The Oxford Vegetarian Study: an overview[1–3]

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ABSTRACT The Oxford Vegetarian Study is a prospective study of 6000 vegetarians and 5000 nonvegetarian control subjects recruited in the United Kingdom between 1980 and 1984. Cross-sectional analyses of study data showed that vegans had lower total- and LDL-cholesterol concentrations than did meat eaters; vegetarians and fish eaters had intermediate and similar values. Meat and cheese consumption were positively associated, and dietary fiber intake was inversely associated, with total-cholesterol concentration in both men and women. After 12 y of follow-up, all-cause mortality in the whole cohort was roughly half that in the population of England and Wales (standardized mortality ratio, 0.46; 95% CI, 0.42, 0.51). After adjusting for smoking, body mass index, and social class, death rates were lower in non-meat-eaters than in meat eaters for each of the mortality endpoints studied [relative risks and 95% CIs: 0.80 (0.65, 0.99) for all causes of death, 0.72 (0.47, 1.10) for ischemic heart disease, and 0.61 (0.44, 0.84) for all malignant neoplasms]. Mortality from ischemic heart disease was also positively associated with estimated intakes of total animal fat, saturated animal fat, and dietary cholesterol. Other analyses showed that non-meat-eaters had only half the risk of meat eaters of requiring an emergency appendectomy, and that vegans in Britain may be at risk for iodine deficiency. Thus, the health of vegetarians in this study is generally good and compares favorably with that of the nonvegetarian control subjects. Larger studies are needed to examine rates of specific cancers and other diseases among vegetarians. *Am J Clin Nutr* 1999;70(suppl):525S–31S.

KEY WORDS Vegetarian, vegan, omnivore, diet, lipids, mortality, ischemic heart disease, cardiovascular disease, coronary artery disease, cancer, testosterone, hypothyroidism, appendicectomy, appendectomy, alcohol

INTRODUCTION

By the late 1970s, studies of mortality in Californian Seventh-day Adventists (SDAs), approximately half of whom were vegetarians, had suggested that SDAs had lower rates of death from major types of cancer than did the general Californian population (1) and that ischemic heart disease mortality was significantly lower in vegetarian male SDAs than in their nonvegetarian counterparts (2). Although the difference in ischemic heart disease mortality persisted after other risk factors were adjusted for, the suspicion remained that some aspect of the SDA lifestyle other than diet might account for the lower death rates (eg, few SDAs either smoke or drink alcohol). Furthermore, if the vegetarian diet did account for the lower death rates, it was thought that the same effect ought to be demonstrable in other vegetarians not belonging to a particular religious group. A large number of vegetarians lived in the United Kingdom and many of them could be contacted through The Vegetarian Society of the United Kingdom. These vegetarians would have nonvegetarian friends and relatives of similar age and socioeconomic status who would make a natural control group. With these thoughts in mind, the Oxford Vegetarian Study was designed.

The primary aim of the Oxford Vegetarian Study was to evaluate mortality in its vegetarian subjects. Particular attention was paid to cardiovascular mortality and the incidence of and mortality from common cancers that are thought to be diet related (including cancers of the digestive tract and breast), in comparison with rates for the nonvegetarian controls. Secondary aims were to compare plasma lipid concentrations among different diet groups and to assess the effects of different foods and nutrients on these concentrations, as well as to investigate other aspects of health in the diet groups.

STUDY DESIGN

The Oxford Vegetarian Study is a long-term, prospective study of the health of >11 000 persons residing in the United Kingdom at the time of recruitment; of the total sample approximately half were vegetarian. All subjects were volunteers. The vegetarian subjects were recruited through the Vegetarian Society of the United Kingdom, publicity in the national and local media, and word of mouth via subjects already recruited. Nonvegetarian subjects were recruited by the vegetarian subjects, who were asked to nominate friends and relatives of similar lifestyle and social class but who ate meat, fish, or both. It was thought that this was the most appropriate means of obtaining a nonvegetarian control group that differed from the vegetarian group primarily with respect to diet rather than other aspects of lifestyle.

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A total of 11 140 subjects were recruited between September, 1980, and January, 1984. Upon entry to the study, subjects completed a questionnaire concerning their diet (in the form of a simple food frequency questionnaire), other lifestyle factors related to health (smoking, alcohol consumption, and amount of exercise), date of birth, occupation, height and weight, medical history (including family history of serious diseases and, for women, reproductive history), and membership in vegetarian organizations. Subjects were divided into appropriate diet groups for subsequent analysis by using their answers to questions about consumption of foods of animal origin (meat, fish, milk, cheese, and eggs). At the same time, each subject was identified at the UK National Health Service central register and subsequently followed-up for information on death and cancer registration. For those subjects who subsequently died, death certificates were obtained and coded for underlying cause of death by a single investigator (JIM) by using the *International Classification of Diseases*, ninth revision (3). This coding was carried out blind to the subject's diet and other lifestyle characteristics.

Between April 1984 and January 1986, all surviving subjects under age 70 y were sent a kit consisting of a 10-mL heparin-containing tube, a syringe, and an explanatory letter for their general practitioner, who was asked to take a blood sample and send it to our laboratory in Oxford for analysis. We obtained plasma lipid measurements for 3773 subjects, a response rate of ≈40%. Total-cholesterol concentration was measured directly and LDL- and HDL-cholesterol concentrations were calculated by subtraction as described elsewhere (4). Triacylglycerol concentration was not measured because, for practical reasons, it was not possible to ensure that the blood samples were collected under fasting conditions.

In a separate exercise, between September 1985 and July 1986 all surviving subjects were sent a dietary record booklet that contained some general questions relating to their usual diet and a 4-d diet diary for completion on the first 2 weekdays after receiving the booklet and both days of the following weekend, as described elsewhere (5). The 4-d diet diaries included photographs of 3 portion sizes for each of 14 common foods; this method has been shown to produce reasonable estimates of nutrient intake in comparison with 7-d records of weighed food consumption (6). At the same time, subjects were also sent a simple form asking whether they had had an appendectomy, and if so, to give their age at the time and further details of the operation which were used to classify each appendectomy as either emergency or nonemergency. Among the general questions in the dietary record booklet was one that asked subjects to list the periods of their life, if any, during which they had not eaten meat. By combining the answers to these 2 separate questions we were able to compare self-reported emergency appendectomy rates in meat eaters and non-meat-eaters.

PLASMA LIPIDS

Plasma lipids and diet groups

The first article published about this study compared concentrations of total cholesterol and various lipoprotein fractions in 4 diet groups: vegans, who never ate animal products; vegetarians, who never ate meat or fish but did eat dairy products, eggs, or both; fish eaters, who ate fish but no meat; and meat eaters (4). Both total- and LDL-cholesterol concentrations were significantly lower in vegans than in meat eaters, whereas vegetarians and fish eaters had similar, intermediate values. HDL-cholesterol concentrations were highest in fish eaters but did not differ among the other diet groups. Mean cholesterol concentrations for vegans, vegetarians, fish eaters, and meat eaters, adjusted for age and sex, are shown in **Table 1**. On the basis of these results, it was predicted that the incidence of ischemic heart disease might be 24% lower in lifelong vegetarians and 57% lower in lifelong vegans than in meat eaters. A brief follow-up article reported that the differences in plasma lipid concentrations among the diet groups remained after further adjustment for body mass index, and a significant inverse relation between height and each of total-, LDL-, and HDL-cholesterol concentrations was found (7).

Plasma lipids and nutrient intake

The relation between diet and plasma lipids was examined further in a 1990 article (5). For this report, cholesterol concentrations in 208 subjects matched for age and sex (26 men and 26 women from each of the same 4 diet groups as in the previous analysis) were analyzed in relation to nutrient intakes calculated from their diet diaries. Macronutrient intakes and cholesterol concentrations were compared by diet group for men and women separately, and partial correlation coefficients were used to compare selected dietary variables with total- and HDL-cholesterol concentrations. Mean daily intakes of selected nutrients by diet group are shown in **Table 2**. Intakes of protein, carbohydrate, total fat, and saturated fat (each expressed as a percentage of total energy), dietary cholesterol, and dietary fiber, and the ratio of polyunsaturated to saturated fatty acids (P:S ratio) each showed significant differences among diet groups for both men and women, although there was no significant difference in total energy intake among the groups for either sex. In general, vegans consumed more carbohydrate and dietary fiber, less saturated fat, negligible quantities of dietary cholesterol, and had a higher P:S ratio than subjects in the other diet groups. Protein intake was generally lower in the non-meat-eating diet groups. There was a highly significant, positive correlation between plasma total-cholesterol concentration and the Keys dietary score (8) after controlling for age, sex, and body mass index (partial

TABLE 1
Plasma lipid concentrations by diet group, adjusted for age and sex[1]

Dietary group	Total cholesterol	LDL cholesterol	HDL cholesterol
		mmol/L	
Vegans (n = 114)	4.29 ± 0.140	2.28 ± 0.126	1.49 ± 0.048
Vegetarians (n = 1550)	4.88 ± 0.100	2.74 ± 0.090	1.50 ± 0.035
Fish eaters (n = 415)	5.01 ± 0.109	2.88 ± 0.098	1.56 ± 0.038
Meat eaters (n = 1198)	5.31 ± 0.101	3.17 ± 0.091	1.49 ± 0.035
Heterogeneity	$P < 0.001$	$P < 0.001$	$P < 0.01$

[1] $\bar{x}$ ± SE. Vegans ate no animal products; vegetarians ate no meat or fish but did eat dairy products, eggs, or both; and fish eaters ate fish but no meat.

$r = 0.37$; $P < 0.001$), with the association being much stronger than that between total cholesterol and fat intake expressed as a percentage of total energy (partial $r = 0.15$; $P < 0.05$). HDL-cholesterol concentration was positively associated with dietary cholesterol (partial $r = 0.14$; $P < 0.05$) and with alcohol intake as a percentage of total energy (partial $r = 0.26$; $P < 0.001$). It was concluded that the nature rather than the quantity of dietary fat is an important determinant of plasma cholesterol concentration, and that both the vegetarians and the nonvegetarians in this study generally selected a fat-modified, rather than a low-fat, diet.

Plasma lipids, foods, and lifestyle

The effects of dietary, lifestyle, and physical factors on total- and HDL-cholesterol concentrations in the Oxford Vegetarian Study were discussed in an article published in 1995 in which the emphasis was on individual foods rather than broad diet groups or nutrients. Stepwise multiple linear regression was used to determine which foods, lifestyle factors, and physical factors were associated with cholesterol concentrations (9). After adjusting for age, both meat and cheese consumption were positively associated and dietary fiber intake was inversely associated with total-cholesterol concentration in both men and women. Other factors that were positively associated with total-cholesterol concentration were smoking in men and the use of saturated spreading fats in women, whereas height in men was inversely associated with total-cholesterol concentration. Tomato consumption in women was positively associated with total-cholesterol concentration, although this unexpected and previously unreported finding may have been due to chance alone. In contrast, none of the dietary factors investigated had a significant effect on HDL-cholesterol concentration (except for a positive association with the use of saturated spreading fats in women). However, alcohol use was positively associated and body mass index was inversely associated with HDL-cholesterol concentration. In **Figure 1,** the percentage differences in total- and HDL-cholesterol concentrations compared with the reference group for the factors included in the regression models are shown; for each factor, one group of subjects was designated the reference group (eg, for age, the reference group was subjects <30 y). The results provided further evidence of the hypocholesterolemic effect of diets with high fiber contents and limited use of meat and cheese, and it was suggested that the exclusion of meat from the diet might result in a 15–25% reduction in risk for ischemic heart disease.

MORTALITY

Mortality by diet group

Mortality in the Oxford Vegetarian Study was first studied after an average of 12 y of follow-up (10). Subjects were divided into meat eaters (who ate meat at least once a week) and non-meat-eaters (all others). Most of the non-meat-eaters were vegetarian or vegan, although 23% of the non-meat-eaters ate meat occasionally but less than once a week, or ate fish, or both. Standardized mortality ratios (SMRs) were calculated for all causes of death, ischemic heart disease (ICD-9 410–414), and all malignant neoplasms (ICD-9 140–208), based on 404 deaths before age 80 y during the follow-up period (3). As expected, the death rate was significantly lower in the whole cohort than in the reference population of England and Wales, with SMRs (and 95% CIs) of 0.46 (0.42, 0.51) for all causes of death, 0.38 (0.30, 0.46) for ischemic heart disease, and 0.62 (0.53, 0.73) for all malignant neoplasms. The lower death rates were attributed to the so-called healthy volunteer effect and the fact that subjects were recruited from a health-conscious sector of the population. Within the cohort, death rates were lower in the non-meat-eaters than in the meat eaters for all 3 endpoints. After adjusting for differences in smoking habits, body mass index, and social class, the death rate ratios (and 95% CIs) for the non-meat-eaters compared with the meat eaters were 0.80 (0.65, 0.99) for all causes of death, 0.72 (0.47, 1.10) for ischemic heart disease, and 0.61 (0.44, 0.84) for all malignant neoplasms. The results were similar for men and women and also after restricting the analysis to subjects who had never smoked.

When the first 5 y of follow-up were excluded from the analysis, the death rate ratios became closer to unity and were no longer statistically significant, partly because the smaller number of deaths meant that the CIs were much wider [death rate ratios (and 95% CIs) for non-meat-eaters compared with meat eaters: 0.99 (0.76, 1.30) for all causes of death, 0.89 (0.51, 1.54)

TABLE 2
Daily nutrient intakes by diet group and sex[1]

Diet group	Total energy	Protein	Carbohydrate	Fat	Saturated fat	P:S ratio	Cholesterol	Dietary fiber
	MJ	*% energy*	*% energy*	*% energy*	*% energy*		*mg*	*g*
Men								
Vegan	10.8 ± 0.1	11.3 ± 0.1	52.5 ± 0.3	33.5 ± 0.3	6.2 ± 0.4	1.85 ± 0.03	7 ± 1	55.3 ± 0.8
Vegetarian	11.0 ± 0.1	12.2 ± 0.1	47.7 ± 0.2	36.4 ± 0.2	12.1 ± 0.6	0.73 ± 0.02	267 ± 6	41.8 ± 0.4
Fish eater	10.5 ± 0.1	13.6 ± 0.1	43.8 ± 0.3	38.2 ± 0.2	12.5 ± 0.7	0.73 ± 0.02	260 ± 4	37.4 ± 0.5
Meat eater	10.7 ± 0.1	14.6 ± 0.1	43.0 ± 0.2	38.1 ± 0.3	13.2 ± 0.6	0.56 ± 0.01	306 ± 5	35.0 ± 0.5
Heterogeneity	NS	$P < 0.001$	$P < 0.001$	$P = 0.045$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$
Women								
Vegan	8.0 ± 0.1	12.2 ± 0.1	51.4 ± 0.3	36.2 ± 0.3	7.4 ± 0.5	1.77 ± 0.03	4 ± 0	42.7 ± 0.5
Vegetarian	8.2 ± 0.1	12.4 ± 0.1	46.4 ± 0.2	39.6 ± 0.2	14.3 ± 0.6	0.63 ± 0.01	201 ± 3	31.3 ± 0.4
Fish eater	8.9 ± 0.1	12.1 ± 0.1	42.9 ± 0.3	40.5 ± 0.2	13.3 ± 0.8	0.75 ± 0.01	250 ± 6	29.4 ± 0.4
Meat eater	8.2 ± 0.1	15.5 ± 0.1	43.2 ± 0.2	38.7 ± 0.2	14.2 ± 0.8	0.49 ± 0.01	266 ± 4	26.8 ± 0.3
Heterogeneity	NS	$P < 0.001$	$P < 0.001$	$P = 0.045$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$

[1] $\bar{x}$ ± SE. n = 26 M, 26 F per group; P:S, polyunsaturated fatty acids:saturated fatty acids. Vegans ate no animal products; vegetarians ate no meat or fish but did eat dairy products, eggs, or both; and fish eaters ate fish but no meat.

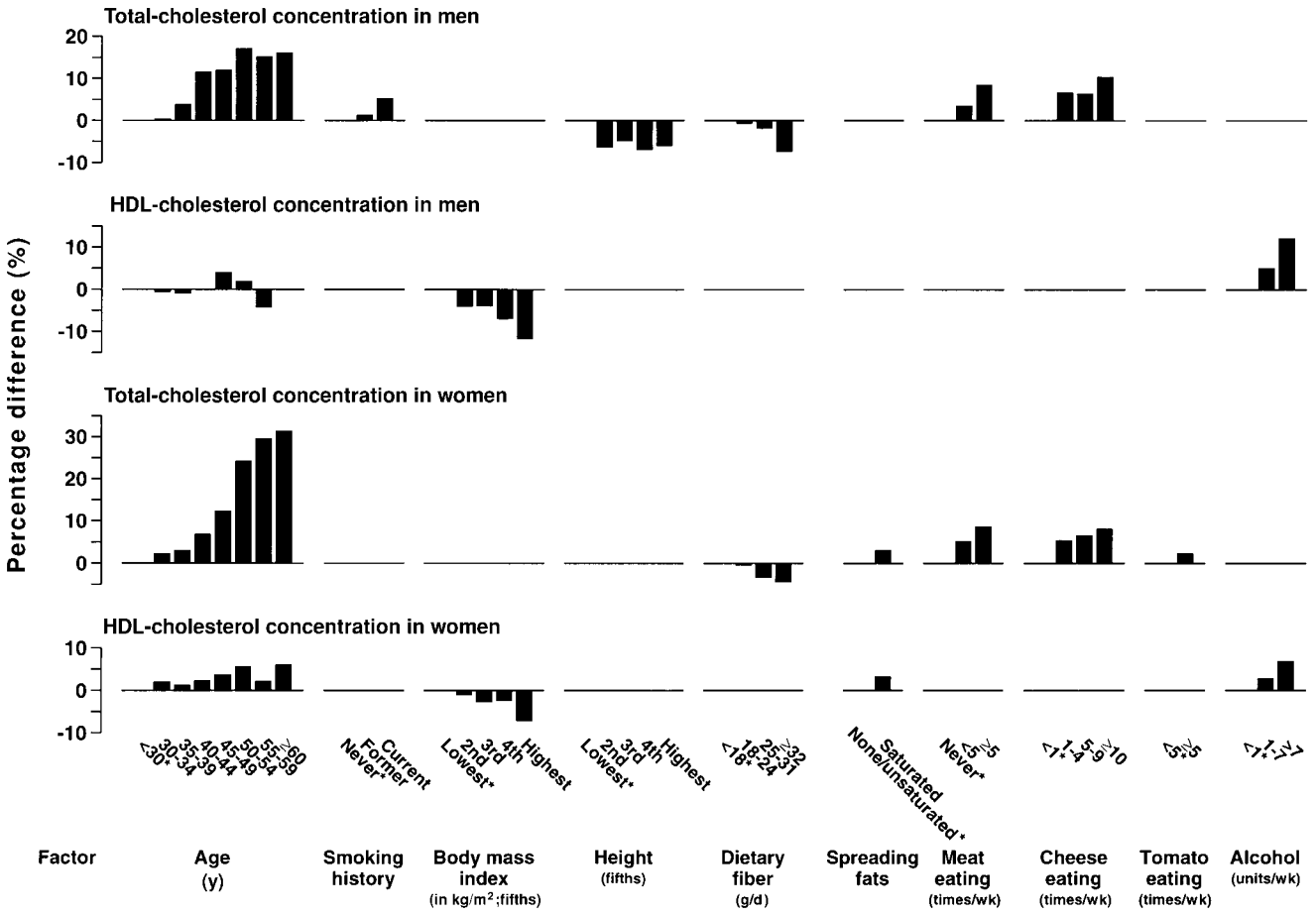

FIGURE 1. Percentage difference in cholesterol concentration compared with the reference group for factors having a statistically significant association with total-cholesterol concentration in men, HDL-cholesterol concentration in men, total-cholesterol concentration in women, and HDL-cholesterol concentration in women (9). Where bars do not appear, the factor concerned does not have a statistically significant association with that combination of sex and cholesterol fraction. One unit of alcohol was defined as 1 glass of wine, 1 measure of spirit, or a half-pint of beer or cider. *Reference group.

for ischemic heart disease, and 0.89 (0.60, 1.32) for all malignant neoplasms]. These large reductions in the apparent effect of diet group may be because the healthy volunteer effect was more pronounced in the vegetarian subjects, who were likely to have been more strongly motivated and, therefore, generally healthier than the nonvegetarian subjects at recruitment. It is also likely that there was some crossover among diet groups during the first 5 y of the study, which would dilute the apparent benefits of a meatless diet. The largest benefit noted, for mortality from all malignant neoplasms, is not in accord with the results of a recent meta-analysis of vegetarian cohort studies (11). It is also difficult to interpret results for such an all-embracing endpoint as death from all malignant neoplasms, and thus the more recent analysis of mortality data from the study described below concentrates on ischemic heart disease as a more clearly defined endpoint.

Mortality in relation to foods, animal fats, and dietary fiber

The effects of various dietary factors on mortality from ischemic heart disease and all causes of death were examined in a recent analysis (12). Subjects were grouped not only according to their diet (meat eater, semivegetarian, or vegetarian/vegan), but also by their consumption of meat, eggs, milk, cheese, fish, green vegetables, carrots, fresh or dried fruit, nuts, and alcohol, according to the answers they provided on the recruitment questionnaire. Subjects were also divided into thirds by estimated intake of total fat, saturated fat, and dietary cholesterol from land animal sources, and into thirds by estimated dietary fiber intake based on their reported consumption of fiber-rich foods. Attention was paid to the possibility of previous cardiovascular disease or diabetes at recruitment, with the main analysis restricted to subjects with no history of preexisting disease. All death rate ratios were adjusted for age, sex, smoking, and social class, and comparisons were made without reference to an external population as was the case in the earlier article. The analysis included a total of 525 deaths before age 80 y during an average of 13.3 y of follow-up; 392 of the deaths were in subjects with no history of cardiovascular disease or diabetes at recruitment, including 64 deaths from ischemic heart disease. Vegetarians and vegans had lower mortality than meat eaters (defined as subjects eating meat at least once a week) for both ischemic heart disease and all causes of death [death rate ratios (and 95% CIs): 0.63 (0.42, 0.93) and 0.91 (0.75, 1.09), respec-

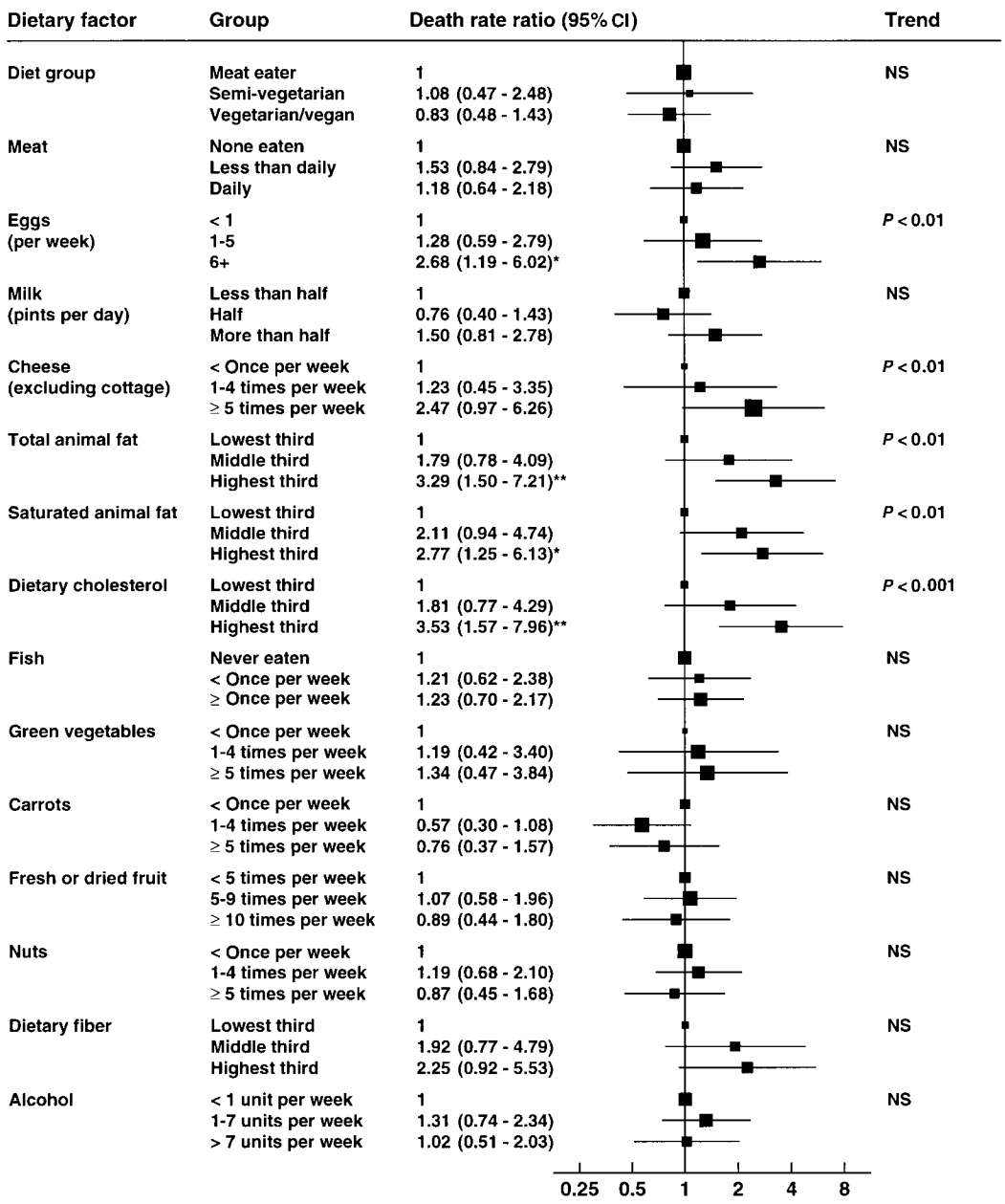

FIGURE 2. Death rate ratios (and 95% CIs) for ischemic heart disease for selected dietary factors, each adjusted for age, sex, smoking, and social class, in subjects with no history of cardiovascular disease or diabetes at recruitment. The area of each square is proportional to the number of deaths from ischemic heart disease in that group. Semi-vegetarian was defined as eating meat less than once a week, eating fish, or both. $^{*}P < 0.05$; $^{**}P < 0.01$ by Fisher's *z* test.

tively] but these effects were reduced when subjects with a history of cardiovascular disease or diabetes were excluded [death rate ratios (and 95% CIs): 0.83 (0.48, 1.43) for ischemic heart disease and 1.02 (0.82, 1.27) for all causes of death]. The most striking results from the analysis were the strong positive associations between increasing consumption of animal fats and ischemic heart disease mortality [death rate ratios (and 95% CIs) for the highest third of intake compared with the lowest third in subjects with no prior disease were 3.29 (1.50, 7.21) for total animal fat, 2.77 (1.25, 6.13) for saturated animal fat, and 3.53 (1.57, 7.96) for dietary cholesterol; *P* for trend: <0.01, <0.01, and <0.001, respectively]. In contrast, no protective effects were noted for dietary fiber, fish, or alcohol consumption. Consumption of eggs and cheese were both positively associated with ischemic heart disease mortality in these subjects (*P* for trend, < 0.01 for both foods). In **Figure 2,** the ischemic heart disease death rate ratios compared with the reference group for each of the selected dietary factors are shown. The effects of individual foods on all-cause mortality were generally indeterminate, although there was a suggestion of an inverse association with nut consumption and a U-shaped relation with the consumption of both eggs and milk.

OTHER ASPECTS OF HEALTH AND DISEASE

Comparison of emergency appendectomy rates by diet group

Dietary factors, including consumption of potatoes, other vegetables, and sugar, have been shown to be associated with acute appendicitis in Britain (13). Data from the Oxford Vegetarian Study were used to compare self-reported emergency appendectomy rates by diet group in 4852 subjects who had simultaneously completed both an appendectomy form and a separate dietary record booklet giving details of their lifetime history of meat consumption (14). The proportion of subjects that reported an emergency appendectomy was higher in lifelong meat eaters (10.7%) than in either lifelong non-meat-eaters (7.8%) or those who had stopped eating meat (8.0%), and the surgery was performed at an earlier age in the meat eaters (mean ages at operation: 18.9, 26.0, and 19.6 y, respectively). The overall age-adjusted emergency appendectomy rate ratio for non-meat-eaters compared with meat eaters was 0.47 (95% CI, 0.35, 0.65), an effect large enough to be real despite the unreliability of retrospective self-reported data concerning medical interventions. Unfortunately, the data did not allow for reliable testing of other hypotheses, and therefore meat consumption may simply be a marker for another dietary, lifestyle, or socioeconomic factor in this instance.

Sex hormone concentrations in male vegans and omnivores

In an investigation of factors thought to influence the risk of developing prostate cancer, concentrations of total testosterone, total estradiol, and sex hormone binding globulin (SHBG) were determined using plasma samples from 108 male subjects (51 vegans and 57 omnivores) who were nonsmokers, were not using long-term medication, and had no history of cardiovascular disease (15). There were no significant differences in mean concentrations of testosterone (total or free) or estradiol between vegans and omnivores, but SHBG was 23% higher in the vegans ($P = 0.001$). In 40 of these subjects who completed a diet diary, there were statistically significant correlations (adjusted for age, body mass index, and diet group) between total testosterone and polyunsaturated fatty acid intake (partial $r = 0.37$), and between SHBG and each of total fat, saturated fatty acids, polyunsaturated fatty acids, and alcohol (partial $r = 0.43$, 0.46, 0.33, and -0.39, respectively).

Thyroid-stimulating hormone in male vegans

The soil in some parts of Britain is deficient in iodine. The most important dietary source of iodine in the general population is dairy products, partly due to the high iodine content of some cattle feed. Therefore, vegans in Britain may be at risk for iodine deficiency (16). To explore this hypothesis, thyroid stimulating hormone (TSH) concentration was measured in plasma samples from 48 vegan and 53 omnivorous men (17). The geometric mean TSH concentration, adjusted for age and body mass index, was 47% higher in the vegans than in the omnivores ($P = 0.001$). Five vegans but none of the omnivores had a TSH concentration above the reference upper limit of 5 mU/L ($P = 0.022$), although only one of these subjects was found to have a thyroxine concentration below the reference range of 70–140 nmol/L. The 3 subjects with the highest TSH concentrations (but no others) all reported taking kelp supplements regularly; kelp is a rich source of iodine. After excluding the results for these subjects, the adjusted geometric mean TSH concentration was still 29% higher in the vegans ($P = 0.012$). It was concluded that the use of kelp can be associated with raised TSH and that the iodine intake of vegans who do not take kelp or other suitable supplements may be low and requires further investigation.

Asymptomatic hypothyroidism and hypercholesterolemia

The relation between biochemically diagnosed hypothyroidism and plasma cholesterol concentration was discussed in an article published in 1991 (18). Thyroid function tests were performed on 3 groups: 272 apparently healthy subjects (179 vegetarians, 93 meat eaters) with plasma cholesterol concentrations >7 mmol/L; 90 subjects who were matched for age, sex, and diet group and had plasma cholesterol concentrations <4.1 mmol/L; and 25 randomly-selected subjects. Of the subjects with high plasma cholesterol, 5.9% had biochemical evidence of hypothyroidism (5.0% of the vegetarians and 7.5% of the meat eaters; difference not significant) compared with none from either the low plasma cholesterol group or the randomly selected group. Most of these subjects with hypothyroidism had thyroid microsomal antibodies (some at very high titres) indicating that the etiology was probably autoimmune. It was concluded that hypothyroidism is relatively common in apparently healthy people with raised plasma cholesterol concentrations, but is no more common in vegetarians than in meat eaters.

Alcohol intake and cardiovascular-related disease

Data from the Oxford Vegetarian Study were used to test the hypothesis that the U-shaped curve relating alcohol consumption and cardiovascular disease may be an artifact of selection whereby individuals with high consumption and high risk of disease migrate to a low- or zero-consumption category just before inclusion. Standardized rates of self-reported previous cardiovascular-related disease were compared by diet group (meat eater, fish eater, vegetarian, vegan), smoking habits, alcohol consumption, and social class for men and women separately (19). There was no significant association between reported cardiovascular-related disease and alcohol consumption for either men or women, thus the data did not support the hypothesis. However, there was an association between diet group and cardiovascular-related disease in women, with a 15% excess in the observed number of meat-eating women with previous disease compared with the expected number after adjustment for age, smoking, drinking, and social class. A similar, though smaller, 8% excess of cardiovascular-related disease was found in male meat eaters.

FUTURE STUDY

The Oxford Vegetarian Study has largely achieved its aims. Mortality in the vegetarian subjects has been evaluated and compared with that of the nonvegetarian control subjects for major causes of death. The plasma lipid concentrations of different diet groups have been compared and we have examined the effects of different foods and nutrients on these concentrations. In substudies, we have *1*) compared hormone concentrations in male vegans and omnivores, *2*) investigated the prevalence of hypothyroidism in hyperlipidemic subjects, *3*) compared emergency appendectomy rates of meat eaters and non-meat-eaters, and *4*) studied the relation between previous cardiovascular-related disease and alcohol consumption.

The size of the study has precluded meaningful investigation of the mortality from and incidence of specific diet-related cancers. Over time, the numbers of cases and deaths from specific cancers will rise, but the gap between recruitment and the event

grows ever larger, making classifications based on the original questionnaire increasingly unreliable. Meta-analyses of vegetarian cohort studies can address this problem to some extent and mortality data from the Oxford Vegetarian Study have been incorporated into a meta-analysis of vegetarian cohort studies described elsewhere in this supplement (11).

A better solution is to design and perform larger cohort studies in which the greater number of subjects provides reasonable numbers of events for specific cancers and other diseases within a period of time during which dietary and other lifestyle factors might be assumed to remain constant; these factors could also be investigated with follow-up questionnaires. With an estimated 5% of the British population now following a vegetarian diet (20), the recruitment of large numbers of vegetarians to a cohort study poses less of a problem than it did in the early 1980s. In addition, improvements in the design of food frequency questionnaires and diet diaries mean that the dietary information collected in contemporary studies is both more comprehensive and more reliable.

The European Prospective Investigation into Cancer and Nutrition (EPIC) Study of diet and cancer should yield reliable information on the relations between diet and both mortality and morbidity (21). In the United Kingdom, 85 000 individuals have been recruited to the study, of whom 25 000 are vegetarians, and therefore this study should produce much more data on the long-term health of Western vegetarians.

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