

# Cancer incidence in vegetarians: results from the European Prospective Investigation into Cancer and Nutrition (EPIC-Oxford)<sup>1–4</sup>

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## ABSTRACT

**Background:** Few prospective studies have examined cancer incidence among vegetarians.

**Objective:** We report cancer incidence among vegetarians and non-vegetarians in the European Prospective Investigation into Cancer and Nutrition–Oxford (EPIC-Oxford) study.

**Design:** This was a prospective study of 63,550 men and women recruited throughout the United Kingdom in the 1990s. Cancer incidence was followed through nationwide cancer registries.

**Results:** The standardized incidence ratio for all malignant neoplasms for all participants was 72% (95% CI: 69%, 75%). The standardized incidence ratios for colorectal cancer were 84% (95% CI: 73%, 95%) among nonvegetarians and 102% (95% CI: 80%, 129%) among vegetarians. Comparing vegetarians with meat eaters and adjusting for age, sex, and smoking, the incidence rate ratio for all malignant neoplasms was 0.89 (95% CI: 0.80, 1.00). The incidence rate ratio for colorectal cancer in vegetarians compared with meat eaters was 1.39 (95% CI: 1.01, 1.91).

**Conclusions:** The overall cancer incidence rates of both the vegetarians and the nonvegetarians in this study are low compared with national rates. Within the study, the incidence of all cancers combined was lower among vegetarians than among meat eaters, but the incidence of colorectal cancer was higher in vegetarians than in meat eaters. *Am J Clin Nutr* 2009;89(suppl):1S–7S.

## INTRODUCTION

Few prospective studies have examined cancer incidence among vegetarians. In the United States, results from the Adventist Health Study have suggested that vegetarians have a significantly lower risk of cancers of the colon and prostate than do nonvegetarians, but that the risk of breast cancer does not differ significantly between these dietary groups (1). In Britain, results from the Oxford Vegetarian Study suggested no large difference in the incidence of colorectal cancer between vegetarians and nonvegetarians (2), whereas the UK Women's Cohort Study suggested that women who do not eat any meat have a lower risk of breast cancer than do meat eaters (3). A pooled analysis of mortality rates in 5 prospective studies, including the Adventist Health Study and the Oxford Vegetarian Study, suggested no large differences in cancer mortality between vegetarians and nonvegetarians (4). We report here on cancer incidence in vegetarians and nonvegetarians in the European Prospective Investigation into Cancer and Nutrition–Oxford (EPIC-Oxford) cohort (5).

## SUBJECTS AND METHODS

### Recruitment of subjects

The EPIC-Oxford cohort is one component of the EPIC, a collaborative study of 500,000 men and women in 10 European countries (6). The EPIC-Oxford cohort was recruited between 1993 and 1999. Further details of the recruitment methods and the baseline characteristics of the participants were described elsewhere (5).

Two methods of recruitment were used: general practice (GP) recruitment and postal recruitment. A multicenter research ethics committee approved the protocol. EPIC nurses working in GP offices in Oxfordshire, Buckinghamshire, and Greater Manchester performed recruitment from the general population through GPs. All men and women aged 35–69 y on the list of each collaborating GP were invited to participate. Questionnaires were mailed to consenting participants, and appointments were made to attend the GP's office for an interview with the nurse, who took measurements and a 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 such as minor ailments and menopausal symptoms. The GP method recruited 7423 participants.

Postal recruitment, aimed at those aged  $\geq 20$  y, 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 United Kingdom and all surviving participants in the Oxford Vegetarian Study (7). 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- or diet-interest magazines, and displayed on counters of health food shops. The main questionnaire was then mailed to all those who returned an insert. These postal methods recruited 58,042 participants.

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<sup>4</sup> Reprints not available. Address correspondence to TJ Key, Cancer Epidemiology Unit, University of Oxford, Richard Doll Building, Roosevelt Drive, Oxford OX3 7LF, United Kingdom. E-mail: tim.key@ceu.ox.ac.uk. doi: 10.3945/ajcn.2009.26736M.

### 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? For each of these 4 questions, participants were asked to reply yes or no, and, if they replied no, to record their age when they last ate the food group concerned. 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 or eggs or both), and vegans (those that eat no animal products); because of the small number of cancers among vegans, in this article the vegans are included in the vegetarian category. 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 (described next).

Participants completed a food-frequency questionnaire, based on that used in the US Nurses' Health Study (8), modified for use in the United Kingdom (9). Each participant estimated his or her average frequency of intake of 130 foods and drinks over the previous 12 mo: never or <1 time/mo, 1–3 times/mo, 1 time/wk, 2–4 times/wk, 5–6 times/wk, 1 time/d, 2–3 times/d, 4–5 times/d, or  $\geq 6$  times/d. Daily mean nutrient intakes were estimated with the use of standard portion sizes, derived largely from the Ministry of Agriculture Fisheries and Food (10), and nutrient contents were estimated by using the fifth edition of *McCance and Widdowson's The Composition of Foods* (11) and its supplements.

### 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  $\text{kg}/\text{m}^2$ ).

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

### Follow-up

All participants who could be traced were followed by record linkage with the UK's National Health Service Central Register, which provides information on cancer diagnoses and all deaths.

### Statistical analysis

The analyses were restricted to participants aged 20–89 y at recruitment with known smoking characteristics and for whom diet group was unambiguous. Standardized incidence ratios (SIRs) for vegetarians and nonvegetarians were calculated from incident cancers before age 90 by comparison with contemporary cancer incidence data for England (12); the SIR is the ratio of the observed number of cancers to the number of cancers expected from the national rates, standardized for age and sex, and expressed as a percentage. Cox regression was used to calculate

incidence rate ratios (IRRs) for cancers of the colorectum, female breast, prostate, ovary, lung, and all malignant neoplasms combined, comparing cancer incidence rates among participants with no prior malignant cancer for various factors, including diet group. The proportional hazards assumption was tested by the method of Grambsch and Therneau (13). This showed non-proportionality of the hazards for men and women in the analysis of all malignant neoplasms, and accordingly we chose to stratify the analyses by sex when appropriate, rather than adjusting for this variable. Therefore, our analyses were stratified by sex and method of recruitment and adjusted for smoking, with age as the underlying time variable. Smoking was categorized as never smoker, former smoker, light smoker, or heavy smoker: heavy smokers were those smoking  $\geq 15$  cigarettes/d; light smokers were all other current smokers, including pipe or cigar smokers; and never smokers were those who have never smoked  $\geq 1$  cigarettes/d for  $\geq 1$  y. Statistical significance was set at the 5% level, and 95% CIs were calculated for both the SIRs and IRRs. All statistical analyses were conducted with the use of STATA statistical software, release 9 (StataCorp, College Station, TX).

## RESULTS

### Standardized Incidence Ratios

The SIRs for 63,550 participants in the EPIC-Oxford study aged  $\leq 90$  y at recruitment who were followed by record linkage, with known diet group, and living in an area covered by the cancer registries of Great Britain, for various incident cancers before age 90 up to 31 December 2005 are shown in **Table 1**. There were 2707 incident cancers overall. The SIRs for stomach cancer were significantly less than 100% in both diet groups and overall. For colorectal cancer, the SIR was significantly less than 100% in nonvegetarians and overall but not in vegetarians (SIR: 102%; 95% CI: 80%, 129%). The SIRs for pancreatic cancer were <100% and were significant for nonvegetarians and overall, and the SIRs for lung cancer were significantly less than 100% in both diet groups and overall. For cancers of the female breast and ovary, none of the SIRs differed significantly from 100%, and for prostate cancer the SIRs were significantly more than 100% for nonvegetarians and overall. For all malignant neoplasms, the SIRs were significantly less than 100% in both diet groups and overall (SIR: 72%; 95% CI: 69%, 75%).

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

The analyses comparing the characteristics and cancer incidence rates of vegetarians and nonvegetarians are based on 52,706 participants aged 20–89 y at recruitment with known smoking characteristics and diet group and who did not have a prevalent malignant neoplasm (except for nonmelanoma skin cancer) and whose address was in an area covered by the cancer registries in Great Britain. The characteristics of these participants are given in **Table 2**. Thirty-two percent of participants were vegetarians and about three-quarters were women. Median age at recruitment was 11 y younger in the vegetarians than in the nonvegetarians. Smoking rates were low overall, with only 10% of vegetarians and 12% of nonvegetarians reporting that

**TABLE 1**

Standardized incidence ratios (SIRs) for selected malignant cancers among 63,550 participants (nonvegetarians and vegetarians) in the European Prospective Investigation into Cancer and Nutrition Oxford cohort<sup>1</sup>

Cancer (ICD10 codes)	Nonvegetarians		Vegetarians		All	
	Cancers	SIR (95% CI)	Cancers	SIR (95% CI)	Cancers	SIR (95% CI)
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Stomach cancer (C16)	31	53 (36, 76)	2	13 (2, 46)	33	45 (31, 63)
Colorectal cancer (C18–C20)	220	84 (73, 95)	70	102 (80, 129)	290	87 (78, 98)
Cancer of the pancreas (C25)	37	67 (47, 92)	12	85 (44, 149)	49	71 (52, 94)
Lung cancer (C34)	98	34 (27, 41)	19	26 (16, 41)	117	32 (27, 39)
Female breast cancer (C50)	688	107 (100, 116)	173	90 (77, 104)	861	103 (97, 111)
Ovarian cancer (C56)	95	102 (82, 124)	25	94 (61, 139)	120	100 (83, 120)
Prostate cancer (C61)	193	129 (112, 149)	42	106 (77, 144)	235	125 (110, 142)
All malignant neoplasms (C00–C97)	2160	74 (71, 77)	547	65 (60, 71)	2707	72 (69, 75)

<sup>1</sup> ICD10, International Classification of Diseases, 10th revision. SIRs were calculated from incident cancers before age 90 y by comparison with contemporary cancer incidence data for England and Wales (14); the SIR is the ratio of the observed number of cancers to the number of cancers expected from the national rates, standardized for sex and age. All of the SIRs with 95% CIs excluding 100 are significantly different from 100 at the 5% level.

they were smokers at the time of recruitment. Median BMI was 1.2 lower in vegetarians than in nonvegetarians, and median alcohol consumption was 0.6 g/d lower in vegetarians than in nonvegetarians. Among the meat eaters, median intakes of meat were 78.1 and 69.7 g/d in men and women, respectively (not shown in Table 2). Median intakes of milk were higher in nonvegetarians than in vegetarians, whereas median intakes of cheese, vegetables, and fruit were higher in vegetarians than in nonvegetarians. Information on diet group  $\approx$ 5 y after baseline was available for 67% of participants, and, among these, 89.6% of vegetarian men and 83.8% of vegetarian women still reported that they were vegetarians.

The IRRs for smoking, BMI, alcohol consumption, and dietary group in relation to the commonest cancers are shown in **Table 3**. There were 2179 incident cancers before age 90 among these participants up to 31 December 2005. Smoking increased the incidence of lung cancer (IRR for heavy smokers: 87.3; 95% CI: 37.8, 202) and of all malignant cancers combined (IRR: 1.52; 95% CI: 1.25, 1.85). BMI was significantly associated with the incidence of breast cancer, with an IRR of 0.65 (95% CI: 0.47, 0.89) among women with a BMI <20 in comparison with women with a BMI of 20–22.4. BMI was not significantly associated with any of the other cancer sites examined. Alcohol consumption was not significantly associated with the incidence of cancers of the colorectum, breast, or prostate or with all malignant neoplasms combined, but for prostate cancer there was an increased risk of borderline statistical significance for men consuming  $\geq$ 8 g alcohol/d, and for ovarian cancer there was a significantly lower risk among women consuming  $\geq$ 8 g alcohol/d.

Comparing vegetarians with nonvegetarians, the risk of colorectal cancer was significantly higher among vegetarians (IRR: 1.49; 95% CI: 1.09, 2.03), whereas the risk of the other cancer sites examined did not differ significantly between vegetarians and nonvegetarians. The risk of all malignant neoplasms was nonsignificantly lower in vegetarians than in nonvegetarians (IRR: 0.93; 95% CI: 0.83, 1.04).

When risks were compared between meat eaters, fish eaters and vegetarians, significant heterogeneity was observed between these groups for the risks of colorectal cancer, lung cancer, and all

malignant neoplasms. The risk of colorectal cancer was nonsignificantly lower in fish eaters and significantly higher in vegetarians than in meat eaters (IRR: 1.39; 95% CI: 1.01, 1.91), and the risk of lung cancer was significantly lower in fish eaters than in meat eaters. The risk of all malignant neoplasms was lower among fish eaters (0.83; 95% CI: 0.71, 0.96) and vegetarians (0.89; 95% CI: 0.80, 1.00) than among meat eaters, although the latter result was not statistically significant ( $P = 0.052$ ).

## DISCUSSION

The overall cancer incidence in the EPIC-Oxford study is lower than the national average. The incidence of lung cancer is particularly low (SIR: 32%) because of the low prevalence of smoking; 13% of men and 11% of women were current smokers at recruitment, compared with 22% of men and 23% of women in the Health Survey for England 2004 (14). The incidence of colorectal cancer overall was 13% lower than the national rate, but among vegetarians it was almost identical to the national rate. The incidence rates for breast cancer and ovarian cancer were not significantly different from the national rates, and the incidence of prostate cancer was 25% higher than the national rate.

Total cancer incidence was significantly lower among fish eaters and borderline significantly lower among vegetarians than among meat eaters. The difference in total cancer incidence between meat eaters and non–meat eaters could not be ascribed to any one of the major cancer sites examined. We are not aware of other data comparing total cancer incidence in meat eaters and non–meat eaters, and the cause of this small difference is not known. More data are needed to further our understanding of this observation, which, if confirmed, is likely to be due to differences for specific cancer sites.

The 2007 report from the World Cancer Research Fund, American Institute for Cancer Research, concluded that the evidence that high intakes of red and processed meat cause colorectal cancer is convincing, but that there was no convincing evidence that high intakes of red or processed meat were causally associated with any other type of cancer (15). A significant positive association between red meat consumption and the risk of colorectal

**TABLE 2**

Characteristics of 52,706 nonvegetarians and vegetarians in the European Prospective Investigation into Cancer and Nutrition Oxford cohort with no history of cancer at baseline<sup>1</sup>

Characteristic	Men		Women	
	Nonvegetarians (n = 7973)	Vegetarians (n = 4257)	Nonvegetarians (n = 27,652)	Vegetarians (n = 12,824)
Age at entry [n (%)]				
20–29 y	556 (7.0)	805 (18.9)	3063 (11.1)	4066 (31.7)
30–39 y	1300 (16.3)	1409 (33.1)	5437 (19.7)	3853 (30.0)
40–49 y	2096 (26.3)	1083 (25.4)	7939 (28.7)	2744 (21.4)
50–59 y	1811 (22.7)	463 (10.9)	6505 (23.5)	1208 (9.4)
60–69 y	1589 (19.9)	266 (6.2)	3409 (12.3)	572 (4.5)
70–79 y	529 (6.6)	165 (3.9)	1129 (4.1)	281 (2.2)
80–89 y	92 (1.2)	66 (1.6)	170 (0.6)	100 (0.8)
Median age at entry (y)	50	39	46	35
Smoking status [n (%)] <sup>2</sup>				
Never smoker	3932 (49.3)	2494 (58.6)	16780 (60.7)	8307 (64.8)
Former smoker	2888 (36.2)	1282 (30.1)	7764 (28.1)	3266 (25.5)
Light smoker	752 (9.4)	320 (7.5)	1779 (6.4)	871 (6.8)
Heavy smoker	401 (5.0)	161 (3.8)	1329 (4.8)	380 (3.0)
BMI [n (%)] <sup>3</sup>				
<20 kg/m <sup>2</sup>	357 (4.6)	461 (11.3)	3045 (11.3)	2446 (19.8)
20–22.4 kg/m <sup>2</sup>	1658 (21.5)	1326 (32.5)	8235 (30.7)	4636 (37.6)
22.5–24.9 kg/m <sup>2</sup>	2618 (34.0)	1290 (31.6)	7252 (27.0)	2970 (24.1)
25–27.4 kg/m <sup>2</sup>	1826 (23.7)	655 (16.0)	4196 (15.6)	1253 (10.2)
≥27.5 kg/m <sup>2</sup>	1248 (16.2)	352 (8.6)	4111 (15.3)	1023 (8.3)
Median BMI (kg/m <sup>2</sup> )	24.3	22.9	23.1	22.0
Alcohol consumption [n (%)]				
<1 g/d	806 (10.1)	828 (19.5)	4831 (17.5)	2852 (22.2)
1–7 g/d	2459 (30.8)	1320 (31.0)	12830 (46.4)	5572 (43.4)
8–15 g/d	2071 (26.0)	970 (22.8)	6555 (23.7)	2886 (22.5)
≥16 g/d	2637 (33.1)	1139 (26.8)	3436 (12.4)	1514 (11.8)
Median alcohol consumption (g/d)	10.5	7.6	5.1	4.9
Daily intake of selected foods				
Total meat (g)	65 (23–106) <sup>4</sup>	—	54 (13–91)	—
Total fish (g)	34 (23–52)	—	35 (22–53)	—
Dairy milk (mL)	293 (146–439)	146 (0–439)	293 (146–439)	146 (50–293)
Dairy cheese (g)	15 (5–27)	19 (5–35)	19 (9–31)	23 (9–38)
Total vegetables (g)	208 (148–286)	247 (177–340)	241 (174–328)	268 (192–372)
Total fresh fruit (g)	182 (103–293)	200 (115–334)	236 (144–361)	240 (140–380)
Diet group at follow-up [n (%)] <sup>3</sup>				
Nonvegetarian	5360 (97.3)	274 (10.4)	18,575 (97.6)	1314 (16.2)
Vegetarian	147 (2.7)	2362 (89.6)	464 (2.4)	6780 (83.8)

<sup>1</sup> The differences in sex, age, smoking status, BMI, and alcohol consumption were statistically significant between nonvegetarians and vegetarians,  $P < 0.001$ .

<sup>2</sup> Heavy smokers included those who smoked  $\geq 15$  cigarettes/d; light smokers included all other current smokers, including pipe or cigar smokers; and never smokers included those who never smoked  $\geq 1$  cigarette/d for  $\geq 1$  y.

<sup>3</sup> Categories or values were unknown for some participants at follow-up.

<sup>4</sup> Median; interquartile range in parentheses (all such values).

cancer has also been observed in a subsequent large prospective study (16), as well as in the whole EPIC-Europe cohort (17). In previous prospective studies of vegetarians, a lower risk of colon cancer (rectal cancer was not reported) was observed among vegetarians compared with nonvegetarians in the Adventist Health Study (1), but there was no significant difference in the incidence of colorectal cancer between vegetarians and nonvegetarians in the Oxford Vegetarian Study (2), and no difference in mortality from colorectal cancer between vegetarians and nonvegetarians was observed in the collaborative analysis of 5 prospective studies (4). Our observation that the incidence of colorectal cancer is higher among vegetarians than among meat eaters in the EPIC-Oxford study is surprising; this difference

might be partly due to chance and speculatively might be related to other dietary differences between the groups.

For breast cancer, no significant difference in incidence between vegetarians and nonvegetarians was observed in the Adventist Health Study or in the EPIC-Oxford study [including a previous analysis of our data (18)], and no consistent differences in incidence or rates of mortality from other common cancers have been observed between vegetarians and nonvegetarians (1, 4).

This is a study of comparisons, and the results depend on the comparison group. In the comparisons within the cohort, the vegetarians were compared with all nonvegetarians or with meat eaters. Meat intake among the meat eaters was only moderate, with median intakes of 78.1 g/d in men and 69.7 g/d in women; these

**TABLE 3**

Numbers of incident cancers and multivariate adjusted incidence rate ratios (IRRs) by various factors among 52,706 participants in the European Prospective Investigation into Cancer and Nutrition Oxford cohort with no prior malignant cancer<sup>1</sup>

Factor and category	Colorectal cancer			Female breast cancer			Prostate cancer			Ovarian cancer			Lung cancer			All malignant neoplasms		
	No. of incident cancer	IRR (95% CI)	No. of incident cancer	IRR (95% CI)	No. of incident cancer	IRR (95% CI)	No. of incident cancer	IRR (95% CI)	No. of incident cancer	IRR (95% CI)	No. of incident cancer	IRR (95% CI)	No. of incident cancer	IRR (95% CI)	No. of incident cancer	IRR (95% CI)		
<b>Smoking<sup>2</sup></b>																		
Never smoker	113	1.00	413	1.00	86	1.00	56	1.00	7	1.00	1124	1.00						
Former smoker	91	1.19 (0.90, 1.57)	241	1.09 (0.93, 1.28)	81	0.79 (0.59, 1.08)	27	0.90 (0.57, 1.43)	35	6.54 (2.89, 14.8)	802	1.11 (1.02, 1.22)						
Light smoker	16	1.55 (0.91, 2.63)	41	1.11 (0.81, 1.53)	11	0.83 (0.44, 1.55)	6	1.27 (0.54, 2.95)	16	27.1 (11.1, 66.4)	141	1.28 (1.07, 1.53)						
Heavy smoker	8	1.25 (0.61, 2.58)	39	1.25 (0.89, 1.73)	5	1.33 (0.54, 3.31)	3	0.81 (0.25, 2.60)	30	87.3 (37.8, 202)	112	1.52 (1.25, 1.85)						
<i>P</i> for heterogeneity		0.345		0.468		0.401		0.873		<0.001		<0.001						
<b>BMI<sup>3</sup></b>																		
<20 kg/m <sup>2</sup>	18	1.01 (0.59, 1.73)	47	0.65 (0.47, 0.89)	8	0.72 (0.34, 1.55)	10	1.26 (0.60, 2.67)	12	2.21 (1.04, 4.71)	169	0.91 (0.77, 1.08)						
20–22.4 kg/m <sup>2</sup>	52	1.00	207	1.00	40	1.00	22	1.00	16	1.00	541	1.00						
22.5–24.9 kg/m <sup>2</sup>	81	1.28 (0.90, 1.82)	215	1.06 (0.87, 1.28)	63	0.98 (0.66, 1.46)	24	1.11 (0.62, 1.99)	23	1.20 (0.63, 2.27)	651	1.08 (0.96, 1.21)						
25–27.4 kg/m <sup>2</sup>	37	0.87 (0.57, 1.33)	118	0.94 (0.75, 1.18)	39	0.85 (0.55, 1.33)	15	1.14 (0.59, 2.22)	19	1.37 (0.70, 2.69)	372	0.95 (0.83, 1.09)						
≥27.5 kg/m <sup>2</sup>	30	0.85 (0.54, 1.33)	127	1.02 (0.81, 1.28)	25	0.86 (0.52, 1.43)	19	1.49 (0.80, 2.78)	18	1.57 (0.79, 3.10)	375	1.11 (0.97, 1.26)						
<i>P</i> for heterogeneity		0.197		0.029		0.850		0.794		0.312		0.070						
<b>Alcohol consumption<sup>4</sup></b>																		
<1 g/d	51	0.99 (0.69, 1.40)	158	0.98 (0.81, 1.19)	32	1.13 (0.72, 1.78)	21	0.76 (0.46, 1.26)	21	1.13 (0.65, 1.97)	487	1.02 (0.91, 1.14)						
1–7 g/d	88	1.00	335	1.00	47	1.00	55	1.00	32	1.00	915	1.00						
8–15 g/d	49	1.10 (0.78, 1.57)	147	0.97 (0.80, 1.18)	50	1.49 (1.00, 2.23)	12	0.48 (0.26, 0.90)	14	0.75 (0.40, 1.41)	441	0.95 (0.85, 1.07)						
≥16 g/d	40	1.24 (0.84, 1.83)	94	1.20 (0.96, 1.52)	54	1.54 (1.04, 2.29)	4	0.32 (0.11, 0.88)	21	1.22 (0.69, 2.16)	336	1.05 (0.92, 1.20)						
<i>P</i> for heterogeneity		0.710		0.382		0.101		0.013		0.506		0.563						
<b>Vegetarian status<sup>4</sup></b>																		
Nonvegetarian	166	1.00	588	1.00	148	1.00	74	1.00	72	1.00	1734	1.00						
Vegetarian	62	1.49 (1.09, 2.03)	146	0.94 (0.77, 1.13)	35	0.90 (0.61, 1.33)	18	0.85 (0.49, 1.46)	16	1.23 (0.69, 2.17)	445	0.93 (0.83, 1.04)						
<i>P</i> for heterogeneity		0.015		0.496		0.608		0.555		0.489		0.182						
<b>Diet group<sup>4</sup></b>																		
Meat eater	151	1.00	496	1.00	135	1.00	68	1.00	70	1.00	1521	1.00						
Fish eater	15	0.64 (0.37, 1.10)	92	1.02 (0.81, 1.29)	13	0.88 (0.49, 1.57)	6	0.43 (0.18, 1.01)	2	0.23 (0.06, 0.95)	213	0.83 (0.71, 0.96)						
Vegetarian or vegan	62	1.39 (1.01, 1.91)	146	0.94 (0.77, 1.15)	35	0.89 (0.60, 1.32)	18	0.73 (0.42, 1.28)	16	1.08 (0.61, 1.91)	445	0.89 (0.80, 1.00)						
<i>P</i> for heterogeneity		0.012		0.778		0.795		0.084		0.028		0.014						

<sup>1</sup> Estimated by Cox proportional hazards regression with age as the underlying time variable, stratified by sex and method of recruitment, using separate models for the different exposures.  
<sup>2</sup> Heavy smokers smoke ≥15 cigarettes/d; light smokers include all other current smokers, including pipe or cigar smokers; never smokers are those who have never smoked ≥1 cigarettes/d for ≥1 y.  
<sup>3</sup> Adjusted for smoking. BMI was unknown for some subjects (an unknown category is added to ensure that all observations contribute to the analysis, but results for this category are not shown, and the tests for heterogeneity relate to the known categories).  
<sup>4</sup> Adjusted for smoking.

intakes are much lower than those reported in the National Diet and Nutrition Survey for the United Kingdom (19). Consumption of vegetables and fruit was higher among vegetarians than among nonvegetarians, but the differences were not large (<20%). Thus, if high intakes of meat had an adverse effect and high intakes of fruit and vegetables had a beneficial effect, the relatively low meat intake and high fruit and vegetable intake of the nonvegetarians in this cohort could reduce the chance of observing lower cancer rates in the vegetarians than in the nonvegetarians. Furthermore, the results may be influenced by residual confounding because of measurement error in the assessment of confounding factors, and by confounding by unknown factors.

A potential weakness of this type of study is the accuracy of the assessment of vegetarian status. Diet group was assigned on the basis of the answer to 4 questions, asking specifically about whether participants ever ate meat, fish, dairy products, and eggs. However, when diet group was assigned on the basis of answers to the same 4 questions in a follow-up questionnaire 5 y later, most participants were allocated to the same diet group as at recruitment. Furthermore, cross-sectional analyses have shown that the self-reported vegetarians have a lower prevalence of obesity (20) and also lower plasma concentrations of vitamin B-12 (21), long-chain n-3 (omega-3) fatty acids (22), and phytanic acid (23).

In conclusion, both the vegetarians and the nonvegetarians in the EPIC-Oxford study have a low total cancer incidence compared with the national average. The incidence of all malignant neoplasms combined was lower among vegetarians and fish eaters than among meat eaters, but the incidence of colorectal cancer was significantly higher among vegetarians than among nonvegetarians. (Other articles in this supplement to the Journal include references 24–50.)

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