

Associations between diet and cancer, ischemic heart disease, and all-cause mortality in non-Hispanic white California Seventh-day Adventists¹⁻³

Gary E Fraser

ABSTRACT Results associating diet with chronic disease in a cohort of 34 192 California Seventh-day Adventists are summarized. Most Seventh-day Adventists do not smoke cigarettes or drink alcohol, and there is a wide range of dietary exposures within the population. About 50% of those studied ate meat products <1 time/wk or not at all, and vegetarians consumed more tomatoes, legumes, nuts, and fruit, but less coffee, doughnuts, and eggs than did nonvegetarians. Multivariate analyses showed significant associations between beef consumption and fatal ischemic heart disease (IHD) in men [relative risk (RR) = 2.31 for subjects who ate beef ≥ 3 times/wk compared with vegetarians], significant protective associations between nut consumption and fatal and nonfatal IHD in both sexes (RR ≈ 0.5 for subjects who ate nuts ≥ 5 times/wk compared with those who ate nuts <1 time/wk), and reduced risk of IHD in subjects preferring whole-grain to white bread. The lifetime risk of IHD was reduced by $\approx 31\%$ in those who consumed nuts frequently and by 37% in male vegetarians compared with nonvegetarians. Cancers of the colon and prostate were significantly more likely in nonvegetarians (RR of 1.88 and 1.54, respectively), and frequent beef consumers also had higher risk of bladder cancer. Intake of legumes was negatively associated with risk of colon cancer in nonvegetarians and risk of pancreatic cancer. Higher consumption of all fruit or dried fruit was associated with lower risks of lung, prostate, and pancreatic cancers. Cross-sectional data suggest vegetarian Seventh-day Adventists have lower risks of diabetes mellitus, hypertension, and arthritis than nonvegetarians. Thus, among Seventh-day Adventists, vegetarians are healthier than nonvegetarians but this cannot be ascribed only to the absence of meat. *Am J Clin Nutr* 1999;70(suppl):532S–8S.

KEY WORDS Seventh-day Adventists, vegetarians, diet, ischemic heart disease, cancer, longevity, mortality, cardiovascular disease, coronary artery disease, diabetes, arthritis, lung cancer, prostate cancer, colon cancer, pancreatic cancer, cancer prevention, nuts, beef, meat

INTRODUCTION

For over 40 y, it has been recognized that Seventh-day Adventists present a unique opportunity to study relations between diet and chronic disease. This is because of the wide variety of dietary habits of Seventh-day Adventists, whose diets are on

average lower in saturated fat and higher in fiber than the diets of other Americans. Of the Seventh-day Adventists we studied, $\approx 20\%$ were meat eaters who ate meat <1 time/wk and $\approx 30\%$ ate no meat products. However, most ate dairy products and eggs and few ate vegan diets. Of the meat-eating Seventh-day Adventists, about half ate meat as frequently as did other Californians.

Hence, there is an opportunity to compare different dietary patterns within the Seventh-day Adventist group. Because the nutrient intake profile of Seventh-day Adventists is closer to that recommended by a number of professional bodies than is the diet of average Americans, several publications have compared the health experiences of Seventh-day Adventists to those of non-Adventists (1–3). Generally, Seventh-day Adventists had lower mortality from cancer, heart disease, and diabetes than did non-Adventists living in the same communities. For this report, we summarized findings associating the use of different foods to risk of cancer, ischemic heart disease (IHD), and other diseases within a Seventh-day Adventist population enrolled in a large cohort study (1976–1988).

SUBJECTS AND METHODS

The study was approved by the ethics review committee of Loma Linda University and has been described elsewhere (4). Briefly, in 1974 a census questionnaire was mailed to all Seventh-day Adventist households in the state of California. The census identified 59 081 Seventh-day Adventists aged ≥ 25 y, who were then mailed a detailed lifestyle questionnaire in 1976. Among non-Hispanic whites, the rate of response to the lifestyle questionnaire exceeded 75%, whereas among other ethnic groups, the response rates were considerably lower. Cancer incidence among 34 198 non-Hispanic white subjects was monitored for a total of 6 y of follow-up. The dietary questionnaire used the food-frequency method and included questions relating to 51 different foods or food groups. The most common format was a sequence of 8 frequency categories, as

¹From the Center for Health Research and the Department of Epidemiology and Biostatistics, Loma Linda University, CA.

²Supported by NIH grants nos. 2 R01 CA14703-15A2, 1 R01 AG08961-01A2, and 2 R01 HL26210-01.

³Address reprint requests to GE Fraser, Loma Linda University, School of Public Health, Nichol Hall Room 2008, Loma Linda, CA 92350. E-mail: gfraser@sph.llu.edu.

TABLE 1
Age and sex distribution of the Adventist Health Study population

Age	Men	Women
y		
25–44	5181	6990
45–64	5541	7645
65–84	2927	5258
>85	208	448
Total	13857	20341

follows: never, <1 time/mo, 1–2 times/mo, 1–2 times/wk, 1 time/d, and >1 time/d.

Because there is some interest in comparing the risk for disease in vegetarian and nonvegetarian Seventh-day Adventists, 3 categories of dietary habits were defined. These were vegetarian, those who ate no fish, poultry, or meat (29.5%); semivegetarian, those who ate fish and poultry, but <1 time/wk (21.2%); and nonvegetarian, referring to the remaining subjects (49.2%). Only 2–3% of Seventh-day Adventists are vegans.

A surveillance program to detect new cancer and IHD cases was conducted, consisting of annual mailings to every member of the cohort requesting information on any hospitalization in the previous 12-mo period of follow-up. If a hospitalization was reported, the name and address of the hospital was recorded and permission to review the resulting medical record was obtained. Adventist Health Study personnel reviewed all medical records for evidence of a cancer or IHD diagnosis; pertinent portions of the records were microfilmed to allow confirmation of the diagnosis by senior medical personnel. All electrocardiograms were microfilmed and coded (5), and cardiac enzyme results were abstracted to a special form. The information taken from the microfilmed hospital records needed to include appropriate histology reports in order for a diagnosis of cancer to be made. Follow-up conducted in this fashion was complete for the hospitalizations of 97% of the cohort.

Computerized record linkage (6) was also used to detect new cancer cases in areas of California that had population-based tumor registries (the Cancer Surveillance Program in Los Angeles County and the Resource for Cancer Epidemiology registry in the San Francisco Bay Area). In addition, computerized matching with state death tapes and the National Death Index was used to identify fatal cases.

A diagnosis of nonfatal myocardial infarction was confirmed if the international diagnostic criteria (7) were met. In summary, these criteria require a diagnostic series of electrocardiographic changes or elevation of cardiac enzyme concentrations plus either prolonged cardiac pain or static electrocardiographic abnormalities. Fatal IHD was also defined by the international diagnostic criteria (7), as either “definite fatal myocardial infarction” or “other definite fatal IHD.” For a diagnosis of definite fatal myocardial infarction, death had to occur within 28 d of a myocardial infarction confirmed by hospital records as described above, or fresh myocardial infarction had to be recorded at autopsy. Other definite fatal IHD required International Classification of Diseases (8) codes 410–414 as the underlying or immediate cause of death on the death certificate, provided there were no other likely lethal causes on the certificate. In addition, for this diagnosis it was necessary to have either a history of IHD, autopsy findings of severe coronary disease, or symptoms compatible with an ischemic cause of death.

TABLE 2
Consumption of selected foods according to vegetarian status¹

Food	Vegetarian	Semivegetarian	Nonvegetarian
Beef	0	0.26	2.98
Poultry	0	0.07	0.67
Fish	0	0.08	0.59
Vegetarian meat substitutes	3.50	3.15	1.40
Soft margarine on bread	6.16	6.09	5.67
Eggs	1.33	1.68	2.17
Doughnuts	0.42	0.56	0.91
Coffee	0.28	1.19	4.83
Tomatoes	3.57	3.50	3.36
Legumes	2.38	1.96	1.26
Nuts	3.71	3.01	2.10
Green salads	4.41	4.41	4.41

¹All differences were significant at $P < 0.001$, except for salads (nonsignificant). Data were adjusted for age and sex. Vegetarians ate no meat, fish, or poultry; semivegetarians ate meat, fish, or poultry in total <1 time/wk; nonvegetarians ate these foods ≥ 1 time/wk.

Persons lost to follow-up accounted for only 3% of the population and all of these subjects contributed some person-years. Of the persons lost to follow-up, 8.5% were current smokers, 27.7% were past smokers, and 63.8% had never smoked. There was a modestly higher percentage of current smokers in this group, but the effect on the total data set would have been small.

RESULTS

The distribution of the study population by age and sex is shown in **Table 1**. There were more women than men and the mean ages were 53.1 y for men and 55.0 y for women.

From the data shown in **Tables 2, 3, and 4**, it is apparent that when dividing the population according to consumption of meats, we also need to recognize that these subgroups differed in many other ways. On average, the nonvegetarian Seventh-day Adventists consumed meat products ≈ 4.25 times/wk, and most of the meat was beef. The vegetarian Seventh-day Adventists consumed more tomatoes, legumes, nuts, and fruit, but much less coffee, donuts, and eggs. Nonvegetarian Seventh-day Adventists were much less likely to prefer whole-grain bread and also consumed alcoholic beverages 20 times more frequently than their

TABLE 3
Consumption of fruit by Seventh-day Adventists according to vegetarian status¹

Type of fruit	Vegetarians	Semivegetarians	Nonvegetarians
Canned	3.29	2.94	2.45
Dried	3.08	2.45	1.82
Citrus	2.80	2.59	2.45
Winter	5.46	4.83	4.27
Other	4.06	3.71	3.29
All fruit	17.71	16.24	14.14

¹All differences were significant at $P < 0.0001$. Data were adjusted for age and sex. Vegetarians ate no meat, fish, or poultry; semivegetarians ate meat, fish, or poultry in total <1 time/wk; nonvegetarians ate these foods ≥ 1 time/wk.

TABLE 4Odds ratios of consuming whole-grain bread and alcoholic beverages according to vegetarian status¹

	Vegetarians	Semivegetarians	Nonvegetarians
Prefers whole-grain bread	1.00	0.57 (0.49, 0.67) ²	0.15 (0.13, 0.17)
Some beer or wine	1.00	3.07 (2.34, 4.02)	22.0 (17.51, 27.58)
Some hard liquor	1.00	2.20 (1.51, 3.19)	22.3 (16.59, 29.99)

¹All values were significantly different from reference group (vegetarians), $P < 0.0001$. Data were adjusted for age and sex. Vegetarians ate no meat, fish, or poultry; semivegetarians ate meat, fish, or poultry in total < 1 time/wk; nonvegetarians ate these foods ≥ 1 time/wk.

²95% CI in parentheses.

vegetarian counterparts. Thus, when comparing the health experiences of vegetarian and nonvegetarian Seventh-day Adventists, we cannot initially infer that any effects are due to differences in meat consumption. Multivariate analyses can be used to test hypotheses relating to single foods or food groups.

The prevalences of obesity, hypertension, diabetes, and arthritis at baseline, obtained by self-report but confirmed by physicians' diagnoses, were strikingly different among the 3 dietary subgroups of Seventh-day Adventists. Obesity, as measured by body mass index (in kg/m^2), increased as meat consumption increased (Table 5) such that a 1.78-m- (70-in-) tall male nonvegetarian weighed 6.4 kg (14 lb) more on average than did his vegetarian counterpart ($P < 0.0001$). A similar comparison for a 1.63-m- (64-in-) tall female revealed a weight difference of 5.5 kg (12 lb) ($P < 0.0001$). These results were for subjects aged 45–60 y, but similar results were seen for the other ages. The prevalences of hypertension and diabetes were both ≈ 2 -fold greater in the nonvegetarians than the vegetarians, and the prevalence of rheumatoid arthritis and rheumatism was $\approx 50\%$ greater (Table 6). These results were statistically significant, consistent for both sexes, and adjusted for age.

Regarding the incidence of IHD in relation to frequency of beef consumption, there were some striking differences by sex and the type of heart disease outcome (Figure 1). The risk of a fatal IHD event in men was significantly related to beef consumption; those who consumed beef ≥ 3 times/wk had a 2.31-fold greater risk than did the vegetarian men ($P < 0.0001$). However, no associations were found between beef consumption and fatal IHD in women. In addition, no associations of significance were found when nonfatal definite myocardial infarction was the endpoint (9). We have previously shown that the age at which a person becomes a vegetarian is an important predictor of IHD mortality in men, but this was less clearly seen in women (10).

The food that was most consistently associated with reduced risk of both fatal and nonfatal IHD was nuts. Those who ate nuts 4–5 times/wk had only $\approx 50\%$ of the risk of those who ate nuts ≤ 1 time/wk (Figure 2). We found this association to be consistent across many different subgroups of the population (9). The association could not be explained by confounding with vegetarian status because it was found equally within both vegetarian and nonvegetarian segments of the Seventh-day Adventist population. The other food that predicted risk of IHD was a preference for whole-grain bread. Those who preferred whole-grain bread had relative risks of 0.89 for fatal IHD ($P < 0.005$) and 0.56 for nonfatal IHD ($P < 0.01$) in comparison to subjects who preferred white bread, after adjusting for all nondietary risk factors and consumption of 7 other foods (9). We also noted that the effects of traditional risk factors for IHD, such as diabetes, hypertension, past smoking, obesity, and physical inactivity, were seen in this Seventh-day Adventist cohort (11), just as in other study populations.

By applying the multiple-decrement-lifetable approach to the IHD endpoint, we have shown that Seventh-day Adventist men and women consuming nuts < 1 time/wk had lifetime risks of 31.3% and 29%, respectively, whereas those consuming nuts ≥ 5 times/wk had lifetime risks of 18.7% and 17%, respectively ($P < 0.05$), which is $\approx 31\%$ lower (12). Similarly, nonvegetarian men had a lifetime risk of 34% whereas vegetarian men had a risk of only 21.3% ($P < 0.05$), which is 37.4% lower.

During the follow-up period of the cohort study, cases of incident cancers at many sites were documented. Because each type of cancer may have its own associations with dietary habits, each must be analyzed separately. The data provided the opportunity for analyses with satisfactory statistical power for several common cancers such as breast, prostate, and colon cancers, but even after 180 000 person-years of observation for other sites, the power was less than optimal. Nevertheless, even for some of

TABLE 5Vegetarian status and obesity¹

	Vegetarians	Semivegetarians	Nonvegetarians	P^2
BMI (in kg/m^2)				
Men	24.26 (24.11, 24.42) ³	25.18 (25.02, 25.34)	26.24 (26.11, 26.37)	0.0001
Women	23.73 (23.58, 23.89)	24.83 (24.66, 25.00)	25.88 (25.75, 26.02)	0.0001
Predicted weight (kg) ⁴				
Men	77	80	83	
Women	63	66	69	

¹For subjects aged 45–64 y; other ages showed similar trends. Vegetarians ate no meat, fish, or poultry; semivegetarians ate meat, fish, or poultry in total < 1 time/wk; nonvegetarians ate these foods ≥ 1 time/wk.

² \bar{x} . A Wald test was used to test the significance of the β coefficients in a regression of BMI on age and diet status. P represents the probability that diet status is not associated with BMI.

³ \bar{x} , adjusted for age. 95% CI in parentheses.

⁴At height of 1.78 m (70 in) for males and 1.63 m (64 in) for females; weight was predicted from the regression models of the upper 2 rows.



TABLE 6Odds ratios and 95% CIs of prevalent diabetes, hypertension, and arthritis by vegetarian status in California Seventh-day Adventists¹

Endpoint	Vegetarians	Semivegetarians	Nonvegetarians
Diabetes			
Men	1.00	1.35 (1.02, 1.78) ²	1.97 (1.56, 2.47) ²
Women	1.00	1.08 (0.89, 1.32) ²	1.93 (1.65, 2.25) ²
Hypertension			
Men	1.00	1.57 (1.36, 1.83) ²	2.23 (1.96, 2.52) ²
Women	1.00	1.44 (1.30, 1.59) ²	2.24 (2.05, 2.44) ²
Rheumatoid arthritis			
Men	1.00	1.14 (0.83, 1.56) ³	1.50 (1.16, 1.95) ³
Women	1.00	1.16 (0.97, 1.39) ²	1.57 (1.35, 1.83) ²
Rheumatism			
Men	1.00	1.20 (1.03, 1.39) ²	1.48 (1.31, 1.68) ²
Women	1.00	1.28 (1.16, 1.41) ²	1.61 (1.49, 1.75) ²

¹Adjusted for age. Vegetarians ate no meat, fish, or poultry; semivegetarians ate meat, fish, or poultry in total <1 time/wk; nonvegetarians ate these foods \geq 1 time/wk.

^{2,3}Significantly different from nonvegetarians, ² $P = 0.0001$; ³ $P = 0.005$.

these latter sites, a number of provocative results were found, several of which achieved statistical significance. Associations of cancer risk with vegetarian status (adjusted for age, sex, and smoking habits where appropriate) are shown in **Table 7** for the more common cancers. Both colon and prostate cancer were significantly more common among the nonvegetarian Seventh-day Adventists.

Despite careful searching, no clear dietary associations with breast cancer could be found in this population. The relative risk in nonvegetarians was modestly greater (1.33), even after multivariate adjustment, but this was not statistically significant (13). However, the risk of prostate cancer was 54% greater in the nonvegetarians ($P \approx 0.03$) and after further multivariate evaluation, the lower risk in vegetarians appeared to be associated with higher consumption of dried fruits ($P < 0.05$) and perhaps tomatoes and lower consumption of fish (14). Although the results for tomatoes and fish did not quite achieve statistical significance ($P < 0.10$), there were impressive dose-response associations for these foods.

The risk of incident colon cancer was increased by 88% in nonvegetarian compared with vegetarian Seventh-day Adventists

($P < 0.003$). On multivariate analysis (15), independent associations were seen with both red and white meats (**Table 8**); these data indicate that both red meat and white meat consumption increase the risk of colon cancer. It was also noted that legume consumption appeared to have a protective effect against colon cancer, but interacted with meat consumption in an interesting way. Legume consumption ≥ 3 times/wk compared with <1 time/wk was associated with much lower relative risk of colon cancer (0.33; 95% CI: 0.13, 0.83), but only among Seventh-day Adventists who ate red meat. In addition, the positive association between colon cancer risk and red meat consumption (relative risk = 2.68; 95% CI: 1.24, 5.78) was only seen in those who consumed legumes infrequently.

Mills et al (16) have published results suggesting that risk for fatal pancreatic cancer in this population is related to consumption of several foods. Despite small numbers, significant negative associations were found for consumption of dried fruits ($P < 0.05$), legumes ($P = 0.01$), and also vegetarian meat analogues ($P = 0.03$); these results were found after adjustment for age, sex, and smoking status.

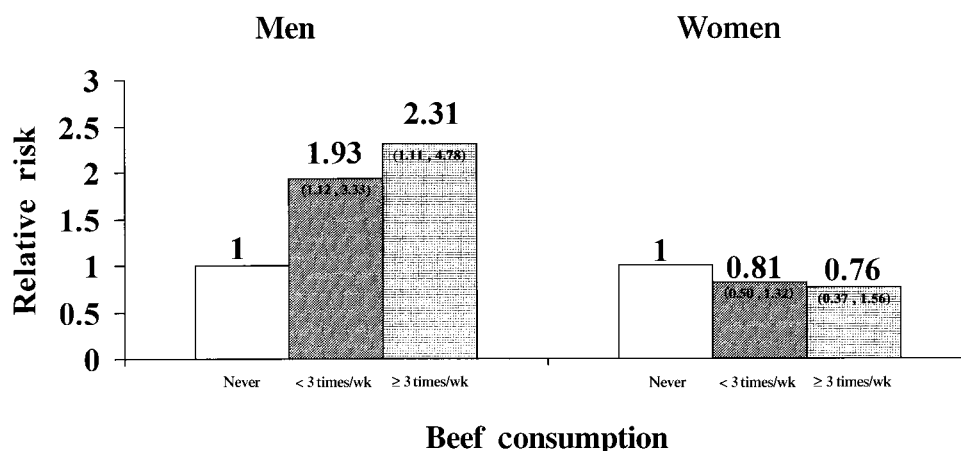


FIGURE 1. Relative risk of definite fatal ischemic heart disease (7) by beef consumption in California Seventh-day Adventists adjusted for age, smoking, exercise, BMI, hypertension, and consumption of bread, nuts, fish, cheese, coffee, legumes, and fruit. Diabetic subjects were excluded; 95% CIs are in parentheses.



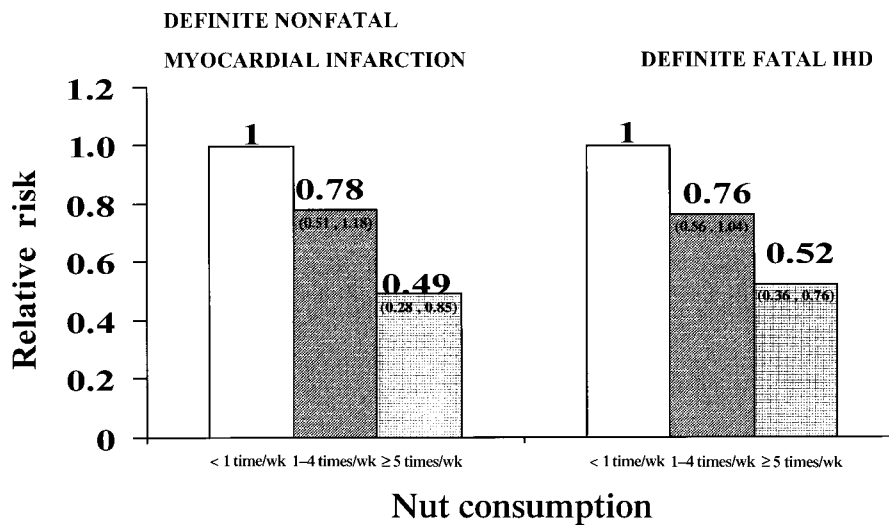


FIGURE 2. Relative risk of ischemic heart disease according to nut consumption in California Seventh-day Adventists adjusted for age, sex, smoking, exercise, BMI, hypertension, and consumption of bread, beef, fish, cheese, coffee, legumes, and fruit. Diabetic subjects were excluded; 95% CIs are in parentheses.

A strong inverse association was found between fruit consumption and risk of lung cancer in this largely nonsmoking population (17) (**Figure 3**). This association was found after cigarette smoking history, age, and sex were adjusted for, and occurred for both of the main histologic subtypes. Mills et al (18) have also evaluated the effect of diet on risk of incident bladder cancer. Despite a small number of cases, those consuming meats ≥ 3 times/wk compared with < 3 times/wk had a > 2 -fold increase in risk ($P < 0.01$) after adjustment for cigarette smoking history, age, sex, and a number of other variables.

Total mortality and longevity also differed according to vegetarian status in California Seventh-day Adventists. After adjusting for age and sex, Seventh-day Adventist vegetarians had a relative risk for total mortality of 0.80 (95% CI: 0.74, 0.87) compared with those who ate any meat products. Using a multivariate, multiple-decrement-lifetable approach (19), we showed that vegetarian Seventh-day Adventist women live 2.52 y longer than their nonvegetarian (meat ≥ 1 time/wk) counterparts ($P < 0.001$), and a similar comparison in men showed a 3.21-y difference in longevity ($P < 0.001$).

DISCUSSION

Our findings strongly suggest that dietary factors have an important influence on longevity and the risk of a number of chronic diseases. In general, we found that vegetarians had lower risks of obesity, hypertension, diabetes, arthritis, colon cancer, prostate cancer, fatal IHD in males, and death from all causes. The consumption of nuts and whole-grain bread were protective against both fatal and nonfatal IHD, whereas beef consumption was hazardous for males. The consumption of fruit and legumes appeared to be protective against a number of cancers, whereas meats probably increase the risk for cancers of the colon and bladder.

It is important to note that vegetarians may have lower disease risk because of their lack of meat consumption, but it is equally possible that this protection could be due to increased consumption of fruits, vegetables, or nuts. Upon multivariate analysis, the

latter often appeared to be the case. It is now well-known that vegetables, fruit, grains, and nuts contain phytosterols and unsaturated fats that lower blood cholesterol concentrations. These same foods contain dietary fiber, which also lowers blood cholesterol and may protect against colon cancer (20). In addition, the content of a number of antioxidant substances (eg, tocopherols, ascorbate, carotenoids, saponins, and flavonoids) may reduce the risk of heart disease by preventing the oxidation of LDL cholesterol, and may also reduce the risk of cancer by preventing oxidative damage to nucleic acids and other cellular components (21). A variety of indoles and isothiocyanates that are present in or formed from cruciferous vegetables activate phase II enzymes that can help detoxify carcinogenic substances and may also inhibit phase I enzymes that convert procarcinogens to carcinogens (22).

In contrast, meat products contain no dietary fiber and often contain substantial quantities of cholesterol and saturated fats that raise LDL-cholesterol concentrations. Meats do not contain significant amounts of phytochemicals, although small quantities may be found in meats as a consequence of the animals having eaten plants. Moreover, there is some evidence that the process of heating and cooking meats, particularly if there is any burning, may form compounds such as polycyclic aromatic hydrocarbons and

TABLE 7

Incidence and relative risk of common cancers in Seventh-day Adventist vegetarians compared with nonvegetarians¹

Cancer	Incidence <i>n</i>	Relative risk (95% CI)	<i>P</i>
Colon	107	1.88 (1.24, 2.87)	0.0032
Breast	128	1.25 (0.87, 1.80)	0.22
Lung ²	45	1.16 (0.56, 2.38)	0.69
Prostate	127	1.54 (1.05, 2.26)	0.03
Uterine	1.16	1.17 (0.81, 1.71)	0.41

¹ Nonvegetarians ate meat ≥ 1 time/wk; vegetarians ate no meat. Adjusted for age and sex.

² Also adjusted for past and present smoking.



TABLE 8Relative risk and 95% CI of colon cancer by consumption of red and white meats in California Seventh-day Adventists¹

	Relative risk
Subjects who consumed white meat <1 time/wk	
Red meat consumption	
Never	1.0
<1 time/wk	1.37 (0.85–2.20)
≥1 time/wk	1.86 (1.15–3.02) ²
Subjects who consumed red meat <1 time/wk	
White meat consumption	
<1 time/wk	1.50 (0.94–2.41)
≥1 time/wk	3.00 (1.45–6.20) ²

¹A Wald test for the trend in frequency of consumption of either red or white meat was used. Some subjects (those who ate both red and white meats <1 time/wk) were included in both analyses. $n = 112$ cases of colon cancer that developed among subjects with low white-meat consumption (from 136864 person-years of observation) and $n = 82$ new cases of colon cancer among subjects with low red-meat consumption (from 100649 person-years of observation).

² P for trend = 0.01

heterocyclic amines that are carcinogenic (23, 24). Consumption of meat has also been shown to increase fecal content of potentially carcinogenic *N*-nitroso compounds (25). Thus, our results are largely in keeping with findings from basic research.

Although there is wide variation, it should be noted that the average Seventh-day Adventist vegetarian does not consume a low-fat diet. Estimates from our 1976 studies of Seventh-day Adventists showed that the average fat consumption was 100.5 g/d in vegetarians and 102.2 g/d in nonvegetarians. The difference between these groups was in the type of fat consumed; the ratio of polyunsaturated to saturated fats was 0.83 in the vegetarians and 0.63 in the nonvegetarians. Thus, the improved health experience of Seventh-day Adventists as a whole and particularly vegetarian Seventh-day Adventists has not required a low-fat diet, but rather the relative avoidance of saturated, primarily animal fats in favor of diets emphasizing vegetables, fruit, nuts, and grains. Preliminary data suggest that very-low-fat diets such as those consumed by vegans do not clearly reduce total or cause-

specific mortality (26) below the rates seen in the more liberal vegetarians, although more evidence is needed.

Our findings that vegetarian dietary habits were associated with reduced prevalence of diabetes, hypertension, and arthritis invite further exploration but may be partially explained by the lower prevalence of obesity among vegetarians. The findings shown in Table 6 resulted from cross-sectional analyses, which often have the weakness of an indeterminate direction of any causal relation. Could the onset of hypertension, diabetes, or arthritis have spuriously caused these associations by causing Seventh-day Adventists with these conditions to change their diets from vegetarian to nonvegetarian? This seems very unlikely. In the Seventh-day Adventist tradition, the onset of poor health typically leads individuals to move toward the recommended vegetarian dietary habits, which would then tend to weaken any causal associations. Hence it seems probable that the observed associations are causal, and if so, almost certainly in the direction suggesting that the diet or associated factors caused the differences in disease frequencies. Previously published data suggest that mortality associated with diabetes mellitus is considerably lower in California Seventh-day Adventists compared with non-Adventists, as well as for vegetarian compared with nonvegetarian Seventh-day Adventist men (27).

The apparent marked difference between men and women in the effect of beef consumption on risk of fatal IHD is of interest, but may be due in part to chance. Note that for women consuming beef ≥3 times/wk, our result allows for the possibility of a relative risk of 1.56 within the 95% CI, despite the best estimate of 0.76. Relevant to this is the recent pooled analysis of vegetarian cohort studies (26) that included this study and did show a significant hazardous effect for nonvegetarian women, although it was not as strong as that seen in men. It has been argued that risk of IHD in women is at least as responsive to lower blood HDL cholesterol concentrations as in men, but less responsive to LDL cholesterol concentrations (28, 29) than in men, and that HDL concentrations drop further in women than men on a low-fat diet (30–32). HDL concentrations are a little lower in Seventh-day Adventists than non-Adventists (33–36), probably because of the trend toward vegetarian, modestly lower-fat diets. However, the decrement in HDL cholesterol concentrations for Seventh-day Adventist women is small and the large sex difference in HDL concentrations is maintained in Seventh-day Adventists.

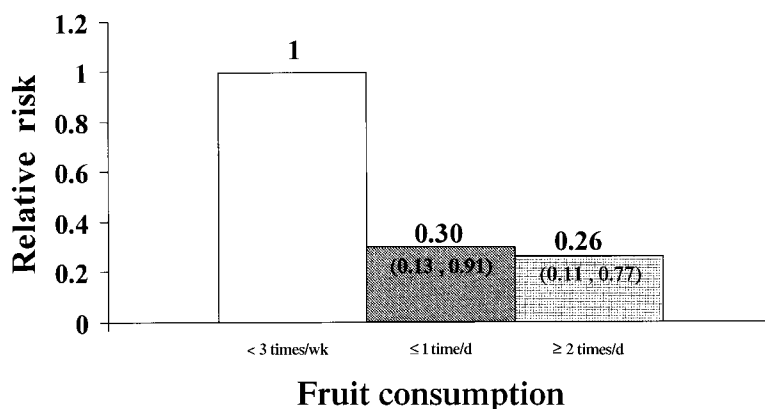



FIGURE 3. Associations between fruit consumption and all incident lung cancers in California Seventh-day Adventists adjusted for age, sex, and cigarette-smoking history. The 95% CIs are shown in parentheses within the bars; $n = 8$ events (in 9128 person-years of observation) for fruit consumption <3 times/wk; $n = 21$ events (in 78375 person-years of observation) for ≤1 time/d; and $n = 23$ events (in 84636 person-years of observation) for ≥2 times/d.



In summary, it is clear that for cancers of the colon and prostate, and fatal heart disease in men, vegetarian Seventh-day Adventists have an advantage over their nonvegetarian counterparts. This is probably also true for risks of diabetes mellitus, hypertension, and arthritis. Moreover, these effects are related to both the reduced consumption of meat and the increased intake of fruit, vegetables, grains, and nuts by the vegetarians. Making comparisons within this special population reduces the likelihood of confounding by other nondietary factors. The absence of tobacco and the limited use of alcohol in this population also reduce the likelihood of confounding. To reach a better understanding of the roles of individual food groups and nutrients in this population, particularly with regard to specific cancers, will require the study of larger Seventh-day Adventist cohorts using improved dietary instruments. 

REFERENCES

- Phillips RL, Kuzma JW, Beeson WL, Lotz T. Influence of selection versus lifestyle on risk of fatal cancer and cardiovascular disease among California Seventh-day Adventists. *Am J Epidemiol* 1980;112:296-314.
- Berkel J, de Waard F. Mortality patterns and life expectancy of Seventh-day Adventists in the Netherlands. *Int J Epidemiol* 1983;12:455-9.
- Fonnebo V. Mortality in Norwegian Seventh-day Adventists 1962-1986. *J Clin Epidemiol* 1992;45:157-67.
- Beeson WL, Mills PK, Phillips RS, et al. Chronic disease among Seventh-day Adventists: a low-risk group. Rationale, methodology, and description of the population. *Cancer* 1989;64:570-81.
- Prineas RJ, Crow RS, Blackburn H. The Minnesota code manual of electrocardiographic findings. London: John Wright PSG, 1982.
- Beeson WL, Fraser GE, Mills PK. Validation of record linkage to two California population-based tumor registries in a cohort study. In: *Proceedings of the 1989 Public Health Conference on Records and Statistics*. Washington, DC: US Department of Health and Human Services, 1989:196-201. (US DHHS publication PHS 90-1214).
- Gillum RF, Fortman SP, Prineas RJ, Kottke TE. International diagnostic criteria for acute myocardial infarction and stroke. *Am Heart J* 1984;108:150-8.
- World Health Organization. Manual of the international statistical classification of diseases, injuries and causes of death. Vol 1. Geneva: World Health Organization, 1977.
- Fraser GE, Sabaté 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.
- Snowdon DA, Phillips RL, Fraser GE. Meat consumption and fatal ischemic heart disease. *Prev Med* 1984;13:490-500.
- Fraser GE, Strahan TM, Sabaté J, Beeson WL, Kissinger D. Effects of traditional coronary risk factors on rates of incident coronary events in a low risk population: the Adventist Health Study. *Circulation* 1992;86:406-13.
- Fraser GE, Lindsted KD, Beeson WL. Effect of risk factor values on lifetime risk of and age at first coronary event. *Am J Epidemiol* 1995;142:746-58.
- Mills PK, Beeson WL, Phillips RL, Fraser GE. Dietary habits and breast cancer incidence among Seventh-day Adventists. *Cancer* 1989;64:591-7.
- Mills PK, Beeson WL, Phillips RL, Fraser GE. Cohort study of diet, lifestyle, and prostate cancer in Adventist men. *Cancer* 1989;64:598-604.
- Singh PN, Linsted KD. Body mass and 26-year risk of mortality from specific diseases among women who never smoked. *Epidemiology* 1998;9:246-54.
- Mills PK, Beeson WL, Abbey DE, Fraser GE, Phillips RL. Dietary habits and past medical history as related to fatal pancreas cancer risk among Adventists. *Cancer* 1988;61:2578-85.
- Fraser GE, Beeson WL, Phillips RL. Diet and lung cancer in California Seventh-day Adventists. *Am J Epidemiol* 1991;133:683-93.
- Mills PK, Beeson WL, Phillips RL, Fraser GE. Bladder cancer in a low risk population: results from the Adventist Health Study. *Am J Epidemiol* 1991;133:230-9.
- Fraser GE, Shavlik D. The estimation of lifetime risk and average age at onset of a disease using a multivariate exponential hazard rate model. *Stat Med* 1999;18:397-410.
- Howe GR, Benito E, Castellato R, et al. Dietary intake of fiber and decreased risk of cancers of the colon and rectum: evidence from the combined analysis of 13 case-control studies. *J Natl Cancer Inst* 1992;84:1887-96.
- Potter JD, ed. Food, nutrition, and the prevention of cancer: a global perspective. Washington, DC: World Cancer Research Fund and American Institute for Cancer Research, 1997.
- Jongen WMF. Glucosinolates in Brassica occurrence and significance as cancer modulating agents. *Proc Nutr Soc* 1996;55:433-46.
- Jagerstad M, Skog K, Grivas S, Olsson K. Formation of heterocyclic amines using model systems. *Mutat Res* 1991;259:219-33.
- Bogovski P, ed. Polynuclear aromatic compounds. Part 1. Chemical, environmental and experimental data. IARC Monogr Eval Carcinog Risk Chem Hum 1983;32:1-453.
- Bingham SA, Pignatelli B, Pollock JR, et al. Does increased endogenous formation of N-nitroso compounds in the human colon explain the association between red meat and colon cancer? *Carcinogenesis* 1996;7:515-23.
- Key TJ, Fraser GE, Thorogood M, et al. Mortality in vegetarians and nonvegetarians: detailed findings from a collaborative analysis of 5 prospective studies. *Am J Clin Nutr* 1999;70(suppl):516S-24S.
- Snowden DA, Phillips RL. Does a vegetarian diet reduce the occurrence of diabetes? *Am J Public Health* 1985;75:507-12.
- Crouse JR. Gender, lipoproteins, diet and cardiovascular risk. *Lancet* 1989;1:318-20.
- Bass KM, Newschaffer CJ, Klag MJ, Bush TL. Plasma lipoprotein levels as predictors of cardiovascular death in women. *Arch Intern Med* 1993;153:2209-16.
- Mata P, Alvarez-Sala LA, Rubio MJ, Nuno J, De Oya M. Effects of long-term monounsaturated- vs polyunsaturated-enriched diets on lipoproteins in healthy men and women. *Am J Clin Nutr* 1992;55:846-50.
- Clifton PM, Nestel PJ. Influence of gender, body mass index, and age on response of plasma lipids to dietary fat plus cholesterol. *Arterioscler Thromb* 1992;12:955-62.
- Cobb M, Teitlebaum H, Risch N, Jekel J, Ostfeld A. Influence of dietary fat, apolipoprotein E phenotype, and sex on plasma lipoprotein levels. *Circulation* 1992;86:849-57.
- Berkel J. The clean life: some aspects of nutritional and health status of Seventh-day Adventists in the Netherlands. Amsterdam: Drukkerij Insulinde, 1979.
- Fønnebo V. The Tromsø Heart Study: coronary risk factors in Seventh-day Adventists. *Am J Epidemiol* 1985;122:789-93.
- Fønnebo V. The Tromsø Heart Study: diet, religion, and risk factors for coronary heart disease. *Am J Clin Nutr* 1988;48:826-9.
- Fraser GE, Dysinger PW, Best C, Chan R. IHD risk factors in middle-aged Seventh-day Adventist men and their neighbors. *Am J Epidemiol* 1987;126:638-46.