Mortality in British vegetarians: review and preliminary results from EPIC-Oxford[1–4]

Timothy J Key, Paul N Appleby, Gwyneth K Davey, Naomi E Allen, Elizabeth A Spencer, and Ruth C Travis

ABSTRACT

Background: Three prospective studies have examined the mortality of vegetarians in Britain.

Objective: We describe these 3 studies and present preliminary results on mortality from the European Prospective Investigation into Cancer and Nutrition–Oxford (EPIC-Oxford).

Design: The Health Food Shoppers Study and the Oxford Vegetarian Study were established in the 1970s and 1980s, respectively; each included about 11 000 subjects and used a short questionnaire on diet and lifestyle. EPIC-Oxford was established in the 1990s and includes about 56 000 subjects who completed detailed food frequency questionnaires. Mortality in all 3 studies was followed though the National Health Service Central Register.

Results: Overall, the death rates of all the subjects in all 3 studies are much lower than average for the United Kingdom. Standardized mortality ratios (95% CIs) for all subjects were 59% (57%, 61%) in the Health Food Shoppers Study, 52% (49%, 56%) in the Oxford Vegetarian Study, and 39% (37%, 42%) in EPIC-Oxford. Comparing vegetarians with nonvegetarians within each cohort, the death rate ratios (DRRs), adjusted for age, sex and smoking, were 1.03 (0.95, 1.13) in the Health Food Shoppers Study, 1.01 (0.89, 1.14) in the Oxford Vegetarian Study, and 1.05 (0.86, 1.27) in EPIC-Oxford. DRRs for ischemic heart disease in vegetarians compared with nonvegetarians were 0.85 (0.71, 1.01) in the Health Food Shoppers Study, 0.86 (0.67, 1.12) in the Oxford Vegetarian Study, and 0.75 (0.41, 1.37) in EPIC-Oxford.

Conclusions: The mortality of both the vegetarians and the nonvegetarians in these studies is low compared with national rates. Within the studies, mortality for major causes of death was not significantly different between vegetarians and nonvegetarians, but the nonsignificant reduction in mortality from ischemic heart disease among vegetarians was compatible with the significant reduction previously reported in a pooled analysis of mortality in Western vegetarians. *Am J Clin Nutr* 2003;78(suppl):533S–8S.

KEY WORDS Vegetarians, mortality, United Kingdom, EPIC-Oxford

INTRODUCTION

Three prospective studies have been set up to study the long-term health and mortality of vegetarians in Britain. The Health Food Shoppers Study (1–3) and the Oxford Vegetarian Study (4) were established in the 1970s and 1980s, respectively; each included about 11 000 subjects and used a relatively short questionnaire. The European Prospective Investigation into Cancer and Nutrition–Oxford (EPIC-Oxford) cohort was established in the 1990s and includes about 56 000 subjects who completed a detailed food frequency questionnaire (5).

Results from the 2 older studies have been reported in several papers, and in particular these 2 studies contributed to the collaborative study of mortality in vegetarians reported at the Third International Congress on Vegetarian Nutrition (6, 7). Since that publication, we have conducted further analyses of both these studies with extended follow-up and including comparisons of the mortality rates in these cohorts with the population average mortality for England and Wales (8). In this paper we start by summarizing the most recent follow-up from these 2 older cohorts, then describe the preliminary results from the new EPIC-Oxford cohort, and end by drawing overall conclusions on the mortality experience of British vegetarians in these 3 studies.

Health Food Shoppers Study

The Health Food Shoppers Study cohort was recruited between 1973 and 1979 from the customers of health food shops, members of vegetarian societies, and readers of relevant magazines (1–3). Subjects lived throughout the United Kingdom and joined the study by completing a short (one-page) questionnaire. Nearly 11 000 subjects were recruited, of whom 10 736 could be characterized according to diet and smoking habits; 43% of these were vegetarians. Follow-up was by record linkage with the National Health Service Central Register. There were 2346 deaths before age 90 up to 31 December 1997 (8). The standardized mortality ratio (SMR) for all causes of death for the whole cohort was 59% (95% CI, 57%, 61%). The SMRs for vegetarians and nonvegetarians for all causes of death were 59% (55%, 63%) and 59% (56%, 62%), respectively. Comparisons of death rates between vegetarians and nonvegetarians within the cohort were made using Cox regression to calculate death rate ratios (DRRs), adjusted for age, sex, and smoking. For all-cause mortality, the DRR in vegetarians compared with nonvegetarians was 1.03 (0.95, 1.13). For specific

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[4] Address reprint requests to TJ Key, Cancer Research UK Epidemiology Unit, University of Oxford, Gibson Building, Radcliffe Infirmary, Oxford OX2 6HE, United Kingdom. E-mail: tim.key@cancer.org.uk.

causes of death examined, the only significant difference between vegetarians and nonvegetarians was for mortality from breast cancer [DRR in vegetarians = 1.73 (1.11, 2.69)]; this difference was noted in an earlier analysis of this cohort and may be partly due to lower parity among the vegetarians (3). Mortality from ischemic heart disease (IHD) was lower in vegetarians than in nonvegetarians, but this difference was not statistically significant [DRR = 0.85 (0.71, 1.01)].

Oxford Vegetarian Study

The Oxford Vegetarian Study cohort was recruited between 1980 and 1984 through the Vegetarian Society of the United Kingdom and the news media, with nonvegetarians recruited by the vegetarian participants from among their friends and relatives (4). More than 11 000 subjects were recruited, of whom 11 045 could be characterized according to diet and smoking habits; 42% of these were vegetarians. Follow-up was by record linkage with the National Health Service Central Register. There were 1131 deaths before age 90 up to 30 June 2000. The SMR for all causes of death for the whole cohort was 52% (49%, 56%). The SMRs for vegetarians and nonvegetarians for all causes of death were 51% (47%, 56%) and 54% (49%, 58%), respectively. Comparisons of death rates between vegetarians and nonvegetarians within the cohort were made using Cox regression to calculate DRRs, adjusted for age, sex, and smoking. For all-cause mortality, the DRR in vegetarians compared with nonvegetarians was 1.01 (0.89, 1.14). For specific causes of death examined, the only significant difference between vegetarians and nonvegetarians was for mortality from mental and neurological diseases [International Classification of Disease-9 (ICD-9) 290–389: DRR in vegetarians = 2.46 (1.21, 5.01)]; this result was based on only 36 deaths. Mortality from IHD was lower in vegetarians than in nonvegetarians, but this difference was not statistically significant [DRR = 0.86 (0.67, 1.12)].

SUBJECTS AND METHODS

Recruitment of subjects

The EPIC-Oxford cohort is one component of the European Prospective Investigation into Cancer and Nutrition, a collaborative study of 500 000 men and women in 10 European countries (9). The EPIC-Oxford cohort was recruited between 1993 and 1999. Further details of the recruitment methods and the baseline characteristics of the participants have been described elsewhere (5).

Two methods of recruitment were used: general practice (GP) recruitment and postal recruitment. A Multi-Centre Research Ethics Committee approved the protocol. EPIC nurses working in GP surgeries in Oxfordshire, Buckinghamshire, and Greater Manchester carried out recruitment from the general population through GPs. All men and women aged 35–69 y on each collaborating GP's list were invited to participate. Questionnaires were mailed to consenting participants, and appointments were made to attend the GP's surgery for an interview with the nurse. The nurse took anthropometric and blood pressure measurements, took a 30-mL blood sample, and checked the completed questionnaire. In addition, a pilot recruitment phase was conducted by collaborating GPs in Scotland who recruited 900 women aged 40–59 y from those attending the surgery for other reasons. The GP method recruited 7379 participants, comprising 21.2% of the meat eaters, 1.2% of the fish eaters, 0.4% of the vegetarians, and no vegans.

Postal recruitment, aimed at those aged 20 y and over, was designed to recruit as many vegetarians and vegans as possible. The main questionnaire was mailed directly to all members of the Vegetarian Society of the UK and all surviving participants in the Oxford Vegetarian Study (4). Respondents were invited to give names and addresses of relatives and friends who might also be interested in receiving a questionnaire. In addition, a short questionnaire (or insert) was distributed to all members of the Vegan Society, enclosed in health and diet magazines, and displayed on health food shop counters. The questionnaire was contained on a single page that could be folded and sealed for prepaid return mailing to the study office. Questions on this insert were limited to 4 dietary categorization questions, date and place of birth, sex, height, weight, age of leaving school, smoking history, alcohol consumption, and brief medical history. The main questionnaire was then mailed to all those who returned an insert indicating an interest in receiving it. Participants who were recruited by these postal methods and who completed the main questionnaire were asked if they would be willing to provide a blood sample. The participant's GP was then approached to take a blood sample on behalf of EPIC-Oxford. These 2 postal methods recruited 58 050 participants, comprising 78.8% of the meat eaters, 98.8% of the fish eaters, 99.6% of the vegetarians, and all of the vegans.

Diet group, food, and nutrient intakes

Participants were categorized into 1 of 4 diet groups according to their replies to 4 questions: Do you eat meat? Do you eat fish? Do you eat dairy products? Do you eat eggs? From these 4 questions, 4 diet groups were established: meat eaters (those that eat meat), fish eaters (those that do not eat meat but do eat fish), vegetarians (those that do not eat meat or fish but do eat dairy products and/or eggs), and vegans (those that eat no animal products). For the women recruited in the pilot phase of the study, and the first 1300 men and women recruited by EPIC nurses, these 4 dietary categorization questions were not asked and diet group was assigned according to responses provided in the food frequency questionnaire (see below).

Participants completed a food frequency questionnaire based on that used in the US Nurses' Health Study (10), modified for use in and validated in the United Kingdom (11, 12). Each participant estimated average frequency of intake of 130 foods and drinks over the previous 12 mo: never or less than once a month, 1–3 times per month, once a week, 2–4 times per week, 5–6 times per week, once a day, 2–3 times per day, 4–5 times per day, or ≥6 times per day. Daily mean nutrient intakes were estimated using standard portion sizes, derived largely from the Ministry of Agriculture, Fisheries and Food (13), and nutrient contents from the fifth edition of McCance and Widdowson's The Composition of Foods (14) and its supplements.

Food diary

A 7-d food diary was distributed to each participant, either at the nurse recruitment interview, or, for those that joined the study by post, a few months after the completion of the main questionnaire. Exactly 31 088 diaries were completed and returned. The data in the food diaries will be reported in future publications.

Nondietary characteristics

Self-reported height and weight were recorded in the main questionnaire, except for the first 2215 participants recruited by a GP or nurse, for whom only height and weight measured by the

nurse were recorded. These data were used to calculate body mass index (BMI; in kg/m^2).

Participants were further characterized according to their smoking habits and alcohol consumption, and were asked to report if they had been diagnosed with any of a list of specified diseases or conditions, and to give details of prescribed medication for any condition.

Follow-up

All participants are followed up by record linkage with the National Health Service Central Register, which provides information on cancer diagnoses and deaths. In addition, participants are sent a follow-up questionnaire for self-completion ≈ 5 y after joining the study. The questionnaire is designed to provide information on changes in lifestyle, diet, and morbidity from a range of common diseases.

Statistical analysis

Statistical analysis was performed with the use of STATA software (version 7.0; Stata Corporation, College Station, TX).

Participants were categorized as either nonvegetarians (ie, meat eaters and fish eaters) or vegetarians (lactoovovegetarians and vegans). The analyses reported here were restricted to participants aged 20–89 y at recruitment for whom smoking characteristics were known and diet group was unambiguous. SMRs for vegetarians and nonvegetarians were calculated from deaths before age 90 by comparison with contemporary mortality data for England and Wales; the SMR is the ratio of the observed number of deaths compared with the number of deaths expected from the national rates, expressed as a percentage. Cox regression was used to calculate DRRs comparing death rates among participants with no prior disease for various factors including diet group, adjusted for age, sex, and smoking. No prior disease was defined as having no previous diagnosis of myocardial infarction, angina, stroke, diabetes, or cancer. Age was categorized as fourteen 5-y age groups from 20–24 y to 85–89 y. Smoking was categorized as never smoker, former smoker, light smoker, or heavy smoker: heavy smokers were those smoking 15 or more cigarettes per day; light smokers were all other current smokers, including pipe or cigar smokers; and never smokers were those who had never smoked one or more cigarettes per day for at least 1 y. Statistical significance was set at the 5% level, and 95% confidence intervals were calculated for both the SMRs and the DRRs.

RESULTS

Subject characteristics

The total number of participants in EPIC-Oxford is 65 429 men and women, aged 20–97 y. For some participants only a short questionnaire was completed, and the analyses presented here are based on 55 041 participants aged 20–89 y at recruitment with known smoking characteristics and diet group for whom complete questionnaire data and follow-up were available at the time of writing. The characteristics of these participants are given in **Table 1**. Thirty-two percent of subjects were vegetarians. About three quarters of the participants were women. Median age at recruitment was 11 y lower in the vegetarians than in the nonvegetarians. Smoking rates were low overall, with only 10% of vegetarians and 12% of nonvegetarians reporting that they were smokers at the time of recruitment. Median BMI was 1.2 lower in vegetarians than in nonvegetarians, and median alcohol consumption was 0.5 g/d lower in vegetarians than in nonvegetarians.

TABLE 1
Characteristics of nonvegetarians and vegetarians in EPIC-Oxford[1]

Characteristic	Nonvegetarians	Vegetarians
Subjects [*n* (%)]	37 267 (67.7)	17 774 (32.3)
Female [*n* (%)]	28 941 (77.7)	13 335 (75.0)
Median age at entry (y)	47	36
Smoking[2] [*n* (%)]		
Never smoker	21 636 (58.1)	11 215 (63.1)
Former smoker	11 152 (29.9)	4743 (26.7)
Light smoker	2659 (7.1)	1239 (7.0)
Heavy smoker	1820 (4.9)	577 (3.2)
BMI, kg/m^2 [*n* (%)][3]		
<20	3583 (9.9)	3032 (17.8)
20–22.49	10 302 (28.5)	6195 (36.3)
22.5–24.99	10 291 (28.5)	4408 (25.8)
25–27.49	6297 (17.4)	1990 (11.7)
≥27.5	5653 (15.6)	1443 (8.5)
Median	23.4	22.2
Previous disease [*n* (%)][3,4]	2628 (7.9)	558 (3.4)
Alcohol consumption, g/d [*n* (%)][3]		
<1	5796 (15.9)	3771 (21.6)
1–7	15 651 (43.0)	7027 (40.3)
8–15	8807 (24.2)	3940 (22.6)
≥16	6182 (17.0)	2712 (15.5)
Median	5.8	5.3

[1] EPIC, European Prospective Investigation into Cancer and Nutrition. The differences between nonvegetarians and vegetarians in sex, age, smoking status, BMI, previous disease, and alcohol consumption are all significant, $P < 0.0001$.

[2] Heavy smokers smoked ≥15 cigarettes/d; light smokers included all other current smokers, including pipe or cigar smokers; never smokers were those who had never smoked ≥1 cigarette/d for ≥1 y. Percentages may not add to exactly 100 because of rounding.

[3] Categories or values are unknown for some participants.

[4] Previous disease refers to reported previous myocardial infarction, angina, stroke, diabetes, or cancer.

SMRs

Table 2 shows the SMRs for EPIC-Oxford for various causes of death based on deaths before age 90 up to 30 June 2002. There were 973 deaths overall, giving an SMR for all-cause mortality for the whole cohort of 39% (37%, 42%). The SMRs for all-cause mortality in nonvegetarians and vegetarians were 39% (36%, 42%) and 40% (35%, 45%) respectively. In both diet groups, SMRs were below 100% for every cause of death category examined, significantly so in many cases.

Mortality rates in relation to smoking, BMI, alcohol consumption, and vegetarian diet

Table 3 shows the DRRs for smoking, BMI, alcohol consumption, and vegetarian status in relation to deaths from circulatory diseases (and separately within this category for IHD and for cerebrovascular disease), all malignant neoplasms, all other causes, and all causes combined. These analyses were restricted to the 46 562 subjects with known smoking habits and diet group and no reported prior disease (myocardial infarction, angina, stroke, diabetes, or cancer) at the time of recruitment. After a mean follow-up period of 5.9 y, there were 558 deaths before age 90 among these subjects up to 30 June 2002.

TABLE 2
Standardized mortality ratios (SMRs) for selected causes of death among 55 041 participants (nonvegetarians and vegetarians) in EPIC-Oxford[1]

Cause of death	Nonvegetarians		Vegetarians	
	Deaths	SMRs	Deaths	SMRs
	n	*% (95% CI)*	*n*	*% (95% CI)*
All malignant neoplasms (140–208)[2]	288	45 (40, 51)	83	46 (37, 57)
Stomach cancer (151)	6	25 (9, 53)	1	14 (0, 76)
Colorectal cancer (153–154)	27	43 (28, 62)	15	84 (47, 138)
Cancer of the pancreas (157)	17	65 (38, 104)	6	83 (31, 181)
Lung cancer (162)	39	28 (20, 39)	8	22 (9, 43)
Female breast cancer (174)	33	36 (25, 51)	8	31 (14, 62)
Ovarian cancer (183)	21	65 (40, 99)	5	62 (20, 146)
Prostate cancer (185)	13	59 (31, 100)	4	50 (14, 129)
Bladder and other urinary cancer (188–189, excluding 189.0)	5	32 (10, 75)	1	21 (1, 117)
Benign and unspecified neoplasms (210–239)	7	84 (34, 172)	1	38 (1, 213)
Endocrine diseases (240–279)	5	18 (6, 43)	3	34 (7, 101)
Diabetes mellitus (250)	4	19 (5, 48)	2	30 (4, 108)
Diseases of the blood (280–289)	3	53 (11, 156)	1	51 (1, 283)
Mental disorders (290–319)	5	25 (8, 59)	4	43 (12, 111)
Diseases of the nervous system (320–389)	17	48 (28, 77)	5	40 (13, 94)
Circulatory diseases (390–459)	267	38 (34, 43)	92	40 (32, 49)
Ischemic heart disease (410–414)	146	37 (31, 43)	41	33 (24, 45)
Cerebrovascular disease (430–438)	66	41 (32, 53)	29	52 (35, 75)
Respiratory diseases (460–519)	45	19 (14, 25)	12	14 (7, 25)
Digestive diseases (520–579)	24	31 (20, 46)	5	19 (6, 45)
Genitourinary diseases (580–629)	5	27 (9, 62)	4	59 (16, 150)
Injury and poisoning (800–999)	35	68 (47, 94)	23	89 (56, 133)
All other causes (1–139, 630–799)	30	66 (44, 94)	9	45 (20, 85)
All causes of death (1–999)	731	39 (36, 42)	242	40 (35, 45)

[1] Values calculated from deaths before age 90 y. EPIC, European Prospective Investigation into Cancer and Nutrition. All of the SMRs with 95% CIs excluding 100 are significantly different from 100 at the 5% level.
[2] Codes from the International Classification of Diseases-9 (ICD-9).

Smoking increased the mortality rates for each of the cause of death categories examined; compared with never smokers, heavy smokers had DRRs of 4.13 (2.54, 6.70) for all malignant neoplasms, 4.10 (2.09, 8.02) for circulatory diseases, and 3.37 (2.37, 4.78) for all causes.

BMI was not strongly associated with mortality. In comparison with the reference group of subjects with a BMI of 20.0–22.5, subjects with a BMI of < 20 had an increased mortality from all malignant neoplasms, circulatory diseases, all other causes, and all causes combined, although none of these increases was statistically significant. Subjects in the highest BMI category (≥ 27.5) had a nonsignificant decrease in mortality from cancer, a nonsignificant increase in mortality from IHD, a significant reduction in mortality from all other causes, and an overall nonsignificant reduction in mortality from all causes combined [DRR = 0.79 (0.58, 1.06)].

Increased alcohol consumption was associated with a moderate but not significant decrease in all-cause mortality. Compared with the reference category of subjects who reported consuming 1–7 g of alcohol per day, those in the highest category of consumption (≥ 16 g/d) had a nonsignificant lower all-cause mortality [DRR = 0.84 (0.64, 1.10)].

Mortality rates did not differ significantly between vegetarians and nonvegetarians. Vegetarians had higher mortality from all malignant neoplasms [DRR = 1.11 (0.82, 1.51)], cerebrovascular disease [DRR = 1.13 (0.65, 1.96)], and all other causes [DRR = 1.10 (0.77, 1.58)] and reduced mortality from all circulatory diseases [DRR = 0.93 (0.65, 1.32)] and IHD [DRR = 0.75 (0.41, 1.37)]. All-cause mortality was not significantly different between vegetarians and nonvegetarians [DRR = 1.05 (0.86, 1.27)].

DISCUSSION

Each of these 3 British cohort studies was designed with the objective of recruiting as many vegetarians as possible, and the proportion of vegetarians in the studies ranged from 32% in EPIC-Oxford to 42% in the Oxford Vegetarian Study and 43% in the Health Food Shoppers Study. Because the methods used to recruit subjects were via vegetarian societies, health food shops, and magazines, it might be expected that the participants in the studies would, on average, be both healthier and more "health-conscious" than the British population in general. This expectation is borne out by the fact that the participants in the studies have relatively low smoking rates and a low prevalence of obesity. Furthermore, the SMRs in all 3 studies were markedly low (59%, 52%, and 39%, respectively, in the Health Food Shoppers Study, the Oxford Vegetarian Study, and EPIC-Oxford). The low SMRs in the 3 cohorts are partly due to factors such as the low prevalence of smoking and partly due to the fact that people who are already ill and therefore likely to die within a few years are much less likely to join this type of study than are people who are healthy (the well-known "healthy volunteer effect").

Comparisons of death rates between vegetarians and nonvegetarians within the studies show few differences. In all 3 studies, mortality from IHD was nonsignificantly lower in vegetarians than in nonvegetarians (DRRs of 0.85, 0.86, and 0.75 in the Health Food Shoppers Study, the Oxford Vegetarian Study, and EPIC-Oxford, respectively). This nonsignificant reduction is similar to the overall highly statistically significant lower DRR for IHD for vegetarians compared with nonvegetarians in a pooled analysis of 5 prospective studies (including the Health Food Shoppers Study and the Oxford Vegetarian Study) of 0.76 (0.62,

TABLE 3
Numbers of deaths and death rate ratios (DRRs) by various factors among 46 562 subjects in EPIC-Oxford with no prior disease (myocardial infarction, angina, stroke, diabetes, or cancer), adjusted for age, sex, and, where applicable, smoking[1]

	All malignant neoplasms		Circulatory diseases		Ischemic heart disease		Cerebrovascular disease		All other causes		All causes	
Factor and category	Deaths	DRRs	Deaths	DRRs	Deaths	DRRs	Deaths	DRRs	Deaths	DRRs	Deaths	DRRs
	n		*n*		*n*		*n*		*n*		*n*	
Smoking[2]												
Never smoker	101	1.00	75	1.00	29	1.00	28	1.00	76	1.00	252	1.00
Former smoker	90	1.36 (1.02, 1.81)[3]	71	1.34 (0.96, 1.87)	24	1.05 (0.61, 1.83)	31	1.76 (1.05, 2.96)	57	1.11 (0.78, 1.57)	218	1.28 (1.06, 1.53)
Light smoker	19	2.27 (1.38, 3.73)	20	3.65 (2.20, 6.04)	10	3.94 (1.89, 8.22)	1	0.63 (0.09, 4.69)	12	1.59 (0.86, 2.95)	51	2.40 (1.77, 3.26)
Heavy smoker	20	4.13 (2.54, 6.70)	10	4.10 (2.09, 8.02)	7	6.40 (2.74, 14.9)	2	2.61 (0.61, 11.2)	7	1.84 (0.84, 4.00)	37	3.37 (2.37, 4.78)
BMI (kg/m^2)[4]												
<20	26	1.22 (0.76, 1.94)	22	1.17 (0.69, 1.96)	6	0.91 (0.35, 2.36)	10	1.17 (0.54, 2.54)	31	1.46 (0.94, 2.29)	79	1.28 (0.97, 1.69)
20–22.49	57	1.00	41	1.00	15	1.00	18	1.00	53	1.00	151	1.00
22.5–24.99	73	1.11 (0.78, 1.57)	51	1.11 (0.73,1.67)	22	1.26 (0.65, 2.43)	15	0.78 (0.39,1.56)	29	0.48 (0.30, 0.75)	153	0.89 (0.71,1.11)
25–27.49	36	0.88 (0.57, 1.33)	25	0.98 (0.59, 1.62)	13	1.27 (0.60, 2.69)	8	0.81 (0.35, 1.89)	20	0.55 (0.33, 0.93)	81	0.79 (0.60, 1.04)
≥27.5	24	0.74 (0.46, 1.20)	25	1.28 (0.78, 2.12)	10	1.38 (0.61, 3.09)	8	0.96 (0.41, 2.23)	12	0.47 (0.25, 0.88)	61	0.79 (0.58,1.06)
Alcohol consumption[4]												
<1 g/d	50	0.86 (0.60, 1.22)	63	1.41 (0.98, 2.04)	23	1.37 (0.76, 2.49)	24	1.38 (0.75, 2.55)	45	1.25 (0.84, 1.86)	158	1.12 (0.91, 1.39)
1–7 g/d	94	1.00	58	1.00	23	1.00	20	1.00	59	1.00	211	1.00
8–15 g/d	36	0.76 (0.51, 1.12)	33	1.12 (0.73, 1.73)	15	1.19 (0.62, 2.30)	10	1.09 (0.51, 2.33)	21	0.63 (0.38, 1.04)	90	0.82 (0.64, 1.05)
≥16 g/d	39	1.04 (0.70, 1.53)	19	0.74 (0.44, 1.26)	9	0.73 (0.33, 1.62)	6	0.88 (0.35, 2.25)	20	0.69 (0.41, 1.17)	78	0.84 (0.64, 1.10)
Vegetarian status												
Nonvegetarian	171	1.00	129	1.00	55	1.00	41	1.00	103	1.00	403	1.00
Vegetarian	59	1.11 (0.82, 1.51)	47	0.93 (0.65, 1.32)	15	0.75 (0.41, 1.37)	21	1.13 (0.65, 1.96)	49	1.10 (0.77, 1.58)	155	1.05 (0.86, 1.27)

[1] EPIC, European Prospective Investigation into Cancer and Nutrition. All of the DRRs with 95% CIs excluding 100 are significantly different from 100 at the 5% level.
[2] Heavy smokers smoked ≥15 cigarettes/d; light smokers included all other current smokers, including pipe or cigar smokers; never smokers were those who had never smoked ≥1 cigarette/d for ≥1 y.
[3] 95% CI.
[4] Unknown for some subjects.

0.94) (6, 7). This reduction in mortality from IHD in vegetarians may be due to their lower serum cholesterol concentrations. Studies of serum cholesterol in subsamples of the 3 cohorts have reported that total serum cholesterol was lower in vegetarians than in nonvegetarians in all 3 cohorts; by 0.61 mmol/L in the Health Food Shoppers Study (15), 0.43 mmol/L in the Oxford Vegetarian Study (16), and 0.39 mmol/L and 0.35 mmol/L in men and women, respectively, in EPIC-Oxford (17, 18). Other evidence suggests that a reduction in serum total cholesterol of this amount would be expected to reduce mortality from IHD by around 20%. For example, Law et al (19) estimated that a 0.6 mmol/L reduction in total cholesterol would cause a 27% reduction in mortality from IHD, and in the Heart Protection Study treatment with a statin caused a reduction in total cholesterol of 1.2 mmol/L and a reduction in mortality from IHD in 5 y of around one-third (20).

For other causes of death, no consistent differences in mortality have been observed between vegetarians and nonvegetarians, although we have observed differences in individual studies. Vegetarians had a significantly increased mortality from breast cancer in the Health Food Shoppers Study and a significantly increased mortality from mental and neurological diseases in the Oxford Vegetarian Study, but these differences were not observed in the other study. These endpoints have not yet been examined in the EPIC-Oxford study, and the nonsignificant increase in mortality from all malignant neoplasms currently seen in EPIC-Oxford has not been observed with considerably larger numbers in the other studies. In all 3 studies, it should be noted that the numbers of deaths from individual causes are relatively small; therefore, potentially important differences might not be detected because of lack of statistical power. For all causes of death combined, the Health Food Shoppers Study and the Oxford Vegetarian Study show almost identical mortality in vegetarians and nonvegetarians; the preliminary analysis of EPIC-Oxford shows slightly, but not significantly, higher all-cause mortality in vegetarians than in nonvegetarians [DRR 1.05 (0.86, 1.27)].

In conclusion, both the vegetarians and the nonvegetarians in these 3 British cohort studies have a low mortality compared with the national average. Comparisons within the cohorts suggest that the vegetarians have a moderately lower mortality from IHD than the nonvegetarians but that there is little difference in mortality from other major causes of death.

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