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Risk of death from cancer and ischaemic heart disease in meat and non-meat eaters

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Abstract

Objective—To investigate the health consequences of a vegetarian diet by examining the 12 year mortality of non-meat eaters and meat eating controls.

Design—Prospective observational study in which members of the non-meat eating cohort were asked to nominate friends or relatives as controls.

Setting—United Kingdom.

Subjects—6115 non-meat eaters identified through the Vegetarian Society of the United Kingdom and the news media (mean (SD) age 38·7 (16·8) years) and 5015 controls who were meat eaters (39·3 (15·4) years).

Main outcome measures—Standardised mortality ratios for cancer, ischaemic heart disease, and total mortality in the two cohorts and death rate ratio in the non-meat eaters compared with meat eaters after adjustment for potentially confounding variables.

Results—Standardised mortality ratios (taking the value among the general population as 100) for ischaemic heart disease were 51 (95% confidence interval 38 to 66) for meat eaters and 28 (20 to 38) for non-meat eaters (P<0·01). Values for all cancers were 80 (64 to 98) and 50 (39 to 62) for meat eaters and non-meat eaters respectively. After adjustment for the effects of smoking, body mass index, and socioeconomic status death rate ratios in non-meat eaters compared with meat eaters were 0·72 (0·47 to 1·10) for ischaemic heart disease and 0·61 (0·44 to 0·84) for all cancers.

Conclusions—The reduced mortality from cancer among those not eating meat is not explained by lifestyle related risk factors, which have a low prevalence among vegetarians. No firm conclusion can be made about deaths from ischaemic heart disease. These data do not justify advice to exclude meat from the diet since there are several attributes of a vegetarian diet apart from not eating meat which might reduce the risk.

Introduction

The diet of vegetarians differs from that of meat eaters in several respects other than the avoidance of meat. Vegetarians have a high intake of vegetables, fruit, cereals, pulses, and nuts and their diet is therefore low in saturated fat and relatively high in unsaturated fats, carbohydrate, and non-starch polysaccharides (dietary fibre).[1] The micronutrient content of the diet also differs from that of meat eaters. Intake of several antioxidant nutrients is higher, while intakes of iron, zinc, and vitamin B12 are lower among vegetarians than meat eaters.[2] Several of the characteristics of a vegetarian diet have been shown to favourably influence cardiovascular risk factors[1,3-5] and some have been associated in epidemiological studies with a reduced risk of ischaemic heart disease or certain cancers.[6,7] Previous studies have reported lower mortality in vegetarians but they have used subjects who are members of religious or other groups or the data on confounding factors in the comparison group has been inadequate.[8-10] Vegetarians tend to be thinner, smoke less, and are generally of higher socioeconomic status than the general population, all factors which are major determinants of total, cardiovascular, and cancer mortality. In an attempt to quantify any beneficial effects of a vegetarian diet and to determine the extent to which diet rather than lifestyle related risk factors determines the favourable mortality in vegetarians we studied mortality in about 6000 non-meat eaters and 5000 meat eating controls.

Subjects and methods

We recruited subjects between September 1980 and January 1984. Non-meat eaters were identified through advertisements in publications of the Vegetarian Society of the United Kingdom, the news media, and by word of mouth. Two of us (MT and JM) recruited subjects and no pressure was put on any members of the Vegetarian Society to participate. Of the 6115 non-meat eaters recruited 5728 were vegetarians (who did not eat meat or fish or ate these foods less than once a week, but did eat eggs or dairy products, or both) or vegans (who did not eat meat, fish, eggs, or dairy products) and 387 were fish eaters (who did not eat meat or ate meat less than once a week, may or may not have eaten eggs or dairy products, and ate fish at least once a week). A total of 2347 of the non-meat eaters were members of vegetarian or vegan societies, 24 were Seventh Day Adventists, and the

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remainder were not known to have any affiliation to religious, cultural, or societal groups advocating vegetarianism. To identify a comparison cohort of meat eaters who were similar to the non-meat eaters with regard to socioeconomic status and lifestyle factors other than diet we asked participants to nominate friends and relatives. They identified 5015 meat eaters, all of whom ate meat at least once a week. Each participant completed a questionnaire concerning diet, lifestyle factors related to health (for example, smoking), medical history, and weight and height (from which body mass index was calculated).

At recruitment the record of each participant was flagged at the NHS central register, and we obtained death certificates for those who subsequently died. Underlying causes of death were coded by a single observer (JM) using the ninth revision of the International Classification of Diseases. He was unaware whether the person who had died was a meat eater or non-meat eater. Initial coding was based on the information available on the death certificate, but for each death we attempted to obtain clinical data from hospital records and, when appropriate, postmortem reports. The box gives the definitions of causes of mortality. Each subject was observed until reaching the age of 80. Observation was continued up to 31 March 1993.

Definition of main end points

All cause mortality—All deaths occurring under the age of 80, including those of unknown cause
Ischaemic heart disease mortality—Deaths under age 80 from causes ICD codes 410-414
Cancer mortality—Deaths under age 80
Causes: ICD codes 140-208

STATISTICAL ANALYSIS

Subjects were assigned to one of 240 subgroups according to diet, sex, smoking history, body mass index, and social class. For each of these 240 subgroups we calculated the number of person years of observation and the expected number of deaths using mortality data for England and Wales for each of nine age groups using the person-years (PYRS) computer program. The 11 130 subjects in the analysis contributed more than 100 000 person years at risk. Linear models of the form $\log (d_{ijk}) = \log (r_{ij} Y_{ijk}) + a + b_k$ were fitted, where i denotes sex, j denotes age-subdivision, k denotes lifestyle group (defined as a particular combination of diet, smoking, body mass index, and social class), d_{ijk}=observed number of deaths for particular causes in sex-age-lifestyle group (ijk), r_{ij}=England and Wales mortality in sex-age group (ij), Y_{ijk}=total person years of observation (that is, number of years at risk, in sex-age-lifestyle group (ijk)), a=a constant term to be estimated in the model fitting, and b_k=a term associated with lifestyle group (k) to be estimated in the model fitting. These data were analysed with the GLIM statistical software package with the expected numbers of deaths acting as the rate multiplier. Standardised mortality ratios for each cause of death category were calculated as the ratio of the observed to the expected numbers of deaths for various subgroups. We calculated death rate ratios and 95% confidence intervals comparing non-meat eaters with meat eaters, both unadjusted and adjusted for various combinations of smoking history, body mass index, and social class.

Results

Table I shows some of the health related characteristics for those members of the two cohorts for whom all relevant information was available. The high proportion of subjects whose social class was defined as "other" is explained by the substantial number who were past retirement age. The cohorts were quite well matched for cigarette smoking habit and social class, but meat eaters tended to have a higher body mass index than non-meat eaters.

Hospital or postmortem data were available for 200 of the 404 subjects who died during the study period. Ninety four participants died of ischaemic heart disease and 164 from cancer. In only five cases did the information derived from hospital or postmortem data suggest an underlying cause of death different from that on the death certificate, and in no case was this sufficient to change the cause of death categories used in the analyses.

After 12 years of follow up the standardised mortality ratio for the whole cohort (meat eaters and non-meat eaters) for all causes was 46 (95% confidence interval 42 to 51). Table II shows the standardised mortality ratio for each diet, smoking, body mass index, and social class group for the three causes of death categories and table III the observed and expected deaths from which the standardised mortality ratios were calculated. Non-meat eaters had significantly lower standardised mortality ratios for all causes, ischaemic heart disease, and cancer than meat eaters. Current heavy smokers had significantly higher all cause and ischaemic heart disease standardised mortality ratios than those who had never smoked and a higher but not significantly different mortality from cancer. There were no associations between body mass index and mortality, and though subjects in social

TABLE I—*Health characteristics of meat eaters and non-meat eaters. Figures are numbers (percentages) unless stated otherwise*

	Meat eaters (n=4912)	Non-meat eaters (n=5927)
Mean (SD) age (years)	39·3 (15·4)	38·7 (16·8)
Female	2761 (56)	3966 (67)
Smoking habit:		
Never smoked cigarettes	2449 (50)	3378 (57)
Smoked previously	1301 (26)	1602 (27)
Current light smoker (<10 cigarettes a day)	471 (10)	466 (8)
Current heavy smoker (≥10 cigarettes a day)	691 (14)	481 (8)
Body mass index:		
1st quintile <19·9	633 (13)	1510 (25)
2nd quintile 19·9-21·0	806 (16)	1351 (23)
3rd quintile 21·1-22·2	980 (20)	1149 (19)
4th quintile 22·3-24·0	1184 (24)	1107 (19)
5th quintile ≥24·1	1309 (27)	810 (14)
Social class (Registrar general's classification):		
I and II	2501 (51)	2795 (47)
III, IV, and V	1364 (28)	1574 (27)
Other (including students and retired)	1047 (21)	1558 (26)

TABLE II—*Standardised mortality ratios (95% confidence interval) for the three cause of death categories by subgroups*

Subset	All causes	Ischaemic heart disease	All malignant neoplasms
All subjects	46 (42 to 51)	38 (30 to 46)	62 (53 to 73)
Diet:			
Meat eater	54 (47 to 62)	51 (38 to 66)	80 (64 to 98)
Non-meat eater	41† (35 to 46)	28† (20 to 38)	50† (39 to 62)
Smoking habit:			
Never smoked	40 (34 to 47)	26 (18 to 37)	60 (47 to 74)
Smoked previously	44 (37 to 52)	41 (30 to 56)	58 (44 to 76)
Current light smoker	60* (42 to 84)	52 (24 to 99)	81 (44 to 136)
Current heavy smoker	91‡ (68 to 119)	84‡ (46 to 140)	88 (50 to 143)
Body mass index:			
First quintile	54 (43 to 68)	36 (19 to 61)	69 (46 to 99)
Second quintile	39 (29 to 51)	15 (5 to 35)	58 (37 to 88)
Third quintile	40 (31 to 52)	20 (8 to 39)	65 (44 to 94)
Fourth quintile	47 (38 to 57)	52 (35 to 74)	59 (41 to 82)
Fifth quintile	49 (41 to 58)	47 (33 to 64)	62 (46 to 82)
Social class:			
I-II	42 (34 to 50)	27 (16 to 41)	58 (44 to 76)
III-V	52 (40 to 65)	33 (17 to 58)	77 (54 to 106)
Others	47 (42 to 54)	45 (34 to 58)	60 (47 to 75)

*P<0·05, †P<0·01, ‡P<0·001 (two tailed test) when the subgroup indicated is compared with the baseline subgroup (meat eater, never smoked, first quintile body mass index, social classes I-II).

TABLE III—*Observed and expected numbers of deaths from the three cause of death categories in the various subgroups given below*

Subset	All causes		Ischaemic heart disease		All malignant neoplasms	
	Observed	Expected	Observed	Expected	Observed	Expected
All subjects	404	871·8	94	249·1	164	262·5
Diet:						
Meat eater	201	370·6	55	108·3	89	111·2
Non-meat eater	203	501·2	39	140·9	75	151·3
Smoking habit:						
Never smoked	171	424·9	30	115·5	77	129·4
Smoked previously	145	330·5	41	99·6	57	97·7
Current light smoker	35	57·9	9	17·3	14	17·3
Current heavy smoker	53	58·4	14	16·7	16	18·2
Body mass index:						
First quintile	74	136·1	13	36·2	28	40·7
Second quintile	49	126·9	5	33·6	23	39·3
Third quintile	59	146·7	8	40·8	29	44·5
Fourth quintile	92	196·9	30	57·6	35	59·1
Fifth quintile	130	265·2	38	80·9	49	78·9
Social class:						
I-II	112	269·2	20	74·9	52	89·2
III-V	71	137·0	12	36·2	36	46·9
Others	221	465·6	62	138·1	76	126·4

TABLE IV—*Adjusted death rate ratios and 95% confidence intervals (non-meat eaters v meat eaters) for each cause of death category by different confounding variables*

	Cause of death		
	All cause	Ischaemic heart disease	All malignant neoplasms
Unadjusted	0·75 (0·62 to 0·91)	0·55 (0·36 to 0·82)	0·62 (0·46 to 0·84)
Adjusted for single factors:			
Smoking	0·80 (0·66 to 0·98)	0·62 (0·41 to 0·94)	0·63 (0·46 to 0·86)
Body mass index	0·74 (0·61 to 0·91)	0·62 (0·40 to 0·94)	0·59 (0·43 to 0·81)
Social class	0·75 (0·62 to 0·91)	0·55 (0·37 to 0·84)	0·61 (0·46 to 0·84)
Adjusted for all three factors	0·80 (0·65 to 0·99)	0·72 (0·47 to 1·10)	0·61 (0·44 to 0·84)

TABLE V—*Adjusted death rate ratios and 95% confidence intervals (non-meat eaters v meat eaters) in never smokers for each cause of death category by different confounding variables*

	Cause of death		
	All cause	Ischaemic heart disease	All malignant neoplasms
Unadjusted	0·85 (0·62 to 1·15)	0·54 (0·26 to 1·09)	0·63 (0·40 to 0·98)
Adjusted:			
Body mass index	0·81 (0·59 to 1·11)	0·55 (0·26 to 1·17)	0·56 (0·35 to 0·89)
Social class	0·85 (0·63 to 1·16)	0·52 (0·24 to 1·10)	0·63 (0·40 to 0·99)
Body mass index plus social class	0·81 (0·59 to 1·12)	0·59 (0·28 to 1·24)	0·56 (0·35 to 0·89)

classes III, IV, and V had higher standardised mortality ratios for all three causes of death than those in social classes I and II, differences were not significant.

We carried out further analyses to determine whether the differences in lifestyle characteristics between the two cohorts (table I) could explain the differences in mortality. Poisson regression modelling was used to fit a "main effects" model to the data for each cause of death category in order to estimate a death rate ratio in non-meat eaters compared with meat eaters after adjustment for the confounding effects of difference in the smoking habit, body mass index, and social class. The unadjusted death rate ratios (non-meat eaters v meat eaters) showed a significant reduction in all cause, ischaemic heart disease, and cancer mortality (table IV). Adjustment for the three variables studied (smoking, body mass index, and social class) had little impact on the reduced cancer mortality among vegetarians. The effect of diet on all cause mortality was reduced after adjustment but remained significant. The effect on ischaemic heart disease mortality was also reduced and became insignificant, suggesting that this apparent effect could be an artefact of unmeasured residual confounding.

Current and previous smoking affect the risk of ischaemic heart disease and several cancers. To eliminate potential confounding due to cigarette smoking we reanalysed the data excluding subjects who had ever smoked (table V). The death rate ratios were similar to those of the whole group, although the smaller number of deaths resulted in wider confidence intervals. We

also attempted to investigate the extent to which the "healthy volunteer" effect (which results in lower than expected mortaltiy during the first few years of a cohort study) might have influenced the results. Standardised mortality ratios and death rate ratios were recalculated excluding deaths that occurred during the first five years of a subject joining the study. There was little change in the standardised mortality ratios for the whole cohort (meat eaters and non-meat eaters); 37 (28 to 48) for ischaemic heart disease mortality and 68 (56 to 82) for cancer mortality. However, death rate ratios were reduced. Death rate ratios adjusted for smoking, body mass index, and social class, were 0·89 (0·51 to 1·54), for ischaemic heart disease, 0·8 (0·60 to 1·32) for all cancers, and 0·99 (0·76 to 1·30) for all cause mortality. The wide confidence intervals, once again resulting from the reduced number of deaths available for analysis preclude a firm conclusion.

Discussion

These data confirm the findings of previous studies that have shown a reduction in all cause, cancer, and cardiovascular mortality among people who do not eat meat.[8-10] The main feature of our study is that we included a control group, which enabled us to estimate the extent to which lifestyle factors other than diet account for the reduced mortality among vegetarians. Our subjects had a low mortality, with the standardised mortality ratio for the whole cohort being 46. This can be explained by the low exposure to lifestyle related risk factors.[12] Smoking rates were low, and those who did smoke were relatively light smokers (they smoked on average 11·6 (SD 9·8) cigarettes a day), obesity was uncommon, and a high proportion of the subjects were of high socioeconomic status. The low rate of lifestyle related risk factors may explain our failure to show significant associations between body mass index, social class, and mortality from all causes, cancer, and ischaemic heart disease. It may also explain the absence of a significant association between heavy smoking and death from all cancers.

The roughly 40% reduction in mortality from cancer in vegetarians and fish eaters compared with meat eaters was unaffected by adjustment for the important lifestyle variables by Poisson regression. Moreover, the adjusted death rate ratios were little changed when those subjects who had never smoked were considered separately. Unfortunately, we had insufficient subjects to be able to analyse data for individual cancers. The low rates of ischaemic heart disease among vegetarians seem to be partly explained by the different smoking prevalence. The point estimate of death rate ratio in non-meat eaters compared with meat eaters was compatible with a reduction in mortality from ischaemic heart disease among vegetarians after adjustment for the three lifestyle variables. However, the wide confidence intervals preclude a firm conclusion. The fact that total mortality was about 20% lower in the non-meat eating group than the meat eaters is perhaps of greatest clinical importance. The difference was significant in the groups as a whole and the point estimate was unchanged when only non-smokers were considered, although the confidence interval was wider.

VALIDITY OF RESULTS

The two cohorts are not representative of the general population of the United Kingdom, but this does not affect the validity of the comparisons between meat eaters and non-meat eaters. Vegetarians tend to be health conscious, regardless of the reason for which they have chosen such dietary practices. The controls similarly had a low rate of lifestyle related risk factors.

No pressure to participate was put on any of the subjects, and we do not believe that the two cohorts differed from any other vegetarians and health conscious meat eaters living in the United Kingdom. Volunteers in cohort studies are known to have lower rates of cancer and other serious diseases at recruitment to studies and therefore to have a low initial mortality, which will contribute to the low overall mortality. This would seem to apply to our study. A reanalysis of the data excluding deaths within the first five years of follow up showed little overall change in standardised mortality ratios but a reduced death rate ratio when comparing non-meat eaters with meat eaters. As a reduced number of deaths were available for this analysis the confidence intervals were too wide to determine whether this is a real effect, and further analysis of the cohort in a few years' time will be important.

The finding of reduced mortality from cancer and the possibility of reduced mortality from ischaemic heart disease are biologically plausible. Vegetarians have lower blood pressure,[13] low density lipoprotein cholesterol concentration,[4] and lower proportions of arachidonate, eicosapentaenoate and docosahexaenoate in platelet phospholipid.[14] On the other hand, platelet phospholipid linoleate and antioxidant concentrations are higher in vegetarians. These factors are likely to lead to reduced oxidation of low density lipoprotein and a reduced tendency to both atherogenesis and thrombogenesis.[15] Some biological markers for cancer show a more favourable profile of risk in vegetarians than meat eaters.[16-18]

In the light of current data it is more difficult to disentangle which features of the vegetarian diet are responsible for conferring the protective effect. Epidemiological and experimental studies suggest that the reduced intake of saturated fatty acids and animal protein or the relatively high intake of vegetable protein, n-3 and n-6 unsaturated fatty acids, carbohydrate, non-starch polysaccharide, and dietary antioxidants, all of which are characteristics of the vegetarian diet, could help to explain the reduced risk of cancer and ischaemic heart disease.[15] The elegant dietary intervention studies from Western Australia suggest that more than one dietary factor is involved in the hypotensive effect of a vegetarian diet.[13] The finding that regular consumption of nuts is associated with a reduced risk of coronary heart disease supports the suggestion that dietary characteristics other than not eating meat at least partly explain the beneficial effect of vegetarianism.[19] A nested case control study of those who died from ischaemic heart disease and cancer and controls in our study may help to define more clearly the foods and nutritional characteristics which confer the protective effect.

DIETARY IMPLICATIONS

Our data do not provide justification for encouraging meat eaters to change to a vegetarian diet. However, they do confirm that those who have chosen to do so might expect reductions in premature mortality due to cancer and possibly ischaemic heart disease. The reduced cancer mortality seems largely due to diet and is not appreciably changed when other lifestyle related variables are controlled for. The protective effects of diet (40% for cancer mortality and 20% for total mortality) are large. Dietary change may be a key determinant of the reduction in total mortality. Current recommendations in most Western countries advise people to adopt many of the attributes of a vegetarian diet, but do not advise excluding meat. This advice seems appropriate in the light of our results.

Clinical implications

● Cancers and ischaemic heart disease are the main causes of death in adults and are partly related to diet

● Previous studies have suggested reduced mortality from cancers and ischaemic heart disease in vegetarians, but the results could have been explained by reduced levels of several risk factors among vegetarians

● In this study the 40% reduction in cancer mortality in non-meat eaters compared with meat eaters could not be explained by differences in smoking habits, obesity, and socioeconomic status

● Some attributes of the vegetarian diet seem to have a beneficial effect on premature mortality

● The results do not justify advice to exclude meat since several features of a vegetarian diet apart from not eating meat might reduce the risk

Only a large randomised trial would provide conclusive evidence for the benefits of a vegetarian diet, but such a trial is unlikely to be undertaken.

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