

ORIGINAL ARTICLE

Dietary fibre intake and ischaemic heart disease mortality: the European Prospective Investigation into Cancer and Nutrition-Heart study

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BACKGROUND/OBJECTIVES: Evidence from prospective studies is consistent in showing an inverse association between dietary fibre intake and risk of ischaemic heart disease (IHD), but whether dietary fibre from various food sources differ in their effect on IHD risk is less clear. The objective of this study was to assess the associations of total and food sources of dietary fibre with IHD mortality in the European Prospective Investigation into Cancer and Nutrition-Heart study.

SUBJECTS/METHODS: Participants were 306 331 men and women from eight European countries. Dietary fibre intake was assessed using centre or country-specific diet questionnaires and calibrated using a 24-h diet recall.

RESULTS: After an average follow-up of 11.5 years, there were 2381 IHD deaths among participants without cardiovascular disease at baseline. The calibrated intake of dietary fibre was inversely related with IHD mortality; each 10 g/day was associated with a 15% lower risk (relative risk (RR) 0.85; 95% confidence interval (CI): 0.73–0.99, $P = 0.031$). There was no difference in the associations of the individual food sources of dietary fibre with the risk of IHD mortality; RR for each 5 g/day higher cereal fibre intake was 0.91 (CI: 0.82–1.01), RR for each 2.5 g/day fruit fibre intake was 0.94 (CI: 0.88–1.01) and RR for each 2.5 g/day vegetable fibre intake was 0.90 (95% CI: 0.76–1.07).

CONCLUSION: A higher consumption of dietary fibre is associated with a lower risk of fatal IHD with no clear difference in the association with IHD for fibre from cereals, fruits or vegetables.

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Ecological comparisons and time trend analyses of ischaemic heart disease (IHD) rates formed the basis for the idea that a higher consumption of dietary fibre was associated with lower rates of heart disease.^{1,2} This hypothesis was supported by the results from a number of prospective studies,³ including an individual participant meta-analysis—the Pooling Project of Cohort Studies on Diet and Coronary Heart Disease (2011 coronary

deaths), which showed that a 10 g/day higher intake of dietary fibre (calibrated for measurement error) was associated with a 27% reduction in the risk of death from coronary diseases.⁴

Several studies have examined the association between specific sources of dietary fibre in relation to the risk of IHD mortality. In the Pooling Project, Pereira *et al.*⁴ demonstrated an inverse association of fibre from cereals and fruits but not from vegetables

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with the risk of fatal or non-fatal IHD. Similar results in relation to IHD death were also reported in a more recent analysis of a Japanese cohort with 422 IHD deaths,⁵ although some studies do not report differences between the specific food sources of dietary fibre and risk of IHD mortality.^{6,7} It is possible that the various sources of dietary fibre differ in their effect on mechanisms that may mediate the association between fibre and IHD⁸ or that these findings are due to error in the measurement of the various fibre sources.

The objective of the present study is to examine the association of total and food sources of dietary fibre with IHD mortality in the multi-centre study, the European Prospective Investigation into Cancer and Nutrition (EPIC)-Heart cohort.

PARTICIPANTS AND METHODS

Study participants

The methods of the EPIC study⁹ and its component EPIC-Heart^{10,11} have been described previously. Briefly, 519978 men and women were recruited by 23 collaborating centres in 10 European countries (Denmark, France, Germany, Greece, Italy, the Netherlands, Norway, Spain, Sweden and the United Kingdom (UK)) between 1992 and 2000. Participants completed questionnaires on their diet, lifestyle and medical history and the data were centralised at the International Agency for Research on Cancer (IARC) in Lyon, France. This study complies with the Declaration of Helsinki; ethical review boards of IARC and all local institutions where participants had been recruited gave approval for the study, and all participants gave written informed consent.

Follow-up for mortality was available for 501584 participants after excluding participants who had missing non-dietary or dietary data, or were in the lowest or highest 1% of the distribution of the ratio of reported total energy intake to energy requirement ($n=18394$). Participants younger than 40 years or 85 years or older at recruitment were excluded ($n=57360$). Participants with self-reported history of myocardial infarction or stroke at recruitment ($n=10107$), and participants who did not answer either or both of the questions on prior myocardial infarction or stroke ($n=18873$) were also excluded, with the exception of participants recruited in Umeå (Sweden) who were without heart disease at baseline. Those with unknown smoking status ($n=8545$) or unknown number of cigarettes smoked ($n=8409$) were excluded. Lastly, the French and Norwegian cohorts ($n=64648$ and $n=27311$, respectively) were excluded due to the small number of eligible IHD deaths at the end of the available follow-up period ($n=29$ and $n=16$ IHD deaths, respectively) leaving a total of 306331 participants, comprising 115176 men and 191155 women.

Baseline dietary and lifestyle questionnaires

Dietary intake during the year before enrolment was measured by centre or country-specific food questionnaires.⁹ Details of these questionnaires including their relative validity have been published elsewhere.^{12–17} In brief, quantitative food frequency questionnaires were used in Germany, Greece, UK, northern Italy and the Netherlands, diet history questionnaires were administered in Spain and Ragusa (Italy), and a semi-quantitative food frequency questionnaire was used in Denmark, Naples (Italy) and Umeå (Sweden). In Malmö (Sweden), a dietary history was combined with a 7-day menu booklet. In order to improve the comparability of dietary data across the participating centres and to correct for measurement error, dietary intakes from the questionnaires were calibrated using a single 24-h diet recall method common to all centres and administered to a stratified random sample (approximately 8%) of participants.^{18,19} Dietary fibre content of foods is measured using the Association of Analytical Communities method in all countries apart from the UK where non-starch polysaccharides are measured using the Englyst method and in Greece where the nutrient values for dietary fibre are derived from the UK nutrient composition tables. The dietary fibre variable used in this analysis was obtained using the EPIC Nutrient DataBase (ENDB) in which the dietary fibre composition of foods was standardised across the participating European countries to take into account the different analytical methods used.²⁰ Food groupings from the country-specific diet questionnaires and the 24-h recall were coded centrally at IARC. The grouping for cereals and cereal products included flour, pasta, rice, other grains, bread, crisp breads, rusks, breakfast cereals, crackers, pastry and pizza dough. The grouping for vegetables did not include potatoes or dried beans. 'Other' fibre was

calculated by subtracting the fibre from cereals, fruits and vegetables from total dietary fibre intake. Fibre from legumes was not included as a separate variable in the current analysis as there was limited information available in the central database for some of the centres. The categories of dietary fibre intake were chosen to obtain roughly equal sized groups with meaningful cut-points and the unit increments for each of the food sources of dietary fibre were chosen to closely approximate a standard deviation.

The non-dietary variables included in this analysis were based on answers provided in the recruitment questionnaire. Missing values were assigned to separate strata for each variable where applicable.

Case ascertainment

Information on vital status was collected from mortality registries at the regional or national level in most centres except in Germany and Greece where vital status was ascertained by active follow-up of study participants and next-of-kin. IHD as the underlying cause of death was defined as codes 410–414 of the WHO International Classification of Diseases for diseases and medical conditions ninth revision or, from 1 April 1996, codes I20–I25 of the tenth revision.

Statistical analysis

Follow-up was analysed from recruitment until the date of death from IHD or censoring at the date of death from other causes, emigration, other loss to follow-up or the date at which follow-up was considered complete in each centre. Hazard ratios as estimates of the relative risks (RR) for fatal IHD and 95% confidence intervals (95% CI) were calculated using Cox proportional hazards regression using age as the underlying time variable. All analyses are stratified by sex, centre and smoking (never, former, current <5, current 5–9, current 10–14, current 15–19, current 20–24 or current ≥ 25 cigarettes/day) and adjusted for alcohol intake (<1, 1–7, 8–19, ≥ 20 g/day), BMI (<20, 20–22.4, 22.5–24.9, 25–27.4, 27.5–29.9, 30–32.4, 32.5–34.9, ≥ 35 kg/m²), physical activity (based on quartiles of the combined occupational physical activity and cycling/other physical exercise and categorised as inactive, moderately inactive, moderately active, active), marital status (married/cohabiting, not married/cohabiting), highest education level (some secondary school, higher secondary/technical school, university degree), current employment (yes or no), hypertension (yes or no), hyperlipidaemia (yes or no), angina pectoris (yes or no) and diabetes mellitus (yes or no), ratio of polyunsaturated to saturated fat (continuous), and total energy intake (continuous) (base model). Each of the different food sources of fibre were also mutually adjusted for each other. Dietary data were calibrated using a multivariable linear calibration model²¹ and the calibrated values of dietary fibre intake on a continuous scale were used in the regression models. Tests for linear trend were obtained by using dietary fibre as a continuous variable in the model.

In a sensitivity analysis, the association between dietary fibre intake and risk of IHD mortality using the base model was also examined after excluding the first 5 years of follow-up. Heterogeneity in association between the intake of dietary fibre and fatal IHD by sex, age at recruitment (<60 years, ≥ 60 years), smoking status (never, past, current <10, current 10–19 and current ≥ 20 cigarettes/day), and country were assessed by adding appropriate interaction terms to the regression models and testing for statistical significance using a likelihood ratio test. All analyses were performed using Stata (StataCorp. 2009, Stata Statistical Software: Release 11. College Station, TX, USA; StataCorp. LP), all tests of significance were two-sided and a P -value < 0.05 was considered statistically significant.

RESULTS

After an average of 11.5 years of follow-up there were 2381 deaths from IHD among the 306331 participants included in this analysis. Crude IHD mortality rates were 12 per 1000 people over 10 years among men and 4 per 1000 people over 10 years among women. The numbers of participants, deaths and the mean intake of dietary fibre (calibrated) by country for men and women are shown in Table 1. Overall, the mean intake of dietary fibre was 23.9 g/day among men and 20.3 g/day among women. Both men and women from Sweden had the lowest intake of dietary fibre (less than 20 g/day) and the highest intakes were among women from Denmark (23.1 g/day) and men from Spain (26.3 g/day).

Table 1. Descriptives of the eight countries included in the EPIC-Heart study

Country	Cohort numbers		Total person-years		Number of IHD deaths		Mean (s.d.) dietary fibre intake (g/day) ^a	
	Men	Women	Men	Women	Men	Women	Men	Women
Denmark	22 781	28 224	236 089	298 616	233	63	26.0 (5.3)	23.1 (5.1)
Germany	20 600	23 203	229 955	262 367	206	56	22.5 (4.1)	20.3 (3.2)
Greece	7860	12 198	73 586	121 615	161	96	23.8 (2.6)	17.8 (1.0)
Italy	12 341	27 699	141 763	325 391	58	36	25.7 (3.3)	19.6 (2.6)
Netherlands	5376	22 408	70 196	292 217	56	100	25.8 (6.5)	21.3 (4.3)
Spain	13 290	20 066	173 639	260 251	117	36	26.3 (5.0)	20.8 (3.7)
Sweden	16 760	23 880	204 880	293 020	384	152	19.2 (3.7)	16.2 (2.7)
UK	16 168	33 477	171 401	377 901	381	246	23.7 (5.8)	21.3 (4.8)
Overall	115 176	191 155	1301 509	2231 378	1596	785	23.9 (5.2)	20.3 (4.3)

Abbreviations: EPIC, European Prospective Investigation into Cancer and Nutrition; IHD, ischaemic heart disease. ^aCalibrated dietary fibre intake.

Table 2. Baseline characteristics of participants according to categories of dietary fibre intake in the EPIC-Heart study

Characteristic	Number of observations ^b	Whole cohort (n = 306 331) Mean (s.d.)	Males (n = 115 176) Mean (s.d.)	Females (n = 191 155) Mean (s.d.)	Dietary fibre intake (g/day) ^a			
					< 17.5 (n = 78 496) Mean (s.d.)	17.5–22.4 (n = 85 647) Mean (s.d.)	22.5–27.4 (n = 69 001) Mean (s.d.)	≥ 27.5 (n = 73 187) Mean (s.d.)
Dietary fibre intake (g/day)—uncalibrated	306 331	22.9 (7.8)	24.2 (8.3)	22.1 (7.4)	14.2 (2.5)	20.0 (1.4)	24.8 (1.4)	33.6 (5.9)
Dietary fibre intake (g/day)—calibrated	306 331	21.6 (5.0)	23.9 (5.2)	20.3 (4.3)	17.0 (2.5)	20.0 (2.5)	22.7 (2.8)	27.6 (4.6)
Number of IHD deaths	2381	2381	1596	785	776	616	480	509
Age (years)	306 331	53.8 (8.0)	53.7 (8.0)	53.9 (8.0)	54.0 (8.2)	53.9 (8.0)	53.8 (7.9)	53.5 (7.9)
Body mass index (kg/m ²)	304 837	26.4 (4.3)	26.8 (3.6)	26.2 (4.6)	26.4 (4.3)	26.5 (4.3)	26.4 (4.2)	26.2 (4.2)
Systolic blood pressure (mm Hg)	244 768	133.7 (19.7)	136.4 (18.6)	132.1 (20.2)	134.3 (20.1)	133.7 (19.6)	133.5 (19.6)	133.3 (19.3)
Diastolic blood pressure (mm Hg)	244 757	82.2 (10.7)	84.5 (10.5)	80.9 (10.5)	82.7 (10.8)	82.3 (10.7)	82.1 (10.7)	81.7 (10.5)
Total energy (kcal/day)	306 331	2090 (623)	2405 (656)	1900 (517)	1644 (443)	1959 (465)	2214 (513)	2604 (634)
Alcohol (g/day)	306 331	13.1 (18.3)	21.4 (23.5)	8.2 (11.7)	13.3 (19.6)	12.7 (17.7)	13.0 (17.6)	13.6 (18.2)
Cereal fibre (g/day)	306 331	9.0 (5.1)	10.5 (5.6)	8.1 (4.5)	5.4 (2.4)	7.7 (3.1)	9.8 (3.9)	13.7 (6.1)
Fruit fibre (g/day)	306 331	4.2 (3.3)	3.7 (3.3)	4.5 (3.3)	2.4 (1.7)	3.6 (2.3)	4.6 (2.8)	6.5 (4.5)
Vegetable fibre (g/day)	306 331	4.4 (2.9)	4.2 (2.9)	4.6 (2.8)	2.8 (1.7)	3.9 (2.1)	4.8 (2.5)	6.3 (3.7)
Other fibre (g/day)	306 331	5.2 (3.0)	5.8 (3.4)	4.8 (2.7)	3.6 (1.8)	4.7 (2.2)	5.6 (2.7)	7.1 (4.0)
Polyunsaturated to saturated fat ratio	306 331	0.46 (0.22)	0.46 (0.22)	0.46 (0.22)	0.41 (0.19)	0.44 (0.20)	0.47 (0.21)	0.52 (0.25)
Sex—women (%)	306 331	62.4	—	—	69.1	65.8	60.9	52.6
Current smokers (%)	306 331	22.3	26.0	20.0	28.3	22.0	20.0	18.3
< 10 Cigarettes/day		5.8	5.5	5.9	6.1	5.9	5.6	5.5
10–19 Cigarettes/day		8.1	7.9	8.2	10.6	8.0	7.2	6.2
≥ 20 Cigarettes/day		8.4	12.6	5.9	11.6	8.0	7.2	6.6
Moderately active or active (%)	303 161	42.6	49.1	38.7	36.0	40.6	44.5	50.3
Educated to a university degree level (%)	296 601	21.2	26.5	18.0	18.0	20.4	22.2	24.9
Married or cohabiting (%)	219 941	78.5	84.3	75.4	75.6	79.5	80.2	79.4
Diabetes (%)	303 888	3.1	3.7	2.7	2.9	3.1	2.9	3.3
Angina (%)	214 166	2.2	2.7	1.9	2.4	2.2	2.3	2.1
Hypertension (%)	298 648	21.5	21.7	21.4	22.5	22.4	21.7	19.4
Hyperlipidaemia (%)	258 784	18.1	22.2	15.7	17.9	18.5	18.0	18.1

Abbreviations: EPIC, European Prospective Investigation into Cancer and Nutrition; IHD, ischaemic heart disease. ^aAs estimated from the country-specific food questionnaires. ^bKnown number of observations for the characteristic variable, for example, for the physical activity variable.

Results in Table 2 show the distribution of participant characteristics according to the four categories of dietary fibre intake (from the diet questionnaires). Participants with the highest intake of dietary fibre were slightly younger and had lower systolic and diastolic blood pressure (by about 1 mm Hg) compared with participants with the lowest intake of dietary fibre. Compared to participants with the lowest intake of dietary fibre, the proportion of participants with the highest intake who were current smokers was lower (28.3% compared with 18.3%), and the proportion who smoked the most (at least 20 cigarettes/day) was lower

(11.6% compared to 6.6%). The proportion of participants who were active or moderately active, educated to a degree level, married or cohabiting, or had diabetes at recruitment was lowest among participants with the lowest intake of dietary fibre. The Spearman's correlation of fruit fibre with vegetable fibre was $r = 0.24$, between fruit and cereal fibre $r = -0.01$, and between vegetable and cereal fibre $r = -0.02$.

In the categorical analysis for dietary fibre intake (from the diet questionnaires), there was an inverse association with IHD mortality after adjustment for confounding variables (Table 3).

Table 3. Relative risk (95% CI) of IHD mortality according to categories of dietary fibre intake in the EPIC-Heart study

	Dietary fibre intake (g/day)						Per 10 g/day higher dietary fibre intake							
	<17.5	17.5–22.4	22.5–27.4	≥27.5	Uncalibrated	Calibrated	RR	95% CI	RR	95% CI	P trend	P trend		
Number of IHD deaths	776	616	480	509	2381	2381								
Base model ^a	1.00	0.71, 0.89	0.78	0.69, 0.89	0.77	0.66, 0.89	0.87	0.81, 0.94	<0.001	0.85	0.73, 0.99	0.031		
		Cereal fibre intake g/day							Per 5 g/day higher cereal fibre intake					
	<5	5–7	8–10	≥11	Uncalibrated	Calibrated								
Number of IHD deaths	572	671	483	655	2381	2381								
Base model	1.00	0.92	0.82, 1.03	0.85	0.75, 0.97	0.85	0.74, 0.97	0.94	0.89, 0.99	0.020	0.91	0.82, 1.01	0.076	
Further adjusted for intakes of fibre from fruit and vegetables and from other sources (g/day)	1.00	0.92	0.82, 1.03	0.84	0.74, 0.96	0.83	0.72, 0.96	0.93	0.88, 0.98	0.010	0.91	0.82, 1.01	0.084	
		Fruit fibre intake g/day							Per 2.5 g/day higher fruit fibre intake					
	<2	2–3	4–5	≥6	Uncalibrated	Calibrated								
Number of IHD deaths	827	776	442	336	2381	2381								
Base model	1.00	0.85	0.77, 0.94	0.88	0.78, 0.99	0.79	0.69, 0.92	0.94	0.90, 0.98	0.004	0.94	0.88, 1.01	0.079	
Further adjusted for intakes of fibre from cereals and from other sources (g/day)	1.00	0.86	0.77, 0.95	0.88	0.78, 1.00	0.79	0.69, 0.91	0.94	0.90, 0.98	0.003	0.94	0.88, 1.01	0.090	
		Vegetable fibre intake g/day							Per 2.5 g/day higher vegetable fibre intake					
	<2	2–3	4–5	≥6	Uncalibrated	Calibrated								
Number of IHD deaths	545	738	523	575	2381	2381								
Base model	1.00	0.88	0.78, 0.99	0.89	0.77, 1.02	0.89	0.76, 1.04	0.98	0.94, 1.03	0.434	0.92	0.78, 1.09	0.319	
Further adjusted for intakes of fibre from cereals and from other sources (g/day)	1.00	0.88	0.78, 1.00	0.89	0.78, 1.03	0.89	0.76, 1.04	0.98	0.94, 1.02	0.387	0.90	0.76, 1.07	0.255	
		Other sources of fibre intake g/day							Per 5 g/day higher other fibre intake					
	<3	3–4	5–6	≥7	Uncalibrated	Calibrated								
Number of IHD deaths	545	764	526	546	2381	2381								
Base model	1.00	0.99	0.87, 1.11	0.94	0.81, 1.09	1.01	0.85, 1.19	0.97	0.88, 1.07	0.520	1.04	0.90, 1.20	0.614	
Further adjusted for intakes of fibre from cereals and from fruit and vegetables (g/day)	1.00	0.98	0.86, 1.10	0.92	0.80, 1.07	0.97	0.82, 1.15	0.94	0.86, 1.04	0.252	1.01	0.87, 1.17	0.890	

Abbreviations: CI, confidence intervals; EPIC, European Prospective Investigation into Cancer and Nutrition; IHD, ischaemic heart disease; RR, relative risk. ^aThe base model is stratified by sex, centre and smoking and adjusted for age, alcohol intake, BMI, physical activity, marital status, highest education level, current employment, hypertension, hyperlipidaemia, angina pectoris, diabetes mellitus, polyunsaturated to saturated fat ratio and total energy intake.

Table 4. Association between the calibrated intake of dietary fibre and risk of fatal IHD by sex, age and smoking status in the EPIC-Heart study

	Number of IHD deaths	Per 10 g/day higher dietary fibre intake (calibrated)			
		RR ^a	95% CI	P trend	P heterogeneity ^b
Overall	2381	0.85	0.73, 0.99	0.031	
Sex					
Men	1596	0.89	0.76, 1.05	0.156	0.162
Women	785	0.74	0.57, 0.95	0.017	
Age at recruitment (years)					
< 60	909	0.81	0.67, 0.97	0.022	0.340
≥ 60	1472	0.89	0.75, 1.05	0.177	
Smoking					
Never	747	0.80	0.63, 1.01	0.055	
Former	834	0.89	0.72, 1.09	0.254	
Current < 10 cigarettes/day	156	0.84	0.51, 1.37	0.475	0.964
Current 10–19 cigarettes/day	272	0.85	0.61, 1.20	0.362	
Current ≥ 20 cigarettes/day	372	0.86	0.65, 1.15	0.320	

Abbreviations: CI, confidence intervals; EPIC, European Prospective Investigation into Cancer and Nutrition; IHD, ischaemic heart disease; RR, relative risk. ^aStratified by sex, centre and smoking and adjusted for age, alcohol intake, BMI, physical activity, marital status, highest education level, current employment, hypertension, hyperlipidaemia, angina pectoris, diabetes mellitus, polyunsaturated to saturated fat ratio and total energy intake. ^bAssessed by adding appropriate interaction terms to the regression models and testing for statistical significance using a likelihood ratio test.

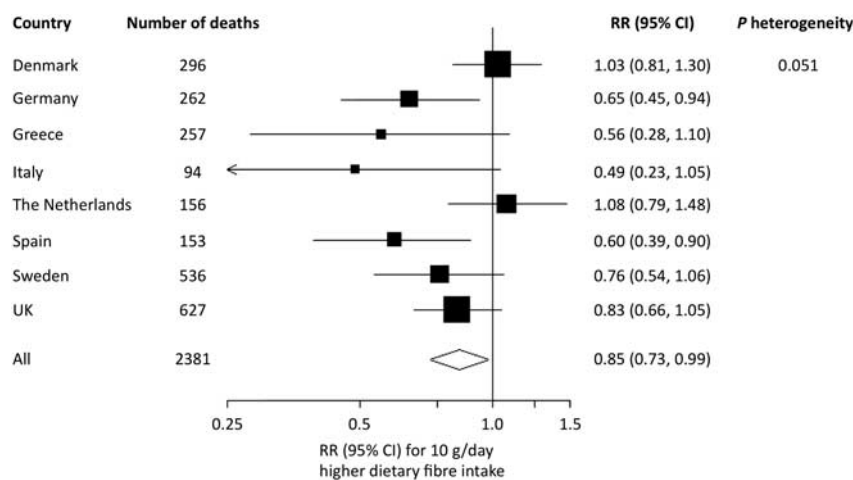


Figure 1. IHD mortality versus dietary fibre intake for the eight countries included in the EPIC-Heart study. RR (95% CI) are per 10 g/day—for example, 20 g/day versus 10 g/day—and are stratified by sex, centre and smoking and adjusted for age, alcohol intake, BMI, physical activity, marital status, highest education level, current employment, hypertension, hyperlipidaemia, angina pectoris, diabetes mellitus, polyunsaturated to saturated fat ratio, and total energy intake. Heterogeneity was assessed by adding appropriate interaction terms to the regression models and testing for statistical significance using a likelihood ratio test.

Compared with participants with the lowest intake of dietary fibre (< 17.5 g/day), the reduction in risk of IHD mortality was 20% (RR = 0.80, 95% CI: 0.71–0.89), 22% (RR = 0.78, 95% CI: 0.69–0.89) and 23% (RR = 0.77, 95% CI: 0.66–0.89) amongst participants consuming 17.5–22.4 g/day, 22.5–27.4 g/day and at least 27.5 g/day, respectively. In analyses using the calibrated intake of dietary fibre, each 10 g/day was associated with a 15% lower risk of fatal IHD (RR = 0.85, 95% CI: 0.73, 0.99). Dietary fibre from the various food sources were associated with a lower risk of IHD mortality; each 5 g/day higher cereal fibre intake corresponded to a 9% reduction (RR = 0.91 95% CI: 0.82–1.01, *P* trend = 0.084), each 2.5 g/day higher fruit fibre intake was associated with a 6% reduction (RR = 0.94 95% CI: 0.88–1.01 *P* trend = 0.090) and each 2.5 g/day higher intake of vegetable fibre was associated with a 10% reduction (RR = 0.90 95% CI: 0.76–1.07 *P* trend = 0.255) (Table 3). However, none of these associations were statistically significant. The association between other sources of fibre (that is,

not cereals, fruits or vegetables) and risk of IHD mortality was null (RR = 1.01 95% CI: 0.87, 1.17, *P* trend = 0.890).

The association between dietary fibre and fatal IHD did not differ by sex, age or smoking (Table 4). The test for heterogeneity for dietary fibre intake and risk of IHD mortality between the eight countries was of borderline significance (*P* = 0.051, Figure 1). The association between the intake of dietary fibre and risk of IHD mortality remained statistically significant after excluding the first 5 years of follow-up, leaving 1589 IHD deaths in the analysis (RR per 10 g/day higher fibre intake = 0.78, 95% CI: 0.65, 0.93 *P* trend = 0.007).

DISCUSSION

The results from this study showed a significant inverse association between dietary fibre and IHD mortality, with no evidence of any difference in the association with IHD for dietary

fibre from cereals, fruits or vegetables after calibration for measurement error. The finding of a lower risk of IHD among those with a higher intake of dietary fibre is in agreement with the results from other observational studies.^{3–5,22} The estimate from the current analysis of a 15% lower risk of IHD mortality associated with a 10 g/day higher dietary fibre intake based on 2381 cases is consistent with but not as large as the 27% reduction in IHD deaths based on 2011 cases from the Pooling Project.⁴ Despite the consistent inverse association between dietary fibre and IHD in observational studies, a strong protective effect of a higher dietary fibre intake on the risk of coronary mortality has not been demonstrated in randomised controlled trials. The Diet and Reinfarction Trial (DART)—a secondary prevention trial—in which men increased their intake of cereal fibre by 8.0 g/day (95% CI: 7.4–8.6) had a RR of IHD mortality of 1.35 (95% CI: 1.02–1.80) after 2 years of follow-up,²³ which was reduced to 1.11 (95% CI: 0.96–1.29) in a 10-year follow-up of a subgroup of the men (mean difference in cereal fibre: 1.2, 95% CI: 1.0–1.3 g/day).²⁴ In the Women's Health Initiative study, dietary fibre intake among the intervention group was 2.4 g/day (95% CI: 2.3–2.6) higher (in combination with a decrease in total fat intake) and, after an average of 8.1 years of follow-up, there was no difference in the rates of major IHD events or IHD death between the intervention and the comparison group.²⁵ However, it should be noted that both these studies may have been underpowered to detect the small effect on long-term risk of IHD that might be predicted given the small difference in fibre intake between the groups.

As there was a strong inverse association between dietary fibre intake and the proportion of current smokers in this study, the association between dietary fibre intake and risk of IHD was examined among subgroups of never, former and light, medium and heavy smokers with results showing no evidence of overall heterogeneity by smoking status. While the analyses included a number of confounding variables, it is difficult to rule out the effect of residual confounding by dietary or lifestyle factors or confounding from other unmeasured variables related to the consumption of dietary fibre.

If a higher intake of dietary fibre is causally related to a lower risk of IHD, likely mechanisms mediating this association could be through the effects of dietary fibre on established IHD risk factors. Meta-analyses of randomised controlled trials have shown that an increased intake of dietary fibre (mainly from isolated or extracted fibre preparations) leads to a modest reduction in plasma low-density lipoprotein cholesterol concentrations⁸ and blood pressure.^{26,27} On the other hand, results from intervention trials where participants increased their intake of dietary fibre from sources such as wholegrain foods (both with and without weight loss), have shown little or no effect on serum low-density lipoprotein cholesterol concentrations or blood pressure.^{28–30} It is possible that a higher intake of dietary fibre may act to reduce the risk of fatal IHD through other mechanisms such as improved insulin sensitivity³¹ and therefore, future research that enables a better understanding of the mechanisms underlying the association between dietary fibre and IHD will be important.

Results from this study did not show any difference in the association between dietary fibre from cereals, fruit and vegetable with risk of fatal IHD, whereas others have shown that the association was only significant for fibre from cereals and fruits but not for fibre from vegetables.^{4,5} While there were differences in the diet questionnaires between the cohorts included in the EPIC-Heart study, food groups were coded centrally and corrected for measurement error therefore reducing the likelihood that these findings were due to between-cohort differences in the food groupings as may be the case for other studies.⁴ It is possible, however, that the inconsistent results between studies could be explained by discrepancies in the categorisation of the various sources of dietary fibre, or differences in the characteristics of the study participants or in the adjustment variables used.

Strengths of this study include being a large prospective study with over 2000 cases of fatal IHD and having a cohort population with a reasonably wide range in the intake of dietary fibre. Results also showed a similar result after excluding the first 5 years of follow-up, thereby reducing the possibility of a differential 'healthy volunteer' effect among participants with a higher intake of dietary fibre. The use of a second measure of diet in a subgroup of the participants also allowed for correction of some of the effect of measurement error in diet. The dietary fibre variable used in this analysis was based on estimates of the dietary fibre content of foods that were standardised across countries to account for some of the variation between countries because of differences in dietary assessment,²⁰ although this approach might not capture all this variation. The finding of an inverse association between dietary fibre intake and risk of fatal IHD must be interpreted in the light of having only measured diet at baseline and so the effects of dietary fibre intake during the entire period of follow-up could not be examined. It should be noted that the resulting values for the mean intake of dietary fibre for the different European countries reported in this study are not directly comparable to figures taken from national diet surveys.

In conclusion, a higher consumption of dietary fibre is associated with a lower risk of fatal IHD but there was no difference in the association with IHD for fibre from cereals, fruits or vegetables.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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