, Gentile A, Fasoli M, Negri E, Parazzini F, La Vecchia C. Association between certain foods and risk of acute myocardial infarction in women. BMJ 1990;300:771–3.
35. Steinmetz KA, Potter JD. Vegetables, fruit and cancer. I. Epidemiology. Cancer Causes Control 1991;2:325–57.
36. Acheson RM, Williams DRR. Does consumption of fruit and vegetables protect against stroke? Lancet 1983;1:1191–3.
37. Nube M, Kok FJ, Vandenbroucke JP, van der Heide-Wessel C, van der Heide RM. Scoring of prudent dietary habits and its relation to 25-year survival. J Am Diet Assoc 1987;87:171–5.
38. Jenkins DJ, Wolever TM, Taylor RH, et al. Glycemic index of foods: a physiological basis for carbohydrate exchange. Am J Clin Nutr 1981;34:362–6.
39. Key TJ, Thorogood M, Appleby PN, Burr ML. Dietary habits and mortality in 11,000 vegetarians and health conscious people: results of a 17-year follow-up. BMJ 1996;313:775–9.
40. Hu F, Stampfer MJ, Manson JE, et al. Frequent nut consumption and risk of coronary heart disease in women: prospective cohort study. BMJ 1998;317:1341–5.
41. Fraser GE, Sabate J, Beeson WL, Strahan TM. A possible protective effect of nut consumption on risk of coronary heart disease. The Adventist Health Study. Arch Intern Med 1992;152:1416–24.
42. Clinton SK, Giovannucci E. Diet, nutrition, and prostate cancer. Annu Rev Nutr 1998;18:413–40.
43. Kromhout D, Bosscheiter EB, de Lezenne Coulander C. The inverse relation between fish consumption and 20-year mortality from coronary heart disease. N Engl J Med 1985;312:1205–9.
44. Ascherio A, Rimm EB, Stampfer MJ, Giovannucci E, Willett WC. Dietary intake of marine n−3 fatty acids, fish intake and the risk of coronary disease among men. N Engl J Med 1995;332:977–82.
45. Hostmark AT, Bjerkedal T, Kierulf P, Flaten H, Ulshagen K. Fish oil and plasma fibrinogen. BMJ 1988;297:180–1.
46. Goldbohm RA, van den Brandt PA, van't Veer P, et al. A prospective cohort study on the relation between meat consumption and the risk of colon cancer. Cancer Res 1994;54:718–23.
47. Giovannucci E, Rimm EB, Stampfer MJ, Colditz GA, Ascherio A, Willett WC. Intake of fat, meat, and fiber in relation to risk of colon cancer in men. Cancer Res 1994;54:2390–7.
48. Willett WC, Stampfer MJ, Colditz GA, Rosner BA, Speizer FE. Relation of meat, fat, and fiber intake to the risk of colon cancer in a prospective study among women. N Engl J Med 1990;323:1664–72.
49. Potter JD, Slattery ML, Bostick RM, Gapstur SM. Colon cancer: a review of the epidemiology. Epidemiol Rev 1993;15:499–545.
50. Rimm EB, Ascherio A, Giovannucci E, Spiegelman D, Stampfer MJ, Willett WC. Vegetable, fruit, and cereal fiber intake and risk of coronary heart disease among men. JAMA 1996;275:447–51.
51. Jacobs DR, Meyer KA, Kushi LH, Folsom AR. Whole grain intake may reduce risk of coronary heart disease death in postmenopausal women: the Iowa Women's Health Study. Am J Clin Nutr 1998;68:248–57.
52. Morris JN, Marr JW, Clayton DG. Diet and heart: a postscript. Br Med J 1977;2:1307–14.
53. Ascherio A, Rimm E, Hernan M, et al. Intake of potassium, magnesium, calcium, and fiber and risk of stroke among U.S. men. Circulation 1998;98:1198–1204.
54. Fuchs CS, Giovannucci E, Colditz G, et al. Dietary fiber and the risk of colorectal cancer and adenoma in women. N Engl J Med 1999;340:169–76.
55. Alberts DS, Martinez ME, Rose DJ, et al. Lack of effect of a high-fiber cereal supplement on the recurrence of colorectal adenomas. N Engl J Med 2000;342:1149–55.
56. Mensink RPM, Katan MB. Effect of dietary *trans* fatty acids on high-density and low-density lipoprotein cholesterol levels in healthy subjects. N Engl J Med 1990;323:439–45.
57. Willett WC, Stampfer MJ, Manson JE, et al. Intake of *trans* fatty acids and risk of coronary heart disease among women. Lancet 1993;341:581–5.
58. Hu FB, Stampfer MJ, Manson JE, et al. Dietary fat intake and the risk of coronary heart disease in women. N Engl J Med 1997;337:1491–9.
59. Sacks F. Dietary fats and coronary heart disease. Overview. J Cardiovasc Risk 1994;1:3–8.
60. Stampfer MJ, Malinow MR, Willett WC, et al. A prospective study of plasma homocyste(e)ine and risk of myocardial infarction in US physicians. JAMA 1992;268:877–81.
61. Rimm EB, Willett WC, Hu FB, et al. Folate and vitamin B-6 from diet and supplements in relation to risk of coronary heart disease among women. JAMA 1998;279:359–64.
62. Giovannucci E, Stampfer M, Colditz GA, et al. Multivitamin use, folate, and colon cancer in women in the Nurses' Health Study. Ann Intern Med 1998;129:517–24.
63. Renaud SC, Beswick AD, Fehily AM, Sharp DS, Elwood PC. Alcohol and platelet aggregation: The Caerphilly Prospective Heart Disease Study. Am J Clin Nutr 1992;55:1012–7.
64. Klatsky AL, Armstrong MA, Friedman GD. Risk of cardiovascular mortality in alcohol drinkers, ex-drinkers, and nondrinkers. Am J Cardiol 1990;66:1237–42.
65. Rimm EB, Giovannucci EL, Willett WC, et al. A prospective study of alcohol consumption and the risk of coronary disease in men. Lancet 1991;338:464–8.
66. Huijbregts P, Feskens EJ, Kromhout D. Dietary patterns and cardiovascular risk factors in elderly men: The Zutphen Elderly Study. Int J Epidemiol 1995;24:313–20.
67. Longnecker MP, Tseng M. Alcohol and cancer. In: Heber D, Blackburn GL, Vay Liang WG, eds. Nutritional oncology. San Diego: Academic Press, 1999:277–98.
68. Giovannucci E, Stampfer MJ, Colditz GA, et al. Folate, methionine, and alcohol intake and risk of colorectal adenoma. J Natl Cancer Inst 1993;85:875–84.
69. Rose GA, Blackburn H. Cardiovascular survey methods. WHO monograph series no. 58. Geneva: World Health Organization, 1982.
70. Walker AE, Robins M, Weinfeld FD. The National Survey of Stroke. Clinical findings. Stroke 1981;12:I13–44.
71. Stampfer MJ, Willett WC, Speizer FE, et al. Test of the National Death Index. Am J Epidemiol 1984;119:837–9.
72. Hu FB, Stampfer MJ, Rimm E, et al. Dietary fat and coronary heart disease: a comparison of approaches for adjusting for total energy

intake and modeling repeated dietary measurements. Am J Epidemiol 1999;149:531–40.
73. Cupples LA, D'Agostino RB, Anderson K, Kannel WB. Comparison of baseline and repeated measure covariate techniques in the Framingham Heart Study. Stat Med 1988;7:205–22.
74. D'Agostino RB, Lee MLT, Belanger AJ, Cupples LA, Anderson K, Kannel WB. Relation of pooled logistic regression to time dependent Cox regression analysis: the Framingham Heart Study. Stat Med 1990;9:1501–15.
75. Huijbregts P, Feskens E, Rasanen L, et al. Dietary pattern and 20 year mortality in elderly men in Finland, Italy, and the Netherlands: longitudinal cohort study. BMJ 1997;315:13–7.
76. Cerhan JR, Potter JD, Gilmore JME, et al. Adherence to AICR cancer prevention guidelines and subsequent morbidity and mortality in the Iowa Women's Health Study cohort. Cancer Epidemiol Biomarkers Prev 2001;10:158 (abstr).
77. Ames BN, Gold LS, Willett WC. The causes and prevention of cancer. Proc Natl Acad Sci U S A 1995;92:5258–65.
78. Sugimura T. Carcinogenicity of mutagenic heterocyclic amines formed during the cooking process. Mutation Res 1985;150:33–41.
79. Giovannucci E, Ascherio A, Rimm EB, Stampfer MJ, Colditz GA, Willett WC. Intake of carotenoids and retinol in relation to risk of prostate cancer. J Natl Cancer Inst 1995;87:1767–76.
80. Michaud DS, Spiegelman D, Clinton SK, Rimm EB, Willett WC, Giovannucci EL. Fruit and vegetable intake and incidence of bladder cancer in a male prospective cohort. J Natl Cancer Inst 1999;91:605–13.
81. Giovannucci E, Rimm EB, Colditz GA, et al. A prospective study of dietary fat and risk of prostate cancer. J Natl Cancer Inst 1993;85:1571–9.
82. Giovannucci E, Rimm EB, Wolk A, et al. Calcium and fructose intake in relation to risk of prostate cancer. Cancer Res 1998;58:442–7.
83. Mills PK, Beeson WL, Phillips RL, Fraser GE. Cohort study of diet, lifestyle, and prostate cancer in Adventist men. Cancer 1989;64:598–604.
84. Le Marchand L, Kolonel LN, Wilkens LR, Myers BC, Hirohata T. Animal fat consumption and prostate cancer: a prospective study in Hawaii. Epidemiology 1994;5:276–82.
85. US Department of Health and Human Services, US Department of Agriculture. Dietary guidelines for Americans. Washington, DC: US Government Printing Office, 2000.

APPENDIX A

Comparison between recommended food scores of Kant et al (1) and those of the present study: individual foods considered recommended foods[1]

Food group	Kant	HPFS, 1986	HPFS, 1990	NHS, 1984	NHS, 1986	NHS, 1990
Vegetables	Tomatoes	Tomatoes	Tomatoes	Tomatoes	Tomatoes	Tomatoes
	Broccoli	Broccoli	Broccoli	Broccoli	Broccoli	Broccoli
	Spinach	Spinach	Spinach	—	Spinach	Spinach
	Mustard and other greens	Kale	Kale	Kale	Kale	Kale
	Carrots	Carrots	Carrots	Carrots	Carrots	Carrots
	Green salad	Iceburg lettuce	Iceburg lettuce	Iceburg lettuce	Iceburg lettuce	Iceburg lettuce
	Sweet potatoes or yams	Yams	Yams	Yams	Yams	Yams
	Other potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes
	Dried beans	Beans	Beans	Beans	Beans	Beans
	—	String beans	String beans	String beans	String beans	String beans
	—	Corn	Corn	Corn	Corn	Corn
	—	Peas	Peas	Peas	Peas	Peas
	—	Mixed vegetables	Mixed vegetables	Mixed vegetables	Mixed vegetables	Mixed vegetables
	—	Celery	Celery	Celery	Celery	Celery
	—	Yellow squash	Yellow squash	Yellow squash	Yellow squash	Squash
	—	Eggplant	Eggplant	Eggplant	Eggplant	Eggplant
	—	Romaine lettuce	Romaine lettuce	Romaine lettuce	Romaine lettuce	Romaine lettuce
	—	Green pepper	—	—	Green pepper	—
	—	Tomato juice	Tomato juice	Tomato juice	Tomato juice	Tomato juice
	—	Tomato sauce	Tomato sauce	Tomato sauce	Tomato sauce	Tomato sauce
	—	Sauerkraut	—	—	Sauerkraut	—
	—	Cabbage	—	Cabbage	Cabbage	Cabbage
	—	Cole slaw	Cole Slaw	—	Cole slaw	—
	—	Cauliflower	Cauliflower	Cauliflower	Cauliflower	Cauliflower
	—	Brussels sprouts	Brussels sprouts	Brussels sprouts	Brussels sprouts	Brussels sprouts
	—	—	Beets	Beets	—	Beets
	—	—	—	—	Cucumber	—
Fruit	Apples or pears	Apples or pears	Apples or pears	Apples or pears	Apples or pears	Apples or pears
	Oranges	Oranges	Oranges	Oranges	Oranges	Oranges
	Cantaloupe	Cantaloupe	Cantaloupe	Cantaloupe	Cantaloupe	Cantaloupe
	Orange or grapefruit juice	Orange juice	Orange juice	Orange juice	Orange juice	Orange juice
		Grapefruit juice	Grapefruit juice	Grapefruit juice	Grapefruit juice	Grapefruit juice
	Grapefruit	Grapefruit	Grapefruit	Grapefruit	Grapefruit	Grapefruit

Continued

APPENDIX A *(Continued)*

Food group	Kant	HPFS, 1986	HPFS, 1990	NHS, 1984	NHS, 1986	NHS, 1990
	Other fruit juices	Other fruit juices	Other fruit juices	Other fruit juices	Other fruit juices	Other fruit juices
	—	Banana	Banana	Banana	Banana	Banana
	—	Apple juice	Apple juice	Apple juice	Apple juice	Apple juice
	—	Strawberries	Strawberries	Strawberries	Strawberries	Strawberries
	—	Blueberries	Blueberries	Blueberries	Blueberries	Blueberries
	—	Peaches	Peaches	Peaches	Peaches	Peaches
	—	Raisins	Raisins	Raisins	Raisins	Raisins
	—	Watermelon	Watermelon	Watermelon	Watermelon	Watermelon
	—	Avocados	—	—	Avocados	—
	—	—	Applesauce	—	—	Applesauce
	—	—	Prunes	Prunes	Prunes	Prunes
	—	—	—	—	Canned peaches	—
	—	—	—	—	Fruit cocktail	—
Protein foods	Baked or stewed chicken or turkey	Chicken or turkey without skin	Chicken or turkey without skin	Chicken or turkey without skin	Chicken or turkey without skin	Chicken or turkey without skin
	Baked or broiled fish	Other fish	Other fish	Other fish	Other fish	Other fish
	—	Dark fish	Dark fish	Dark fish	Dark fish	Dark fish
	—	Canned tuna	Canned tuna	Canned tuna	Canned tuna	Canned tuna
	—	Tofu	Tofu	Tofu	Tofu	Tofu
	—	Shrimp	Shrimp	Shrimp	Shrimp	Shrimp
Grains	Dark breads such as whole wheat, rye, or pumpernickel	Dark breads	Dark breads	Dark breads	Dark breads	Dark breads
	Cornbread, tortillas, and grits	—	—	—	—	—
	High-fiber cereals, such as bran, granola, or shredded wheat	Whole-grain cereals (predefined write-ins)	Whole-grain cereals (predefined write-ins)	Whole-grain cereals (predefined write-ins)	Whole-grain cereals (predefined write-ins)	Whole-grain cereals (predefined write-ins)
	Cooked cereals	Cooked cereals	Cooked cereals	Cooked cereals	Cooked cereals	Cooked cereals
	—	Oatmeal	Oatmeal	Oatmeal	Oatmeal	Oatmeal
	—	Brown rice	Brown rice	Brown rice	Brown rice	Brown rice
Dairy	2% fat milk	—	—	—	—	—
	1% fat or skim milk	Skim milk	Skim milk	Skim milk	Skim milk	Skim milk
Highest possible score[2]	23	52	51	49	56	51

[1] HPFS, Health Professional's Follow-up Study; NHS, Nurses' Health Study. For each food listed that was consumed at least once a week, 1 point was given (eg, a total score of 23 indicated that 23 different recommended foods were eaten at least once a week).

REFERENCE

1. Kant AK, Schatzkin A, Graubard BI, Schairer C. A prospective study of diet quality and mortality in women. JAMA 2000;283:2109–15.