Mortality in vegetarians and non-vegetarians: a collaborative analysis of 8300 deaths among 76,000 men and women in five prospective studies

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Abstract

Objective: To compare the mortality rates of vegetarians and non-vegetarians.

Design: Collaborative analysis using original data from five prospective studies. Death rate ratios for vegetarians compared to non-vegetarians were calculated for ischaemic heart disease, cerebrovascular disease, cancers of the stomach, large bowel, lung, breast and prostate, and for all causes of death. All results were adjusted for age, sex and smoking. A random effects model was used to calculate pooled estimates of effect for all studies combined.

Setting: USA, UK and Germany.

Subjects: 76,172 men and women aged 16–89 years at recruitment. Vegetarians were those who did not eat any meat or fish ($n = 27,808$). Non-vegetarians were from a similar background to the vegetarians within each study.

Results: After a mean of 10.6 years of follow-up there were 8330 deaths before the age of 90 years, including 2264 deaths from ischaemic heart disease. In comparison with non-vegetarians, vegetarians had a 24% reduction in mortality from ischaemic heart disease (death rate ratio 0.76, 95% CI 0.62–0.94). The reduction in mortality among vegetarians varied significantly with age at death: rate ratios for vegetarians compared to non-vegetarians were 0.55 (95% CI 0.35–0.85), 0.69 (95% CI 0.53–0.90) and 0.92 (95% CI 0.73–1.16) for deaths from ischaemic heart disease at ages <65, 65–79 and 80–89 years, respectively. When the non-vegetarians were divided into regular meat eaters (who ate meat at least once a week) and semi-vegetarians (who ate fish only or ate meat less than once a week), the ischaemic heart disease death rate ratios compared to regular meat eaters were 0.78 (95% CI 0.68–0.89) in semi-vegetarians and 0.66 (95% CI 0.53–0.83) in vegetarians (test for trend $P < 0.001$). There were no significant differences between vegetarians and non-vegetarians in mortality from the other causes of death examined.

Conclusion: Vegetarians have a lower risk of dying from ischaemic heart disease than non-vegetarians.

Keywords
Vegetarian
Mortality
Ischaemic heart disease
Colorectal cancer

The number of vegetarians is increasing in many Western countries. Studies of risk factors for chronic disease have shown that vegetarians have lower serum cholesterol concentrations, lower body mass indices, and possibly lower blood pressures than comparable non-vegetarians[1], but the associations of a vegetarian diet with mortality from specific causes are not firmly established[2].

Five prospective cohort studies set out to include a large proportion of vegetarians and also to include non-vegetarians with a shared interest in healthy living or a similar social/religious background. Each study has reported some evidence that infrequent meat consumption or vegetarianism was associated with a reduction in mortality from ischaemic heart disease, but some of these individual results were not statistically

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significant or were not observed in both sexes[3–7]. The current analysis sought to reanalyse these five studies together using, as far as possible, common definitions in order to provide an overall estimate of any association of a vegetarian diet with the risk of death from ischaemic heart disease and to explore whether such an association varied with sex, age, duration of vegetarianism and the presence of cardiovascular disease or diabetes at recruitment.

There is some evidence suggesting that meat consumption increases the risk for cancers of the colorectum[8], breast[9] and prostate[10]. In previous analyses of food consumption and cancer mortality among Seventh-day Adventists, meat consumption was weakly associated with an increased mortality from prostate cancer[11] but not with mortality from cancers of the colorectum and breast[12,13]. We sought to extend these observations by combining the five studies of vegetarians to give reasonable power for detecting associations with mortality for these cancer sites. We also report mortality from cerebrovascular disease, stomach cancer and lung cancer, although for these causes of death there was no strong *a priori* hypothesis that a vegetarian diet would be associated with mortality.

The data available enabled us to classify subjects in all the studies as to whether or not they were vegetarian. However, the data were not sufficient to enable us to estimate nutrient intakes, or even to assess the consumption of important food groups in a comparable way across all the studies.

This paper reports the main findings. Further details of the studies and further analyses of mortality will be published separately[14].

Subjects and methods

Studies

We identified five prospective cohort studies which have deliberately recruited vegetarians or populations known to contain a large proportion of vegetarians (Table 1). The Adventist Mortality study recruited members of the Seventh-day Adventist church from 198 congregations in California; follow-up for mortality was by record linkage and personal contact (follow-up for this study until 31 December 1965 only is used in this analysis). The Health Food Shoppers study recruited people in Britain from health food shops, vegetarian societies and magazines; follow-up was by record linkage with the National Health Service Central Register. The Adventist Health study recruited Seventh-day Adventists from throughout California; follow-up was through record linkage with the California death certificate file, the National Death Index and church records. There is no overlap between the follow-up periods in the two studies of Seventh-day Adventists. The Heidelberg study cohort was recruited through vegetarian magazines in the former Federal Republic of Germany; follow-up was through the registrar's office of the last place of residence. The Oxford Vegetarian study cohort was recruited through the Vegetarian Society of the UK and the news media, with non-vegetarians recruited from the friends and relatives of vegetarians; follow-up was the same as for the Health Food Shoppers study, and 863 subjects who were members of both these cohorts were excluded from the Health Food Shoppers study and retained in the Oxford Vegetarian study because the latter collected more information on potential confounding variables.

Definitions and main analyses

Subjects were eligible for analysis if they were aged 16–89 years at recruitment, if they had not been diagnosed with cancer before recruitment (except for ICD9 173, non-melanoma skin cancer), and if they had sufficient information for classifying diet group and smoking category. Information on existing cardiovascular disease and diabetes at recruitment was available for four of the studies, and the influence of prior disease on the results was examined in a subanalysis.

The main analysis compared vegetarians with non-vegetarians. In the Health Food Shoppers study vegetarians were people who replied yes to the question 'Are you a vegetarian?'; 289 subjects were interviewed between 1.5 and 6 years after the recruitment questionnaire was completed, and of these subjects 66% of those who initially reported that they were vegetarian were then eating meat or fish less than once a month[15]. This suggests that the single question on the recruitment form is informative but that

Table 1 Description of the studies

Study	Location	Median (range) year of recruitment	Number of subjects[1]	End of follow-up	Total person-years at risk
Adventist Mortality	California	1960 (1959–1960)	24,538	31/12/1965	138,304
Health Food Shoppers	Britain	1974 (1973–1979)	9878	31/12/1995	182,156
Adventist Health	California	1976 (1976–1980)	28,952	31/12/1988	320,818
Heidelberg	Germany	1978 (1978–1981)	1757	31/05/1989	17,317
Oxford Vegetarian	Britain	1981 (1980–1984)	11,047	31/12/1995	150,799

[1] Number of subjects aged 16–89 years at recruitment for whom data on smoking and diet group were available.

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there is some misclassification and probably some real dietary change. In the other four studies there were questions on the frequency of consumption of various types of meat and fish, and vegetarians were defined as people who reported that they did not eat any meat or fish, with non-vegetarians defined as all other people. There was sufficient information from all studies to subdivide the vegetarians according to whether they had followed their current diet for up to 5 years or for more than 5 years; in the two studies of Seventh-day Adventists the surrogate variable age at baptism was used, because Adventists who follow a vegetarian diet typically establish this behaviour at the time of baptism into the church.

Smoking was categorized in four groups: (a) never smoked; (b) ex-smoker; (c) current light smoker (1–14 cigarettes per day and/or other tobacco user); and (d) current heavy smoker (15 or more cigarettes per day). This information was available from all studies with the following exceptions:

- in the Adventist Mortality study the cut-off point between light and heavy smoking was 20 cigarettes per day;
- in the Health Food Shoppers study there was no information on ex-smokers and all non-current smokers were therefore categorized as never smokers;
- in the Adventist Health study the information on amount smoked was for the maximum ever smoked and this was therefore assumed to be the current consumption in current smokers;
- in the Heidelberg study there was no information on amount smoked and all smoking was assumed to be light because the prevalence of smoking was very low in this study (4.3% current smokers).

Adjustment for potential confounders

The principal analyses included all subjects for whom we had sufficient data to allow categorization as described above for diet group and smoking. We also explored the effects of adjusting the results for four potential confounders: body mass index, alcohol intake, education and exercise. Men and women were categorized into thirds of the distribution of body mass index for all men and all women respectively. Alcohol intake was categorized as regular drinker or non-regular drinker; definitions varied between studies but the guideline was that regular drinking is at least one alcoholic drink per week. Education was classified as high, equivalent to American high school or above, or low; for the Oxford Vegetarian study social class only was available and social classes I and II were considered equivalent to high education. Exercise was classified as high or low on the basis of criteria used to define the level of physical activity in each study. For these four potential confounding variables there were some missing data in each study, and there was no information at all on body mass index, alcohol, education or exercise in the Health Food Shoppers study and no information on exercise for any women in the Adventist Mortality study.

Causes of death and statistical methods

The endpoints examined were ischaemic heart disease (ICD9 410–414), cerebrovascular disease (ICD9 430–438), stomach cancer (ICD9 151), colorectal cancer (ICD9 153 and 154), lung cancer (ICD9 162), female breast cancer (ICD9 174), prostate cancer (ICD9 185) and all causes of death.

Subjects were censored on reaching the age of 90 years. Person-years at risk were calculated using the Person-Years computer program[16], and death rate ratios for vegetarians compared to non-vegetarians in each study were calculated by Poisson regression using GLIM-4. All death rate ratios were adjusted for age (< 40, 40–44,...85–89), sex and smoking. The death rate ratios for the separate studies were then combined to give a pooled estimate of effect using the random effects model of DerSimonian and Laird[17], which also yields a test for heterogeneity between studies.

Results

Smoking rates varied between studies, but in all five studies the proportion of smokers was lower among the vegetarians than among the non-vegetarians (Table 2). Vegetarians had a consistently lower mean body mass index and a lower percentage of current alcohol drinkers, but a consistently higher percentage of high exercisers. Variations between vegetarians and non-vegetarians in level of education were small and inconsistent.

Subjects were followed for a mean of 10.6 years. Table 3 shows the death rate ratios for vegetarians compared to non-vegetarians in each study, adjusted for age, sex and smoking, together with the test for heterogeneity between studies, the all studies estimate from the random effects model, and the numbers of deaths from each cause. There was evidence of heterogeneity between studies for mortality from ischaemic heart disease, breast cancer and, especially, for mortality from all causes combined.

For ischaemic heart disease, the death rate ratio for vegetarians versus non-vegetarians varied between studies from 0.45 to 0.97. The all studies rate ratio was 0.76 (95% CI 0.62–0.94). None of the death rate ratios for other causes of death was statistically significant for all studies together, although some of the individual study results were statistically significant in different directions. For all cause mortality the all study rate ratio was 0.95 (0.82–1.11).

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Table 2 Characteristics of the subjects

Study	Diet group	Number[1]	Number of deaths before age 90	Median age (years)	% Current smoker	Mean body mass index (kg m^{-2})	% Current alcohol	% High education	% High exercise
Men									
Adventist Mortality	Non-vegetarian	5023	423	49	7.2	25.7	2.0	54.4	77.9
	Vegetarian	3971	303	51	2.9	24.6	0.7	63.3	81.2
Health Food Shoppers	Non-vegetarian	2462	598	46	30.6	–	–	–	–
	Vegetarian	1519	385	41	20.1	–	–	–	–
Adventist Health	Non-vegetarian	9045	1372	52	8.5	25.4	14.0	78.7	65.8
	Vegetarian	3169	362	51	0.2	23.8	0.4	86.5	71.3
Heidelberg	Non-vegetarian	304	33	45	9.9	22.1	29.4	62.8	34.8
	Vegetarian	480	58	43	4.2	21.3	14.1	56.4	40.3
Oxford Vegetarian	Non-vegetarian	2572	208	34	29.1	23.0	86.0	67.9	62.6
	Vegetarian	1603	168	33	17.5	22.0	63.2	64.8	67.4
Women									
Adventist Mortality	Non-vegetarian	9257	491	50	1.2	25.1	1.6	51.6	–
	Vegetarian	6287	418	54	0.1	24.0	0.7	59.7	–
Health Food Shoppers	Non-vegetarian	3626	640	45	18.0	–	–	–	–
	Vegetarian	2271	504	47	12.3	–	–	–	–
Adventist Health	Non-vegetarian	11,904	1332	52	2.7	24.8	4.8	78.4	51.9
	Vegetarian	4834	498	54	0.2	23.0	0.2	85.4	54.9
Heidelberg	Non-vegetarian	370	19	49	3.2	21.3	24.9	46.6	32.8
	Vegetarian	603	75	53	2.2	20.9	7.3	43.7	37.0
Oxford Vegetarian	Non-vegetarian	3801	216	34	18.5	22.1	76.3	59.9	58.4
	Vegetarian	3071	227	32	13.4	21.3	56.5	60.1	65.4

[1] Number of subjects aged 16–89 years at recruitment for whom data on smoking and diet group were available. Data on body mass index, alcohol, education and exercise were not available for the Health Food Shoppers study, and data on exercise were missing for women in the Adventist Mortality study. Overall, data on body mass index, alcohol, education and exercise were available for 81.5, 83.4, 83.0 and 66.1% of subjects, respectively.

Table 3 Death rate ratios (95% confidence intervals) for vegetarians versus non-vegetarians

Study	Ischaemic heart disease	Cerebrovascular disease	Stomach cancer	Colorectal cancer	Lung cancer	Female breast cancer	Prostate cancer	All causes
Adventist Mortality	0.74 (0.63–0.88)	0.65 (0.48–0.87)	0.64 (0.30–1.36)	1.37 (0.73–2.56)	–	0.65 (0.28–1.52)	1.41 (0.49–4.04)	0.83 (0.76–0.92)
number of deaths	598	182	30	41	6	26	15	1635
Health Food Shoppers	0.97 (0.81–1.16)	0.99 (0.78–1.26)	1.23 (0.62–2.47)	0.90 (0.58–1.39)	1.13 (0.67–1.92)	1.74 (1.11–2.72)	1.31 (0.65–2.66)	1.11 (1.02–1.21)
number of deaths	521	292	34	90	66	79	32	2127
Adventist Health	0.62 (0.53–0.73)	0.93 (0.73–1.19)	1.58 (0.68–3.70)	1.01 (0.66–1.56)	0.69 (0.37–1.27)	0.52 (0.27–0.97)	0.79 (0.44–1.41)	0.80 (0.74–0.87)
number of deaths	921	317	26	104	96	64	66	3564
Heidelberg	0.45 (0.22–0.95)	1.69 (0.69–4.15)	–	–	–	–	–	1.17 (0.85–1.63)
number of deaths	29	31	8	5	2	5	3	185
Oxford Vegetarian	0.90 (0.68–1.20)	1.17 (0.76–1.80)	–	0.94 (0.49–1.80)	0.66 (0.31–1.37)	1.10 (0.57–2.12)	0.42 (0.16–1.09)	1.00 (0.87–1.15)
number of deaths	195	87	9	38	33	36	21	819
χ^2_4 for heterogeneity	15.98	8.73	4.83	2.56	2.52	10.89	4.71	36.09
P for heterogeneity	< 0.01	NS	NS	NS	NS	< 0.05	NS	< 0.0001
All studies	0.76 (0.62–0.94)	0.93 (0.74–1.17)	1.02 (0.64–1.62)	0.99 (0.77–1.27)	0.84 (0.59–1.18)	0.95 (0.55–1.63)	0.91 (0.60–1.39)	0.95 (0.82–1.11)
number of deaths	2264	909	107	278	203	210	137	8330

NS denotes *P* for heterogeneity > 0.05. Death rate ratios are adjusted for age, sex and smoking. The tests for heterogeneity and the all studies death rate ratios were obtained using a random effects model. Number of deaths refers to deaths before the age of 90 years. No death rate ratio is given where the number of deaths is less than 10.

The association of vegetarianism with mortality was further examined in relation to sex, age, duration of current diet among vegetarians, and diet in three groups (regular meat, fish only or occasional meat, vegetarian). The results for ischaemic heart disease are described below; similar analyses for mortality from cancers of the colorectum, breast and prostate did not show any significant associations (results not shown).

Further analyses of vegetarianism and mortality from ischaemic heart disease

The ischaemic heart disease death rate ratios for vegetarians compared to non-vegetarians among men and women were 0.69 (0.56–0.84) and 0.80 (0.67–0.95), respectively. This difference was not statistically significant.

The reduction in mortality was greater at younger ages than at older ages, with rate ratios of 0.55, 0.69 and 0.92 for deaths at ages < 65, 65–79 and 80–89 years, respectively (test for trend $P = 0.02$; Table 4).

To assess whether the duration of diet was associated with mortality from ischaemic heart disease we subdivided the vegetarians according to whether they had followed their current diet for up to 5 years or for more than 5 years. There was no reduction in mortality among the minority of vegetarians who had followed their diet for 5 years or less, but the majority of vegetarians had followed their diet for more than 5 years and in comparison with non-vegetarians their death rate ratio was 0.74 (0.60–0.90) (Table 5).

The heterogeneity between studies in the association of a vegetarian diet with mortality from ischaemic heart disease could not be explained by the variation between studies in the distribution of age at death or by the variation in the proportion of vegetarians who had followed their diet for more than 5 years (results not shown).

In four studies there was information on the frequency of meat consumption (not available for the Health Food Shoppers study), and this was used to subdivide the non-vegetarians into regular meat eaters (those who ate meat at least once a week) and semi-vegetarians (those who ate fish only or who ate meat occasionally but less than once a week). In comparison with regular meat eaters (reference group), the death rate ratio for ischaemic heart disease was 0.78 in the semi-vegetarians and 0.66 in the vegetarians (test for trend $P < 0.001$; Fig. 1).

Table 4 Ischaemic heart disease death rate ratios for vegetarians versus non-vegetarians by age at death

Age at death (years)	Death rate ratio (95% CI)	Number of deaths
< 65	0.55 (0.35–0.85)	259
65–79	0.69 (0.53–0.90)	1086
80–89	0.92 (0.73–1.16)	919

Death rate ratios are adjusted for age (within categories), sex and smoking, and for study using a random effects model.

Table 5 Ischaemic heart disease death rate ratios by duration of diet

Duration of diet	Death rate ratio (95% CI)	Number of deaths
Non-vegetarian	1.00 (reference group)	1530
Vegetarian ≤ 5 years	1.20 (0.90–1.61)	49
Vegetarian > 5 years	0.74 (0.60–0.90)	625

Death rate ratios are adjusted for age, sex and smoking, and for study using a random effects model. Duration was unknown for 1785 vegetarians.

Adjustment for potential confounding factors

Information on alcohol, education, exercise and body mass index was available for 43,038 subjects, of whom 1047 died from ischaemic heart disease before the age of 90 years. Restricting the data set reduced the death rate ratio from 0.76 to 0.61 (0.53–0.70), largely because of the elimination of the Health Food Shoppers study, but adjustment for alcohol consumption, educational level and exercise changed the death rate ratio only slightly from 0.61 to 0.64 (0.53–0.77). Further adjustment for body mass index also had very little effect (death rate ratio increased to 0.66 (0.55–0.79)).

Mortality from ischaemic heart disease among people with and without a history of cardiovascular disease or diabetes at recruitment

Information on cardiovascular disease (heart disease, stroke and high blood pressure) and diabetes at recruitment was not available for the Health Food Shoppers study, but among the other four studies this information was complete for 96.0% of participants. The prevalence of these diseases at recruitment was lower in vegetarians than in non-vegetarians in all four studies, and among subjects for whom prior disease status was known the overall proportions with prior cardiovascular disease or diabetes were 16.5% and 24.1% among vegetarians and non-vegetarians, respectively.

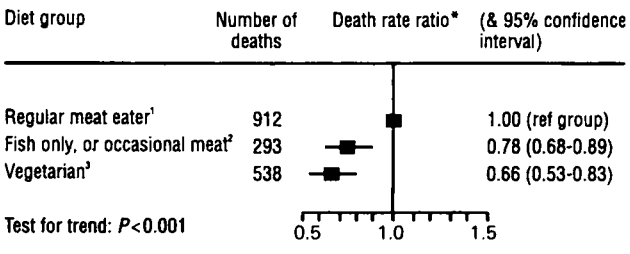

Fig. 1 Ischaemic heart disease death rate ratios by diet group. * Death rate ratios are adjusted for age, sex and smoking, and for study using a random effects model. [1] Meat eaten at least once per week. [2] Fish but not meat eaten, or meat eaten less than once per week. [3] No meat or fish eaten.

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The all study ischaemic heart disease death rate ratio for vegetarians compared to non-vegetarians, with the results for each study adjusted for age, sex and smoking, was 0.80 (0.70–0.92) among participants with a history of prior disease and 0.76 (0.59–0.97) among participants without a history of prior disease.

Discussion

We have pooled the data from five large prospective studies. As far as we know this is all the data available concerning mortality in Western-style vegetarians. The all study death rate ratios represent the average experience of vegetarians in comparison with non-vegetarians with a broadly similar life-style. It should be noted that the overall standardized mortality ratios (SMRs) for all causes of death were considerably below 100% in all four studies for which these values have been published. Thus, SMRs for all subjects (vegetarians and non-vegetarians combined) were 49% in the Adventist Mortality study[18], 56% in the Health Food Shoppers study[19], 48% in the Heidelberg study[6], and 46% in the Oxford Vegetarian study[7], no SMRs having been published for the Adventist Health study. Therefore, certain aspects of life-style shared by the vegetarians and the non-vegetarians in these studies appear to confer a substantial reduction in mortality in comparison with national rates. Much of this reduction in mortality is due to the relatively low prevalence of smoking in these cohorts, but some of it might also be due to differences in diet between the subjects studied and the general population in each country.

The principal finding of this pooled analysis is that vegetarians had a 24% lower mortality from ischaemic heart disease than non-vegetarians. This reduction in mortality was greater at younger ages, with a 45% reduction in risk of death from ischaemic heart disease before the age of 65 years. The reduction was confined to those who were assessed to have been vegetarian for more than 5 years, and was increased when the reference group was restricted to those who ate meat at least once a week (34% reduction). The reduction in mortality was little affected by adjustment for alcohol intake, education, exercise and body mass index, suggesting that it cannot be explained by confounding by these variables.

The highly significant association observed and the association with the amount of meat consumed, together with the absence of evidence of confounding, suggest that the reduction in mortality from ischaemic heart disease is caused by the dietary differences between vegetarians and non-vegetarians. Furthermore, the reduction in mortality from ischaemic heart disease was substantial regardless of whether or not participants had evidence of cardiovascular disease or diabetes at recruitment, suggesting that this result is not due to self selection of exceptionally healthy vegetarians[20].

Vegetarian diets can differ in many ways from non-vegetarian diets, and vegetarian diets themselves vary between different vegetarian groups, therefore it is impossible to draw any conclusions as to which aspect of the diet is protective. One possible explanation for the lower mortality from ischaemic heart disease among the vegetarians is that they have lower serum total cholesterol concentrations than non-vegetarians, largely because meat is a major source of hypercholesterolaemic saturated fatty acids but probably augmented by the hypocholesterolaemic effects of some plant foods[21]. Measurements of serum cholesterol concentrations in samples of participants in three of the studies have demonstrated lower total serum cholesterol concentrations in the vegetarians than in the non-vegetarians: 0.61 mmol l^{-1} lower in the Health Food Shoppers study[22]; 0.43 mmol l^{-1} lower in the Oxford Vegetarian study[23]; and 0.33 mmol l^{-1} lower in the Heidelberg study[24]. Differences of a similar size have been observed in a comparison of vegetarian and non-vegetarian Seventh-day Adventists[25]. Law *et al.*[26] estimated that a 0.6 mmol l^{-1} difference in total serum cholesterol concentration would cause a 27% difference in mortality from ischaemic heart disease. This suggests that the lower mortality from ischaemic heart disease in the vegetarians could be largely due to their lower total serum cholesterol. It is also possible that some of the reduction in mortality from ischaemic heart disease in vegetarians is due to other mechanisms such as reduced oxidation of low density lipoprotein cholesterol or changes in blood clotting[21].

There was heterogeneity between studies in the reduction in mortality from ischaemic heart disease among vegetarians. The reduction in mortality was greatest in the Adventist studies and in Heidelberg and least in the two British studies. We were unable to identify variables which explained this heterogeneity. Earlier analyses of the Health Food Shoppers cohort reported larger reductions in mortality from ischaemic heart disease in association with vegetarianism: a 31% reduction with follow-up until 1980[15] and a 29% reduction with follow-up until 1985[5]. The most recent separate publication from this cohort, however, reported only a 15% reduction in mortality from ischaemic heart disease among vegetarians with follow-up until 1995 (for deaths before the age of 80 years)[19]; this decrease in the size of the reduction in risk associated with vegetarianism might be due to changes in diet during the long follow-up for this study. Some heterogeneity between studies would be expected, because the dietary differences between vegetarians and non-vegetarians will vary between different populations, but we did not have sufficient dietary data from these studies to evaluate this fully.

Our results suggest that being a vegetarian *per se* does not have a substantial effect on the risk of death from colorectal cancer, although it should be noted that, as for the other cancer sites examined, the number of deaths is an order of magnitude lower than for ischaemic heart disease and the confidence intervals do not exclude moderate associations. Our results are similar to those in a study of cancer mortality among nuns with different dietary patterns, some of whom did not eat any meat[27]. Some large well-designed prospective studies have found a direct relationship between red meat consumption and the incidence of colon cancer[28,29], but other comparable studies have not found any relationship[30,31], and a very large prospective study found no association between frequency of red meat consumption and mortality from colon cancer[32]. It is possible that meat may be associated more with the incidence of colorectal cancer than with mortality from this disease, or that meat is only an important risk factor among people with a low intake of certain plant foods, but the absence of any association of vegetarianism with colorectal cancer mortality in the current analysis suggests that meat (and fish) may have little effect on the development of this cancer and that other dietary hypotheses, such as a detrimental effect of refined carbohydrates, deserve more careful evaluation[33].

Our analyses did not show significantly lower mortality from breast cancer or prostate cancer among vegetarians. We were not able to adjust the analysis of breast cancer mortality for established reproductive risk factors because we did not have this information from all the studies, but the result is consistent with previous reports from three of the studies in the current analysis[13,19,34], with other studies of vegetarianism and breast cancer[27,35], and with the negative results of a collaborative analysis of prospective studies of total fat, fat type and breast cancer risk[36]. For prostate cancer, a previous analysis of data from the Adventist Mortality study showed a weak relationship with meat consumption and a stronger relationship with total consumption of meat, milk, cheese and eggs[11]. In the current analysis we found a non-significant 9% reduction in prostate cancer mortality among vegetarians, suggesting that meat (and fish) may have only a minor effect on prostate cancer mortality.

For the other causes of death examined (cerebrovascular disease, lung cancer, stomach cancer) no marked association with vegetarianism was expected and none was observed. The all study estimate of all cause mortality was 5% lower in vegetarians than in non-vegetarians, but the confidence intervals for this estimate were relatively wide because of the substantial heterogeneity between studies.

In conclusion, this analysis has shown that vegetarians have a lower mortality from ischaemic heart disease than non-vegetarians, but has not established any associations of a vegetarian diet with other major causes of death.

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