Public Health Nutrition: 5(6B), 1179–1196 DOI: 10.1079/PHN2002398

Consumption of vegetables, fruit and other plant foods in the European Prospective Investigation into Cancer and Nutrition (EPIC) cohorts from 10 European countries

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Abstract

Objective: To describe and compare the consumption of the main groups and sub-groups of vegetables and fruits (V&F) in men and women from the centres participating in the European Prospective Investigation into Cancer and Nutrition (EPIC).

Design: Cross-sectional analysis. Dietary intake was assessed by means of a 24-hour dietary recall using computerised interview software and standardised procedures. Crude and adjusted means were computed for the main groups and sub-groups of V&F by centre, separately for men and women. Adjusted means by season, day of the week and age were estimated using weights and covariance analysis.

Setting: Twenty-seven centres in 10 European countries participating in the EPIC project.

Subjects: In total, 35 955 subjects (13 031 men and 22 924 women), aged 35–74 years, randomly selected from each EPIC cohort.

Results: The centres from southern countries had the highest consumption of V&F, while the lowest intake was seen in The Netherlands and Scandinavia for both genders. These differences were more evident for fruits, particularly citrus. However, slightly different patterns arose for some sub-groups of vegetables, such as root vegetables and cabbage. Adjustment for body mass index, physical activity, smoking habits and education did not substantially modify the mean intakes of vegetables and fruits.

Conclusions: Total vegetable and fruit intake follows a south–north gradient in both genders, whereas for several sub-groups of vegetables a different geographic distribution exists. Differences in mean intake of V&F by centre were not explained by lifestyle factors associated with V&F intake.

Keywords
Vegetables
Fruit
Cohort studies
Cross-sectional analysis
EPIC study
24-Hour dietary recall
Europe

Vegetables and fruits (V&F) are foods relatively rich in vitamins, minerals and other bioactive compounds, and low in energy. Historically, consumption of V&F has been thought to prevent a wide range of conditions, more based on belief than on scientific evidence. However, during recent decades many studies have assessed the association between V&F and health[1]. Epidemiological data strongly support a protective effect of increased V&F consumption

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against epithelial cancers, mainly of the respiratory and digestive tract[2,3]. Current scientific evidence also suggests a protective role against cardiovascular disease[4,5], and evidence is accumulating for a protective effect against stroke[6]. This scientific evidence has resulted in the fact that most dietary recommendations promote the daily consumption of at least five portions (400 g) of V&F[2,7,8].

There seems to be a trend towards lifestyle and dietary uniformity in Europe, with changes towards healthier diets in northern countries, while Mediterranean countries have moved towards more northern dietary patterns[9]. The differences in V&F consumption patterns between regions as well as within populations need to be considered to improve knowledge about nutrition and the health effects of dietary factors. There are several problems in the assessment of V&F consumption in epidemiological studies and comparison across countries. Many studies are carried out in small groups with relatively homogeneous diets, and attenuation of differences because of measurement error cannot be discounted. A major issue when comparing results across populations is the validity and standardisation of the instrument used to assess dietary intake. Research on V&F should pay attention not only to the overall intake, but also to the consumption of individual foods and sub-groups. Inconsistencies in grouping and classifying V&F, and in expressing these foods as raw weights or weights as consumed, must be considered when comparing and/or pooling results from different studies. The classification of V&F is particularly important, bearing in mind that specific components and mechanisms responsible for health effects are not yet well understood.

The present study assesses V&F consumption in adult populations from cohorts participating in the European Prospective Investigation into Cancer and Nutrition (EPIC) project. The cohorts belong to 10 European countries with wide differences in dietary patterns and other lifestyle factors. A sample of subjects from these cohorts was interviewed in a standardised way to obtain dietary intake information. The specific aims are to describe the dietary intake of V&F overall and for different sub-groups, as well as to compare V&F consumption across countries and regions.

Methods

The results presented here arise from analysis of data from the calibration study carried out within the EPIC project. Details on the design and rationale of both the main study and the calibration study are given elsewhere[10,11]. Briefly, the EPIC project is a large prospective study involving 519 978 men and women in 23 administrative centres in 10

Table 1 Classification by major groups and sub-groups of vegetables, fruits and other plant foods used in the European Prospective Investigation into Cancer and Nutrition (EPIC) study

Major group	Sub-groups	Selected foods
Potatoes and other tubers	Unclassified	
	Potatoes	Potato
	Other tubers	Sweet potato
Vegetables	Unclassified	
	Leafy vegetables	Borage, chard, endive, lettuce, spinach, thistle
	Fruiting vegetables	Artichoke, aubergine, cucumber, eggplant, pepper, pumpkin, tomato
	Root vegetables	Beetroot, carrot, celery, parsnip, radish, salsify, turnip
	Cabbages	Broccoli, Brussels sprouts, cabbage, cauliflower, kale
	Mushrooms	Mushrooms, champignon, truffle
	Grain and pod vegetables	Peas, corn
	Onion, garlic	Garlic, young garling, onion, shallot
	Stalk vegetables, sprouts	Asparagus, bamboo, fennel, leek
	Mixed salads, mixed vegetables	
Legumes	Unclassified	
	Legumes	Beans, chickpeas, lentils
Fruits	Unclassified	
	Citrus fruits	Grapefruit, lemon, lime, orange, tangerine
	Fruits (non-citrus)	Apple, apricot, banana, cherry, date, fig, grape, kiwi, melon, nectarine, peach, pear, pineapple, plum, raisin, strawberry
	Nuts and seeds	Almond, chestnut, coconut, hazelnut, macadamia, peanut, pistachio
	Mixed fruits	
	Olives	Olives
Non-alcoholic beverages	Fruit and vegetable juices	
Condiments and sauces	Tomato sauces	

The list of foods given is not exhaustive of each group or sub-group. The sub-group 'citrus' is not included in the standard classification but has been built for this particular analysis. The groups 'non-alcoholic beverages' and 'condiments and sauces' include several other sub-groups, but only those relevant for this paper are shown in the table.

European countries. Baseline information on usual diet and lifestyle was collected from all subjects, together with anthropometric measurements and a blood sample, which was stored in a centralised biological bank. Dietary information was collected from each study subject by means of country-specific questionnaires. In addition, a single 24-hour dietary recall (24-HDR) was collected from a sample in each centre, as the calibration reference.

Subjects

The calibration population was an age- and sex-stratified random sample from each cohort, with weights according to the number and age–sex distribution of expected cancer cases in most centres. The sampling procedure was defined to control for seasonal and day-to-day variations. Participation rates, which ranged from 54% to 92%, were about 75% or above in seven out of 10 countries. The initial dataset included 36 900 subjects interviewed; after some exclusions because of incomplete information or technical problems and age restriction to 35–74 years, 35 955 individuals (13 031 men and 22 924 women) were included in the present analysis. In Greece, data collection was co-ordinated in Athens, but subjects were recruited from all regions of the country. The Bilthoven centre (The Netherlands) in fact covers several towns from which subjects were recruited (Amsterdam, Doetinchem, Maastricht). In the UK, subjects recruited from the general population in Oxford and Cambridge were grouped together; another group consisted of so-called 'health-conscious' subjects, which included vegetarians, vegans and fish eaters. Finally, in France and Norway, the centres were redefined according to geographical criteria; however, the term 'centre' is used for simplicity for both centres and geographical areas in the rest of this paper. The final analysis involved 27 redefined centres for women and 19 for men; only women were recruited in France, Norway, Utrecht (The Netherlands) and Naples (Italy).

Dietary assessment

Information on dietary intake was gathered by means of a computerised 24-hour dietary recall interview; the structure and details of the software (EPIC-SOFT) have been given elsewhere[12]. Information on all foods and beverages consumed during the recalled day was collected, entered and coded. During the dietary interview each reported food was searched for, described, quantified and checked according to common rules. Methods of quantification included pictures, household measures and standard units. For each food described, the final amount consumed was calculated taking into account the cooking method used and the edible part consumed, in order to express the food as finally consumed by the subject.

Classification of V&F

The present analysis concentrates on two major groups, vegetables and fruits. Each main group was in turn classified into sub-groups. The classification is unique to the EPIC study; it groups foods that could be described and quantified according to common rules across countries. A detailed description of the classification, including the main foods belonging to each group or sub-group, is given in Table 1.

For vegetables, the following sub-groups were used: 'leafy vegetables', 'fruiting vegetables', 'root vegetables', 'cabbages', 'mushrooms', 'grain and pod vegetables', 'onion and garlic', 'stalk vegetables and sprouts', 'mixed salads and mixed vegetables' and 'unclassified'. The sub-group 'unclassified' contained, in most cases, food items not fully described during the interview. In this paper, the results for 'leafy', 'fruiting', 'root', 'cabbages' and 'onion/garlic' are presented separately; the remaining sub-groups accounted for a relatively small proportion of total vegetable intake and were put under the general heading 'other'. Results on vegetables are also presented according to the way they are consumed, in two broad categories: raw or cooked.

Initially there were five sub-groups of fruits: 'fruits' (main sub-group), 'nuts and seeds', 'olives', 'mixed fruits' and 'unclassified'. The main sub-group 'fruits' was mainly formed of fresh fruits but it included dried and canned fruits as well. This sub-group accounted for about 90% of total consumption of fruits, so results for the remaining sub-groups are not presented. On the other hand, 'citrus fruits' were considered as a specific sub-group. Thus, results in the current paper are presented for two sub-groups: 'citrus fruits' and 'non-citrus fruits', the latter including mainly fresh fruits other than citrus.

'Legumes' and 'potatoes and other tubers' were considered as independent groups in our classification system. Although they are foods of plant origin and are sometimes included under the broad category of vegetables, most often they are considered separately[2]. They are different from vegetables regarding energy and carbohydrate contents and they are frequently used as a substitute for cereals rather than vegetables. On the other hand, juices and sauces were considered as specific groups in EPIC-SOFT, and two sub-groups, 'fruit and vegetable juices' and 'tomato sauces', are actually components of vegetables and fruits. We handled them separately since they are not the same nutritionally. Furthermore, since they were quantified in liquid form, the amount of such food items consumed was difficult to pool together with V&F consumption, which was mainly expressed as solid foods. In order to obtain a complete picture of V&F consumption, data on legumes, potatoes and tubers, fruit and vegetable juices, and tomato sauce have been included in this paper, although separately from the two main groups.

Table 2a Consumption of vegetables by sub-groups in men in 19 centres of the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Mean (g day^{-1}) and standard error (SE), crude and adjusted by age, season and day of the week

		Vegetables (total)			Leafy vegetables			Fruiting vegetables			Root vegetables			Cabbages			Onion, garlic		
			Adjusted			Adjusted			Adjusted			Adjusted			Adjusted			Adjusted	
Country and centre	*n*	Crude mean	Mean	SE	Crude mean	Mean	SE	Crude mean	Mean	SE	Crude mean	Mean	SE	Crude mean	Mean	SE	Crude mean	Mean	SE
Greece																			
Greece	1312	263.9	269.7	4.3	36.1	30.1	1.4	162.2	178.6	3.2	8.7	8.6	1.2	15.6	13.6	1.5	29.3	28.6	0.8
Spain																			
Granada	214	232.5	221.6	10.5	29.0	31.1	3.4	156.6	145.0	7.8	8.1	8.0	2.9	2.7	2.0	3.7	26.2	25.7	1.9
Murcia	243	264.3	266.8	9.9	29.1	29.3	3.2	161.5	164.4	7.3	12.0	11.7	2.7	16.7	15.6	3.4	33.5	34.7	1.8
Navarra	444	246.5	246.9	7.3	89.9	89.2	2.4	101.0	103.5	5.4	6.7	6.8	2.0	7.0	7.1	2.5	18.7	18.4	1.4
San Sebastian	490	235.1	234.0	7.0	44.9	45.8	2.3	115.8	111.9	5.2	12.8	13.2	1.9	10.3	12.3	2.4	30.6	30.7	1.3
Asturias	386	145.4	150.2	7.8	21.3	22.5	2.5	64.7	68.3	5.8	7.4	7.7	2.2	16.6	15.6	2.7	21.7	21.7	1.4
Italy																			
Ragusa	168	175.7	179.5	11.9	31.2	35.3	3.8	83.4	78.3	8.8	2.2	2.3	3.3	10.1	11.1	4.1	12.3	14.6	2.2
Florence	271	210.1	212.8	9.3	26.2	28.5	3.0	105.3	106.8	6.9	10.3	10.8	2.6	15.0	17.0	3.3	5.1	4.4	1.7
Turin	677	251.9	246.1	5.9	42.8	43.7	1.9	121.1	114.2	4.4	12.5	12.6	1.6	16.8	19.1	2.1	16.0	14.3	1.1
Varese	328	179.3	204.9	8.5	35.5	34.3	2.7	54.0	80.6	6.3	11.6	14.8	2.3	21.1	15.6	3.0	7.7	10.6	1.6
Germany																			
Heidelberg	1033	172.3	169.5	4.8	19.2	20.8	1.6	77.9	69.2	3.6	17.4	18.1	1.3	20.4	21.6	1.7	7.4	7.6	0.9
Potsdam	1235	147.1	151.3	4.4	7.7	7.7	1.4	69.7	71.0	3.2	14.9	14.7	1.2	24.1	25.8	1.5	7.5	7.7	0.8
The Netherlands																			
Bilthoven	1024	135.6	136.7	5.0	25.4	27.7	1.6	46.1	41.6	3.7	9.4	10.3	1.4	24.5	27.1	1.7	12.3	12.6	0.9
United Kingdom																			
General population	404	157.4	160.8	7.6	6.6	6.6	2.5	51.2	53.7	5.7	27.4	27.5	2.1	31.6	31.2	2.7	9.4	9.7	1.4
'Health-conscious'	114	220.2	225.4	14.4	11.5	14.2	4.7	79.4	76.5	10.7	26.3	25.3	4.0	29.2	35.7	5.0	17.9	17.8	2.7
Denmark																			
Copenhagen	1356	141.1	147.4	4.2	11.2	11.1	1.4	51.0	56.6	3.1	21.6	20.6	1.2	17.3	17.5	1.5	14.0	13.6	0.8
Aarhus	567	130.9	134.1	6.5	8.2	8.9	2.1	43.1	46.8	4.8	21.1	21.5	1.8	18.9	17.7	2.3	15.5	16.2	1.2
Sweden																			
Malmö	1421	119.1	120.3	4.3	9.5	7.7	1.4	50.8	56.3	3.2	20.2	19.2	1.2	16.4	14.7	1.5	8.6	8.3	0.8
Umeå	1344	104.6	103.4	4.2	10.6	9.7	1.4	47.8	47.2	3.1	17.5	17.4	1.2	10.3	10.7	1.5	8.7	8.8	0.8

Table 2b Consumption of vegetables by sub-groups in women in 27 centres of the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Mean (g day^{-1}) and standard error (SE), crude and adjusted by age, season and day of the week

		Vegetables (total)			Leafy vegetables			Fruiting vegetables			Root vegetables			Cabbages			Onion, garlic		
		Crude	Adjusted		Crude	Adjusted		Crude	Adjusted		Crude	Adjusted		Crude	Adjusted		Crude	Adjusted	
Country and centre	*n*	mean	Mean	SE	mean	Mean	SE	mean	Mean	SE	mean	Mean	SE	mean	Mean	SE	mean	Mean	SE
Greece																			
Greece	1374	208.7	207.0	3.9	33.0	28.6	1.2	122.0	126.8	2.8	10.3	9.6	1.4	13.1	12.2	1.3	20.2	19.4	0.6
Spain																			
Granada	300	230.0	216.0	8.3	24.0	24.9	2.7	161.2	148.2	6.0	9.1	8.9	3.0	4.9	5.0	2.9	21.6	20.9	1.3
Murcia	304	253.2	253.3	8.3	30.2	30.2	2.7	143.2	142.1	5.9	11.5	11.9	3.0	14.4	15.0	2.9	44.1	44.4	1.3
Navarra	271	194.1	196.1	8.7	64.2	63.6	2.8	85.8	88.3	6.3	5.4	5.8	3.1	10.7	11.6	3.1	10.7	11.0	1.4
San Sebastian	244	217.9	212.7	9.2	33.3	32.9	3.0	104.6	101.1	6.6	15.5	15.5	3.3	13.5	14.0	3.3	24.6	23.6	1.5
Asturias	324	104.9	103.3	8.0	17.9	17.8	2.6	43.7	42.5	5.7	6.0	6.1	2.9	11.9	11.3	2.8	13.7	14.1	1.3
Italy																			
Ragusa	138	146.0	138.3	12.3	24.9	30.8	4.0	65.8	54.8	8.8	2.2	3.0	4.4	10.2	11.7	4.3	10.5	11.0	2.0
Naples	403	167.8	173.7	7.2	19.0	19.3	2.3	74.3	88.4	5.1	8.1	9.1	1.6	30.9	22.4	2.5	6.2	5.9	1.1
Florence	785	195.2	197.2	5.1	24.8	24.3	1.7	94.8	91.6	3.7	11.4	11.4	1.8	12.8	12.9	1.8	8.8	9.6	0.8
Turin	392	234.2	233.8	7.3	37.8	36.8	2.4	115.3	116.5	5.2	14.4	14.7	2.6	14.2	16.0	2.6	13.0	12.6	1.1
Varese	794	166.7	160.0	5.1	32.0	30.6	1.6	79.2	72.5	3.6	10.7	10.7	1.8	8.2	7.9	1.8	7.6	6.6	0.8
France																			
South coast	612	226.5	260.9	5.8	51.6	51.7	1.9	92.4	127.1	4.2	20.8	23.4	2.1	15.5	13.3	2.0	9.2	11.0	0.9
South	1396	221.0	218.0	3.8	47.0	45.5	1.2	93.0	93.8	2.7	26.5	25.2	1.4	17.3	17.2	1.3	5.2	5.1	0.6
North-west	622	193.0	208.7	5.8	41.4	40.6	1.9	69.3	81.4	4.1	30.4	33.2	2.1	13.5	11.8	2.0	5.8	6.5	0.9
North-east	2009	215.9	215.1	3.2	42.0	40.9	1.0	89.3	91.8	2.3	31.5	30.6	1.1	16.3	15.8	1.1	7.9	7.7	0.5
Germany																			
Heidelberg	1087	170.3	165.4	4.4	21.7	22.0	1.4	76.2	66.7	3.1	18.7	19.3	1.6	21.4	23.8	1.5	6.7	7.0	0.7
Potsdam	1063	174.7	167.0	4.4	11.3	11.2	1.4	90.4	80.8	3.2	21.1	21.2	1.6	22.6	25.7	1.5	5.7	5.6	0.7
The Netherlands																			
Bilthoven	1086	131.8	128.3	4.4	21.5	22.0	1.4	45.6	40.6	3.2	11.0	11.7	1.6	25.3	26.0	1.5	10.8	11.0	0.7
Utrecht	1874	131.8	131.7	3.3	23.8	23.9	1.1	47.0	47.4	2.4	12.4	11.7	1.2	24.3	24.4	1.2	8.7	8.5	0.5
United Kingdom																			
General population	571	165.4	163.7	6.0	9.0	8.6	1.9	66.6	65.3	4.3	25.8	25.3	2.1	29.8	30.0	2.1	8.6	8.4	0.9
'Health-conscious'	197	220.9	220.1	10.3	18.4	20.6	3.3	83.6	82.8	7.4	24.5	23.0	3.7	36.2	34.0	3.6	13.4	12.7	1.6
Denmark																			
Copenhagen	1485	147.2	149.8	3.7	11.0	10.2	1.2	54.9	60.0	2.7	28.3	25.1	1.3	19.1	19.4	1.3	10.3	10.3	0.6
Aarhus	510	145.4	149.2	6.4	10.6	10.9	2.1	49.1	55.8	4.6	33.9	30.7	2.3	20.6	19.1	2.2	10.6	11.3	1.0
Sweden																			
Malmö	1711	126.0	130.5	3.5	11.9	11.7	1.1	60.5	65.6	2.5	17.8	17.2	1.3	13.7	13.7	1.2	6.7	6.7	0.5
Umeå	1574	122.7	122.5	3.6	10.4	10.1	1.2	54.6	55.0	2.6	22.3	22.6	1.3	16.7	16.1	1.3	7.6	7.8	0.5
Norway																			
South & East	1136	131.0	130.7	4.3	8.5	9.2	1.4	43.5	40.5	3.1	32.4	34.0	1.5	22.9	23.3	1.5	5.4	5.6	0.7
North & West	662	119.4	118.3	5.6	4.1	4.2	1.8	35.5	32.1	4.0	39.4	40.9	2.0	22.3	22.6	2.0	4.9	5.0	0.9

Table 3a Consumption of raw or cooked vegetables in men in 19 centres of the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Proportion (%) of total vegetable intake consumed raw or cooked; mean ($g\,day^{-1}$) and standard error (SE), crude and adjusted by age, season and day of the week

		Vegetables, raw				Vegetables, cooked			
				Adjusted				Adjusted	
Country and centre	*n*	%	Crude mean	Mean	SE	%	Crude mean	Mean	SE
Greece									
Greece	1312	39.6	104.6	118.9	3.1	60.4	159.3	150.8	3.1
Spain									
Granada	214	53.5	124.4	118.3	7.7	46.7	108.5	104.0	7.8
Murcia	243	56.9	150.4	155.1	7.2	43.1	113.9	111.7	7.3
Navarra	444	41.8	103.0	104.1	5.3	58.2	143.5	142.8	5.4
San Sebastian	490	50.4	118.4	111.1	5.1	52.0	122.3	128.4	5.2
Asturias	386	43.6	63.4	68.1	5.7	56.4	82.0	82.1	5.8
Italy									
Ragusa	168	39.8	69.9	77.5	8.7	60.2	105.7	102.1	8.8
Florence	271	47.0	98.8	96.7	6.8	53.0	111.3	116.1	6.9
Turin	677	45.7	115.2	109.5	4.3	54.3	136.7	136.6	4.4
Varese	328	37.1	66.6	86.4	6.2	62.9	112.7	118.5	6.3
Germany									
Heidelberg	1033	50.5	87.0	79.8	3.5	49.5	85.3	89.8	3.6
Potsdam	1235	44.0	64.8	64.3	3.2	56.0	82.3	87.0	3.2
The Netherlands									
Bilthoven	1024	30.5	41.4	35.6	3.6	69.5	94.2	101.1	3.7
United Kingdom									
General population	404	31.0	48.8	52.8	5.6	69.0	108.7	108.0	5.7
'Health-conscious'	114	36.2	79.7	78.5	10.5	63.8	140.5	146.9	10.7
Denmark									
Copenhagen	1356	49.0	69.2	73.8	3.0	51.0	72.0	73.8	3.1
Aarhus	567	37.9	49.6	53.4	4.7	62.1	81.3	80.8	4.8
Sweden									
Malmö	1421	51.3	61.1	68.3	3.1	48.7	58.0	51.9	3.2
Umeå	1344	65.4	68.4	67.4	3.0	34.6	36.1	36.0	3.1

Non-dietary variables

This information was collected using a self-administered questionnaire in most countries. Education was categorised into five levels: uncompleted primary school, primary school completed, technical, secondary school and university degree. Smoking any type of tobacco was used to classify subjects as never, current and former smokers. Physical activity sections consisted of questions on occupational and recreational activities, including cycling; the latter was not available for Norway and Naples (Italy). Current job was classified into sedentary, standing, manual and heavy manual. Total hours per week ($h\,week^{-1}$) of recreational activities were computed and categorised into four levels: $0\,h\,week^{-1}$, $0–3.5\,h\,week^{-1}$, $>3.5–7\,h\,week^{-1}$ and $>7\,h\,week^{-1}$. Height and weight were used to estimate the body mass index (BMI) in the usual way, as weight in kilograms divided by the square of height in metres. In the present analysis, four categories of BMI were considered: subjects with BMI $< 20\,kg\,m^{-2}$ were classified as 'lean', those with BMI $= 20–24.99\,kg\,m^{-2}$ as 'normal', those with BMI $= 25–29.99\,kg\,m^{-2}$ as 'overweight' and those with BMI $\geq 30.00\,kg\,m^{-2}$ as 'obese'. Further details on the definition and distribution by centre of non-dietary variables are presented elsewhere[11].

Data analysis

The crude mean and standard error of the intake in grams per day were calculated for all groups and sub-groups mentioned above. All analyses were carried out separately for men and women at the centre level. In order to improve the comparability between centres, means with corresponding standard errors adjusted for age, season and day of the week were estimated as well. Although sampling procedures were designed to control for seasonal and day-of-the-week variation, the distribution of these variables was not homogeneous across centres. In the same way, the sample was composed of middle-aged populations but the mean age varied across cohorts. Under 'ideal' sampling, all centres should have 25% of subjects interviewed each season. Furthermore, 28.6% of the recalled days should correspond to the weekend (2/7), and 71.4% to a weekday (Monday–Friday). Since sampling was not perfect, subjects were assigned weights to account for over- or under-sampling. Weights were calculated for all subjects, in each particular season and day of the week combination, as the ratio between the expected frequency under ideal conditions and the actual frequency. To further adjust for age the analysis of covariance was used[13]: a weighted regression model was fitted using the variable of interest as the dependent

Table 3b Consumption of raw or cooked vegetables in women in 27 centres of the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Proportion (%) of total vegetable intake consumed raw or cooked; mean (g day^{-1}) and standard error (SE), crude and adjusted by age, season and day of the week

		Vegetables, raw				Vegetables, cooked			
				Adjusted				Adjusted	
Country and centre	*n*	%	Crude mean	Mean	SE	%	Crude mean	Mean	SE
Greece									
Greece	1374	37.8	78.8	83.5	2.7	62.2	129.9	123.5	2.9
Spain									
Granada	300	55.4	127.5	113.8	5.8	45.1	103.7	103.2	6.2
Murcia	304	48.0	121.6	119.9	5.8	52.0	131.6	133.5	6.2
Navarra	271	45.9	89.2	89.5	6.2	54.1	104.9	106.5	6.5
San Sebastian	244	42.1	91.7	89.3	6.5	59.9	130.6	127.1	6.9
Asturias	324	51.0	53.5	51.8	5.6	49.0	51.5	51.5	6.0
Italy									
Ragusa	138	37.9	55.4	52.6	8.6	62.1	90.6	85.7	9.2
Naples	403	30.4	51.1	58.3	5.0	69.6	116.7	115.3	5.4
Florence	785	44.0	85.9	86.3	3.6	56.0	109.3	110.9	3.8
Turin	392	43.1	101.0	101.3	5.1	56.9	133.2	132.5	5.4
Varese	794	46.8	78.0	73.2	3.6	53.2	88.7	86.8	3.8
France									
South coast	612	37.1	84.1	101.8	4.1	62.9	142.4	159.1	4.3
South	1396	38.3	84.6	83.0	2.7	61.7	136.5	135.1	2.9
North-west	622	41.9	80.9	88.6	4.0	58.1	112.1	120.1	4.3
North-east	2009	38.9	83.9	85.6	2.2	61.1	131.9	129.6	2.4
Germany									
Heidelberg	1087	51.1	87.0	77.9	3.1	48.9	83.3	87.5	3.3
Potsdam	1063	56.9	99.5	88.1	3.1	43.1	75.3	79.0	3.3
The Netherlands									
Bilthoven	1086	40.7	53.6	48.2	3.1	59.3	78.1	80.1	3.3
Utrecht	1874	33.7	44.4	45.1	2.3	66.5	87.6	86.8	2.5
United Kingdom									
General population	571	40.4	66.7	64.7	4.2	59.6	98.6	99.0	4.5
'Health-conscious'	197	42.5	93.9	94.7	7.2	57.5	127.0	125.4	7.7
Denmark									
Copenhagen	1485	53.9	79.4	82.3	2.6	46.2	68.1	67.8	2.8
Aarhus	510	51.9	75.4	79.7	4.5	48.1	70.0	69.6	4.8
Sweden									
Malmö	1711	59.6	75.1	80.2	2.5	40.4	50.9	50.3	2.6
Umeå	1574	69.7	85.6	85.8	2.5	30.3	37.2	36.7	2.7
Norway									
South & East	1136	56.6	74.1	72.7	3.0	43.4	56.9	58.0	3.2
North & West	662	47.8	57.1	55.0	4.0	52.2	62.4	63.3	4.2

variable and the variables centre and age as independent covariates, with weights as defined above. The adjusted means reported actually correspond to the mean consumption of populations with a balanced distribution of subjects interviewed over seasons and between weekend and weekdays, with mean age of 56.8 years for men and 55.3 years for women.

To take into account the effect of anthropometric and lifestyle factors, each variable representing such factors (BMI, education, physical activity, smoking) was added into the previous model. Significance was assessed by means of the partial *F*-test[13]; we also looked at the change in R^2 of the model as well as the modification of the centre-adjusted means after including the new variable. Since we were mainly interested in the overall pattern across centres, we also looked at differences in the rankings of mean consumption of V&F after adjustment for each factor.

Results

Consumption of vegetables, overall and for the main subgroups, is shown in Tables 2a and 2b for men and women, respectively. Among men, there is a clear south–north gradient of total intake of vegetables, with a ratio of 2.6 between Greece and Umeå (Sweden), the highest and lowest adjusted mean (270 g day^{-1} vs. 103 g day^{-1}). Two exceptions to this gradient are Asturias, one of the Spanish centres, with a relatively low consumption, and the 'health-conscious' population group in the UK, with a high proportion of vegetarians. After adjustment, the highest consumption among women is observed in the South of France; there is also a south–north pattern, but less clearly defined, as some centres in Italy and Spain had low vegetable intake. The highest to lowest ratio is 2.5, comparing 261 g day^{-1} in the South of France to 103 g day^{-1} in Asturias, in the north of Spain.

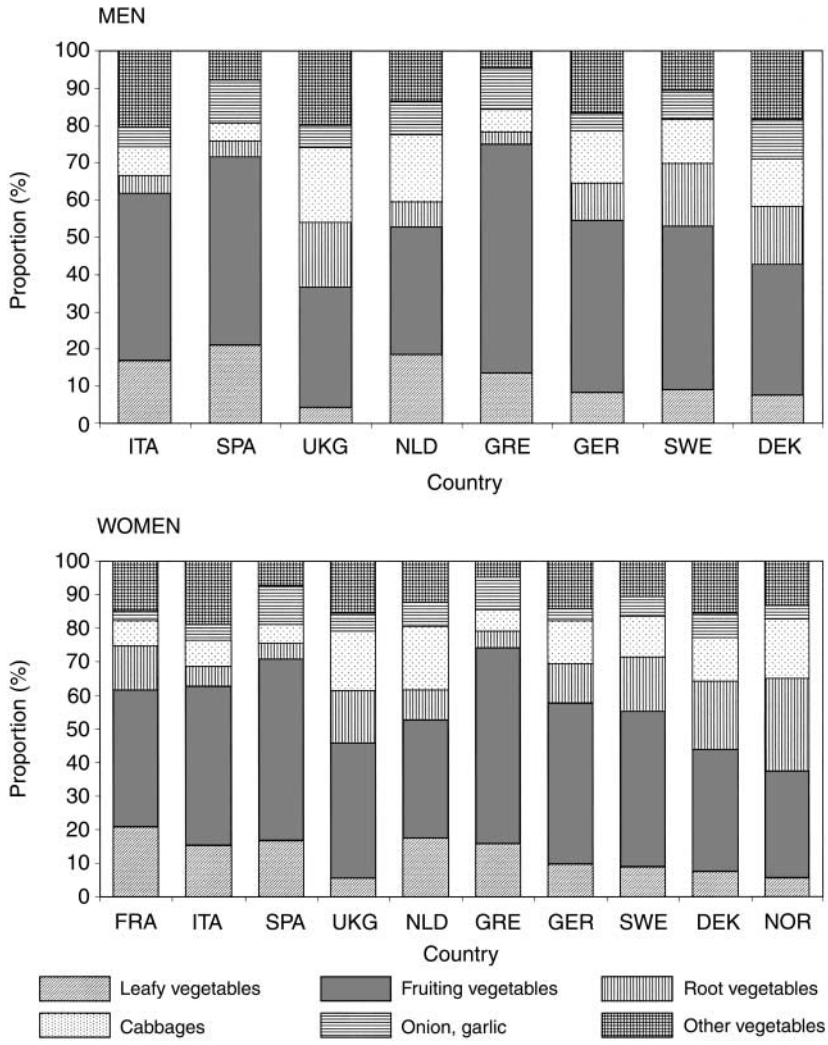

Fig. 1 Consumption of vegetables by sub-groups in the European Prospective Investigation into Cancer and Nutrition (EPIC) countries: FRA – France; ITA – Italy; SPA – Spain; UKG – UK (general population); NLD – The Netherlands; GRE – Greece; GER – Germany; SWE – Sweden; DEK – Denmark; NOR – Norway. Other vegetables includes: mushrooms, grain and pod vegetables, stalk vegetables and sprouts, mixed, and unclassified

A different picture arises when sub-groups of vegetables are considered. In addition to Table 2, with data by centre, the graphical distribution of vegetable sub-groups is shown in Fig. 1 grouped by country. Fruiting vegetables are by far the most consumed; in many centres they account for about half of total vegetable intake, ranging from one- to two-thirds in low and high consumers, respectively, with a geographical pattern similar to that of total vegetables. Leafy vegetables, root vegetables and cabbages have similar proportions overall (10–15%), but they show broad variations and different patterns. While the Mediterranean countries consume a relatively large quantity of leafy vegetables, Scandinavian countries and the UK have the highest proportion of root vegetable consumption, and the UK, The Netherlands and Germany have the highest proportion of cabbage. The intake of onion and garlic is lower than for previous vegetable sub-groups in most countries, led by the southern Spanish centres and Greece in men and women.

Data regarding how vegetables are consumed are shown in Tables 3a and 3b. Mediterranean countries and France consume more vegetables either raw or cooked, both among men and women, taken as absolute values. However, some differences exist when the proportion of total intake is considered: the centres in Norway, Sweden and Germany have the highest proportion of vegetables consumed raw, while in Greece, France, some Italian centres, the UK and The Netherlands people tend to consume more cooked vegetables.

The north–south pattern seen for vegetables is even more marked for fruits (Tables 4a and 4b): the ratio between the highest and lowest consumers is 3.7 among men, comparing the adjusted mean of $454\,g\,day^{-1}$ in Murcia (Spain) to $122\,g\,day^{-1}$ in Malmö (Sweden). Among women the ratio is 2.7, comparing $400\,g\,day^{-1}$ in Ragusa (Italy) to $151\,g\,day^{-1}$ in Malmö (Sweden). The difference from vegetable consumption is that Greece and France show an intermediate position for fruit intake. The highest

Table 4a Consumption of fruits by sub-groups in men in 19 centres of the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Mean (g day^{-1}) and standard error (SE), crude and adjusted by age, season and day of the week

		Fruits (total)			Citrus fruits			Other fresh fruits		
			Adjusted			Adjusted			Adjusted	
Country and centre	*n*	Crude mean	Mean	SE	Crude mean	Mean	SE	Crude mean	Mean	SE
Greece										
Greece	1312	236.2	273.0	6.6	66.1	51.1	3.0	155.7	207.5	6.0
Spain										
Granada	214	382.4	360.4	16.3	72.5	86.7	7.4	297.9	260.8	14.9
Murcia	243	438.2	453.6	15.3	158.3	151.3	6.9	256.2	277.8	14.0
Navarra	444	315.2	317.4	11.3	92.6	89.4	5.1	211.6	217.3	10.3
San Sebastian	490	369.4	386.1	10.9	89.4	92.1	4.9	264.3	279.4	9.9
Asturias	386	337.3	340.7	12.1	53.6	49.5	5.5	275.0	282.4	11.1
Italy										
Ragusa	168	391.3	447.6	18.4	57.4	76.2	8.4	321.5	361.8	16.8
Florence	271	373.8	396.1	14.5	51.5	58.0	6.6	309.8	326.2	13.2
Turin	677	410.4	421.5	9.1	54.5	59.4	4.1	350.6	356.5	8.4
Varese	328	343.4	348.2	13.1	107.8	73.3	6.0	224.7	264.3	12.0
Germany										
Heidelberg	1033	173.1	175.1	7.4	17.4	24.2	3.4	146.5	142.2	6.8
Potsdam	1235	236.8	239.3	6.8	31.5	31.0	3.1	192.2	194.6	6.2
The Netherlands										
Bilthoven	1024	155.8	167.8	7.7	33.1	39.6	3.5	109.1	114.1	7.0
United Kingdom										
General population	404	148.7	148.7	11.8	21.6	21.2	5.4	116.2	116.5	10.8
'Health-conscious'	114	261.0	264.2	22.3	57.0	53.5	10.1	183.5	183.6	20.4
Denmark										
Copenhagen	1356	140.6	142.3	6.4	25.0	18.0	2.9	107.5	117.4	5.9
Aarhus	567	180.4	178.1	10.0	33.0	27.6	4.5	141.9	145.2	9.1
Sweden										
Malmö	1421	135.3	121.5	6.6	32.5	22.4	3.0	97.3	94.0	6.0
Umeå	1344	124.9	121.9	6.5	30.0	27.9	2.9	91.7	90.8	5.9

consumption of citrus fruit was observed in Spanish centres, mainly in Murcia, while the Italian centres, mainly Ragusa, led for intake of other non-citrus fruits.

Although there are striking differences in the amount of fruit consumed, the pattern of consumption is similar in qualitative terms, as can be seen in Fig. 2. The apple is the most consumed fruit in all countries, accounting for approximately 25% of fruit consumption. Only three items account for slightly more than 50% of total fruit intake: in addition to apples, the most consumed fruits in countries with high consumption (Italy and Spain) are oranges and pears, while bananas and oranges take second and third place in northern countries.

Consumption of other food groups of plant origin is shown in Tables 5a and 5b. The Scandinavian and Dutch centres have the highest intake of potatoes and tubers in both men and women. The ratio of consumption is more than three times that of Greece and the southern Italian centres. Legumes are consumed mainly in Spain, and intermediate consumption was observed in Greece and the 'health-conscious' cohort in the UK. The German centres had the highest consumption of vegetable and fruit juices by both genders; British men and Dutch women showed high intakes as well. The centres with high intake of fruits, however, reported low consumption of juices. The Italian centres, particularly Ragusa, reported a much higher consumption of tomato sauce than any other centre, among both men and women.

Finally, Tables 6a and 6b, 7a and 7b show the influence of smoking, education, physical activity and BMI on the mean consumption of vegetables and fruits, respectively. Overall, the factors considered had more influence on the consumption of both groups among women than among men. Regarding vegetables, adjustment produced a modification lower than 1% of the mean intake in most centres, compared with the mean adjusted for age, season and day of the week (baseline adjustment). Only smoking among men and years of school among women had a more marked influence on the mean consumption, although this did not produce substantial changes in the ranking of centres according to mean intake. Regarding fruits, the time spent on recreational activities had the highest influence on mean intake, producing differences in the range of 5–10% compared with the baseline-adjusted mean; centres from Spain, Sweden and Norway were most affected by such an adjustment. However, the overall pattern of consumption, defined by the ranking of centres according to mean fruit intake, did not change substantially.

Discussion

Among 27 European centres, we have shown a south–north gradient in the mean intake of total vegetables and fruits in both genders. The ratio between highest and lowest consumers was around 2.5 for vegetables and 3 for

Table 4b Consumption of fruits by sub-groups in women in 27 centres of the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Mean (g day^{-1}) and standard error (SE), crude and adjusted by age, season and day of the week

		Fruits (total)			Citrus fruits			Other fresh fruits		
			Adjusted			Adjusted			Adjusted	
Country and centre	*n*	Crude mean	Mean	SE	Crude mean	Mean	SE	Crude mean	Mean	SE
Greece										
Greece	1374	219.6	241.9	5.6	53.7	45.1	2.5	156.7	188.3	5.2
Spain										
Granada	300	352.5	353.3	12.1	87.2	101.0	5.5	259.1	244.7	11.2
Murcia	304	372.6	378.9	12.0	118.9	116.8	5.5	239.4	247.2	11.2
Navarra	271	320.3	332.4	12.7	99.2	98.7	5.8	213.6	225.9	11.8
San Sebastian	244	370.0	372.8	13.4	77.9	78.4	6.1	280.1	283.6	12.5
Asturias	324	325.5	336.4	11.7	57.4	58.0	5.3	257.1	267.4	10.8
Italy										
Ragusa	138	362.9	399.9	17.9	53.3	63.8	8.1	306.3	332.7	16.6
Naples	403	289.9	292.7	10.4	100.7	71.1	4.7	182.4	214.2	9.7
Florence	785	321.5	328.1	7.5	55.8	54.3	3.4	254.8	263.5	6.9
Turin	392	357.6	361.1	10.6	70.5	60.8	4.8	281.5	294.3	9.8
Varese	794	334.7	335.0	7.4	47.7	66.0	3.4	276.8	259.6	6.9
France										
South coast	612	231.0	249.3	8.5	51.0	39.1	3.8	168.8	196.4	7.9
South	1396	256.8	257.7	5.6	37.4	35.0	2.5	204.5	207.5	5.2
North-west	622	237.5	247.9	8.4	56.2	45.1	3.8	171.4	191.3	7.8
North-east	2009	244.8	248.0	4.7	45.6	41.8	2.1	186.9	193.0	4.3
Germany										
Heidelberg	1087	202.1	212.7	6.4	21.1	26.0	2.9	168.7	173.8	6.0
Potsdam	1063	247.8	259.9	6.4	25.6	38.4	2.9	211.9	210.5	6.0
The Netherlands										
Bilthoven	1086	157.2	169.8	6.5	34.4	37.1	2.9	113.7	123.9	6.0
Utrecht	1874	222.2	213.5	4.9	48.3	49.9	2.2	163.5	152.7	4.5
United Kingdom										
General population	571	172.9	171.7	8.8	29.1	28.2	4.0	134.0	134.3	8.1
'Health-conscious'	197	261.7	274.1	14.9	35.7	35.5	6.8	206.3	215.9	13.9
Denmark										
Copenhagen	1485	186.6	181.4	5.4	40.4	31.0	2.4	138.5	142.1	5.0
Aarhus	510	239.2	231.2	9.3	48.9	37.2	4.2	186.3	188.6	8.6
Sweden										
Malmö	1711	162.5	151.0	5.2	33.7	30.0	2.3	124.6	116.4	4.8
Umeå	1574	164.5	159.4	5.3	41.1	38.9	2.4	120.3	117.4	4.8
Norway										
South & East	1136	163.3	173.7	6.3	36.1	32.5	2.8	121.4	135.9	5.8
North & West	662	147.0	162.7	8.2	29.9	28.7	3.7	111.4	129.2	7.6

fruits. This pattern, however, is not homogeneous for all centres within the countries, nor is it similar for all vegetable sub-groups. Fruiting and leafy vegetables are consumed mainly in southern countries, Scandinavian countries and the UK consume more root vegetables, and Germany and The Netherlands consume more cabbage. The south–north gradient is more evident for fruit consumption, with a remarkably high consumption of citrus fruits in southern centres in Spain and fresh fruits other than citrus in southern Italy. Concerning other plant groups, legumes are consumed almost exclusively in the Mediterranean countries while the Scandinavian and Dutch centres have the highest intake of potatoes.

In interpreting our results, several methodological issues must be taken into account. First of all, in most countries we did not study representative population samples[11]. Methods of recruitment of cohorts were not homogeneous across centres or countries. Generally speaking, we dealt with healthy adult populations from 10 European countries. Cohorts from the Spanish centres, as well as from Turin and Ragusa (Italy), included a high proportion of blood donors. Furthermore, in most countries the centres were selected bearing in mind the main purpose of the EPIC study: namely, the identification of cancer cases. Thus, although for some centres or countries it has been shown that our population has the same characteristics as populations with the same age–sex structure[14], results shown here should not be considered as being representative at the country level.

Regarding the dietary assessment instrument, we used standardised 24-HDR. The principal limitation is that it does not provide a reliable estimate of an individual's usual intake because of day-to-day variations[15]. The 24-HDR is also prone to measurement errors, with an overall tendency to underreport total energy. Although it relies on the subject's memory, it is less prone to recall errors than questionnaire methods that refer to usual diet over an extended period in the past. It is especially appropriate for

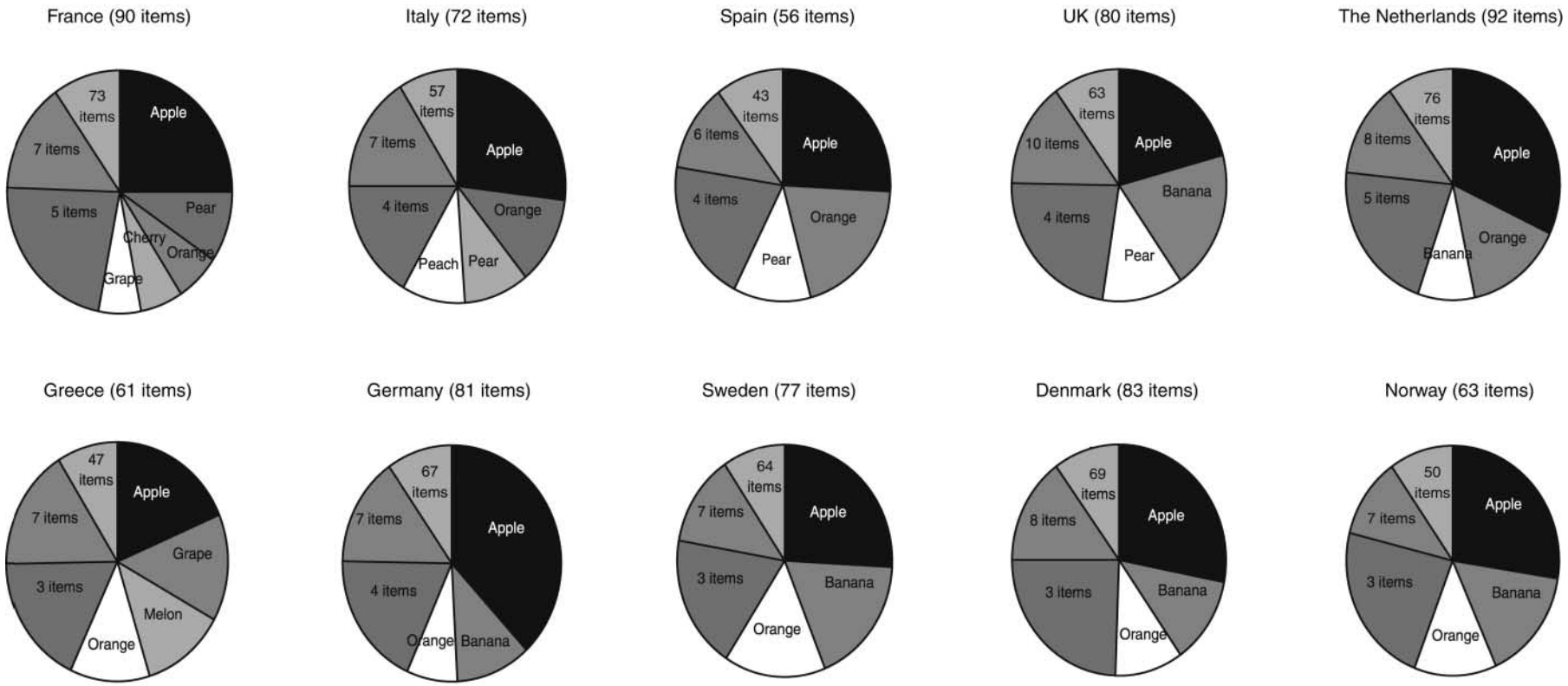

Fig. 2 Consumption of fruits in the European Prospective Investigation into Cancer and Nutrition (EPIC) countries: ranking according to the amount consumed. In each country, individual values are shown only for fruits accounting for at least 50% of total fruit intake (or the nearest higher value). Then, three groups are presented separately, indicating only the number of items contributing up to 75%, 90% and 100% of total fruit consumption, respectively. Numbers in parentheses after the country name indicate the total number of different items reported. France: apple 25%, pear 9%, orange 6%, cherry 6%, grape 6%; Italy: apple 26%, orange 12%, pear 10%, peach 10%; Spain: apple 26%, orange 20%, pear 12%; UK: apple 21%, banana 19%, pear 12%; The Netherlands: apple 32%, orange 15%, banana 9%; Greece: apple 18%, grape 14%, melon 12%, orange 12%; Germany: apple 38%, banana 11%, orange 7%; Sweden: apple 26%, banana 18%, orange 15%; Denmark: apple 29%, banana 12%, orange 10%; Norway: apple 27%, banana 16%, orange 12%

Table 5a Consumption of other groups of plant foods in men in 19 centres of the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Mean (g day^{-1}) and standard error (SE), crude and adjusted by age, season and day of the week

		Potatoes & other tubers			Legumes			Fruit & vegetable juices			Tomato sauce		
			Adjusted			Adjusted			Adjusted			Adjusted	
Country and centre	*n*	Crude mean	Mean	SE	Crude mean	Mean	SE	Crude mean	Mean	SE	Crude mean	Mean	SE
Greece													
Greece	1312	46.3	43.1	3.4	35.1	32.9	1.5	31.6	34.7	4.7	6.2	8.1	0.9
Spain													
Granada	214	81.1	79.2	8.4	37.2	35.5	3.7	46.9	53.5	11.6	3.7	3.9	2.4
Murcia	243	84.6	85.5	7.9	36.7	36.7	3.5	43.6	42.1	10.8	7.9	7.1	2.2
Navarra	444	69.9	71.4	5.8	50.1	48.1	2.5	28.6	28.4	8.0	7.8	7.7	1.6
San Sebastian	490	87.0	90.3	5.6	55.7	59.7	2.4	24.6	18.4	7.7	9.7	7.6	1.6
Asturias	386	99.1	98.9	6.3	64.9	61.6	2.7	38.5	34.8	8.6	5.9	6.0	1.8
Italy													
Ragusa	168	59.0	53.9	9.5	13.4	14.7	4.2	11.9	8.3	13.1	52.5	57.0	2.7
Florence	271	50.8	52.0	7.5	19.2	19.4	3.3	22.7	20.2	10.3	30.0	30.2	2.1
Turin	677	49.6	51.9	4.7	9.7	9.7	2.1	24.6	23.2	6.5	22.3	21.8	1.3
Varese	328	49.7	45.6	6.8	8.7	8.3	3.0	23.3	19.0	9.4	36.1	33.8	1.9
Germany													
Heidelberg	1033	79.6	85.3	3.8	4.9	5.1	1.7	186.7	179.4	5.3	5.7	4.1	1.1
Potsdam	1235	109.5	114.4	3.5	4.8	4.3	1.5	145.6	140.3	4.8	5.5	5.3	1.0
The Netherlands													
Bilthoven	1024	120.9	128.3	4.0	6.0	6.6	1.7	70.3	61.0	5.4	3.6	1.0	1.1
United Kingdom													
General population	404	111.2	110.9	6.1	9.2	9.2	2.7	69.4	69.2	8.4	11.3	11.3	1.7
'Health-conscious'	114	92.9	99.2	11.6	28.0	23.7	5.1	111.4	110.0	15.9	18.6	12.5	3.3
Denmark													
Copenhagen	1356	100.8	106.8	3.3	1.3	1.2	1.4	58.1	61.3	4.6	4.1	4.0	0.9
Aarhus	567	115.5	115.0	5.2	0.5	0.4	2.2	56.7	56.1	7.1	2.9	2.1	1.4
Sweden													
Malmö	1421	131.7	128.3	3.4	6.1	5.7	1.5	42.7	50.8	4.7	12.4	14.7	0.9
Umeå	1344	147.6	148.2	3.3	2.1	1.7	1.4	40.4	41.8	4.6	17.5	17.3	0.9

measuring the current diet in groups of individuals, and it is particularly suited to assessing group means. In our case the issue of comparability is even reinforced because of highly standardised procedures in its administration[11,12]. The validity of the group mean intake is also enhanced because of weighting the results to a balanced seasonal and day-of-the-week distribution.

Concern about confounding factors is another issue to keep in mind when discussing V&F intake and protective effects, either on cancer or other chronic conditions. It has been suggested that high intake of V&F may simply be a proxy for behaviour patterns with an important impact on disease risk[16]. It has been reported that V&F intake and a healthy lifestyle for dietary factors tend to cluster[17,18]. Particularly relevant are a positive association with high educational level and physical activity, and a negative association with smoking habits. In the present study the three factors mentioned above were correlated with V&F intake, more strongly among women. Although smoking habits, years of school and time spent in recreational activities explained part of the variability in mean V&F intake, modifications of the mean consumption of fruit, with or without adjustment by these factors, were small and were negligible for vegetables. Furthermore, even after taking such adjustments into account, the overall geographical pattern was almost unchanged: although the adjustment modified absolute mean values in some centres, the ranking of consumption remained almost the same. Thus, factors such as physical activity, education or smoking were not able to explain the large geographical differences in the mean V&F consumption across the EPIC centres.

With these provisos, we can compare our results with V&F intake estimates in similar populations. Consumption of vegetables in our study was slightly higher among men in Sweden, Denmark, the UK, Germany and The Netherlands than estimates based on national dietary surveys[19]; the same applies for women, except in Norway and The Netherlands, where our estimates are slightly lower. A similar pattern was observed concerning fruit intake, with some differences: our estimates were remarkably higher in the UK and Germany for both sexes, while we found lower values for men in Sweden and women in Norway. Data on household budget surveys (HBS) for both sexes combined have been reported for Germany, Greece, Norway, Spain, the UK[20] and France[21]. Except for Greece and Norway (fruits only), we also found slightly higher estimates for both vegetable and fruit intakes. Most HBS are not primarily designed for nutritional purposes; they provide information on food available at the household level, but they lack information on foods eaten away from home and on individuals'

Table 5b Consumption of other groups of plant foods in women in 27 centres of the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Mean (g day^{-1}) and standard error (SE), crude and adjusted by age, season and day of the week

		Potatoes & other tubers			Legumes			Fruit & vegetable juices			Tomato sauce		
			Adjusted			Adjusted			Adjusted			Adjusted	
Country and centre	*n*	Crude mean	Mean	SE	Crude mean	Mean	SE	Crude mean	Mean	SE	Crude mean	Mean	SE
Greece													
Greece	1374	34.0	32.5	2.4	21.0	19.6	0.9	41.6	49.4	4.0	4.1	4.4	0.7
Spain													
Granada	300	54.4	54.4	5.1	18.6	17.9	1.9	36.2	33.2	8.7	6.1	4.7	1.5
Murcia	304	67.6	68.2	5.1	19.7	19.8	1.9	37.6	33.5	8.6	5.6	4.9	1.4
Navarra	271	51.5	54.9	5.4	25.4	24.5	2.0	28.2	26.6	9.1	5.7	5.2	1.5
San Sebastian	244	61.7	62.9	5.7	39.3	40.3	2.1	24.3	20.7	9.6	6.3	5.4	1.6
Asturias	324	70.3	72.1	4.9	35.4	36.0	1.8	39.4	35.0	8.4	4.7	4.4	1.4
Italy													
Ragusa	138	25.4	27.6	7.6	14.1	15.6	2.8	9.9	4.3	12.8	32.8	28.5	2.2
Naples	403	29.0	31.9	4.4	13.9	14.1	1.6	21.6	21.5	7.5	19.8	21.7	1.2
Florence	785	31.7	31.5	3.1	12.2	12.0	1.1	24.3	23.4	5.3	13.2	13.3	0.9
Turin	392	32.0	32.5	4.5	3.6	3.9	1.6	28.8	26.4	7.6	15.4	15.7	1.3
Varese	794	34.6	36.5	3.1	7.1	7.8	1.1	18.5	19.1	5.3	19.2	19.3	0.9
France													
South coast	612	37.8	31.0	3.6	9.4	10.2	1.3	48.2	47.0	6.1	3.8	4.6	1.0
South	1396	50.9	49.4	2.3	7.4	7.1	0.8	51.6	53.7	4.0	4.3	4.7	0.7
North-west	622	68.8	68.3	3.5	6.4	6.0	1.3	56.6	62.3	6.0	3.4	3.2	1.0
North-east	2009	55.3	56.5	2.0	7.0	6.6	0.7	55.7	58.8	3.3	3.2	3.5	0.5
Germany													
Heidelberg	1087	62.1	67.0	2.7	3.1	3.7	1.0	175.7	167.3	4.6	4.3	3.1	0.8
Potsdam	1063	81.9	84.0	2.7	2.3	2.8	1.0	158.2	153.1	4.6	4.0	4.2	0.8
The Netherlands													
Bilthoven	1086	81.9	86.2	2.7	3.7	4.2	1.0	104.1	97.0	4.6	2.3	1.1	0.8
Utrecht	1874	87.2	84.8	2.0	4.7	4.7	0.7	100.3	104.5	3.5	1.9	2.5	0.6
United Kingdom													
General population	571	73.2	72.0	3.7	7.7	7.5	1.4	65.5	69.2	6.3	9.5	9.8	1.0
'Health-conscious'	197	75.7	78.3	6.3	20.0	18.9	2.3	94.7	87.1	10.7	10.6	9.5	1.8
Denmark													
Copenhagen	1485	66.8	70.2	2.3	1.0	0.7	0.8	52.9	54.4	3.9	3.6	4.3	0.6
Aarhus	510	72.8	71.0	3.9	0.6	0.4	1.4	59.0	55.6	6.6	2.1	2.2	1.1
Sweden													
Malmö	1711	86.8	82.4	2.2	2.4	1.9	0.8	46.9	52.8	3.7	10.0	11.2	0.6
Umeå	1574	90.8	91.6	2.2	2.8	2.8	0.8	42.8	43.0	3.8	13.7	13.6	0.6
Norway													
South & East	1136	69.7	73.8	2.6	1.2	1.7	1.0	93.8	92.7	4.5	6.1	5.2	0.7
North & West	662	85.0	90.6	3.5	0.7	1.1	1.3	89.2	84.0	5.9	5.0	3.5	1.0

consumption within households. HBS and dietary surveys, however, have the advantage of being suited to wide population groups, usually representative at the country level. Interestingly, a dietary survey carried out in Murcia, one of the Spanish centres, using a 24-HDR, reported slightly lower estimates than those from the present study for fruit (both sexes) and vegetable intakes among women, while men consumed smaller amounts of vegetables in our study[22]. Apart from differences in the dietary assessment method, other factors that may account for differences are varying age ranges and periods covered. In the USA[23], men and women aged 40–59 years have an intermediate intake of vegetables compared with the EPIC countries, but they have much lower fruit consumption: US women consumed less than in any EPIC country and only Swedish men had lower fruit consumption than men in the USA.

The large variability across centres, particularly at the sub-group level, is one of the most interesting findings of our paper. There seems to be greater heterogeneity in the type of vegetables than for fruits. As already shown, there is a clear south–north gradient, particularly consistent for citrus and non-citrus fruits; this concerns centres where there is a high production of such products. On the other hand, it seems that consumption of juices may be associated with different food habits to V&F consumption. V&F is a very broad category of foods, and until now it has been unclear whether some specific vegetables are more important than others[24]. Thus, the different geographical patterns found for vegetable sub-groups, such as cabbage, root, leafy and fruiting vegetables, must be kept in mind when interpreting results from both descriptive and aetiological studies.

In conclusion, we observed a large south–north gradient and large variability in fruit and vegetable consumption among men and women from 27 EPIC

Table 6a Consumption of vegetables ($g\,day^{-1}$) in men in 19 centres of the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Influence of non-dietary variables. Baseline adjustment by: age, season and day of the week. Additional adjustment for other factors: difference (Diff.) from the baseline-adjusted mean and ranking of centres for each model

	Baseline-adjusted		Adjusted BMI		Adjusted PA work		Adjusted PA recr.		Adjusted smoke		Adjusted school	
Country and centre	Ranking	Mean	Ranking	Diff. (%)	Ranking	Diff. (%)	Ranking	Diff. (%)	Ranking	Diff. (%)	Ranking	Diff. (%)
Greece												
Greece	1	269.7	1	−0.1	1	0.6	2	−1.4	2	−0.3	1	0.0
Spain												
Granada	7	221.6	7	0.2	6	0.9	7	1.1	7	0.2	7	0.1
Murcia	2	266.8	2	−0.1	2	0.5	1	0.7	1	0.8	2	0.6
Navarra	3	246.9	3	−0.1	3	0.5	3	0.8	3	1.4	3	1.5
San Sebastian	5	234.0	5	2.4	5	2.6	5	3.1	5	3.2	5	4.3
Asturias	14	150.2	14	−0.1	13	1.1	14	1.3	13	0.8	13	0.2
Italy												
Ragusa	10	179.5	10	0.0	10	0.1	10	1.2	10	−0.4	10	−0.4
Florence	8	212.8	8	0.1	8	−0.6	8	0.9	8	−2.2	8	0.0
Turin	4	246.1	4	0.0	4	−0.8	4	0.7	4	−0.6	4	−0.6
Varese	9	204.9	9	0.1	9	−1.1	9	0.7	9	−0.1	9	−0.4
Germany												
Heidelberg	11	169.5	11	0.0	11	−1.0	11	1.0	11	−1.5	11	0.9
Potsdam	13	151.3	13	−0.1	14	−1.6	13	1.4	14	−0.6	14	−1.8
The Netherlands												
Bilthoven	16	136.7	16	0.1	16	0.7	16	1.0	16	0.6	16	−0.8
United Kingdom												
General population	12	160.8	12	0.1	12	−1.4	12	1.3	12	−0.8	12	−0.3
'Health-conscious'	6	225.4	6	0.1	7	−1.0	6	0.9	6	−1.0	6	−0.8
Denmark												
Copenhagen	15	147.4	15	0.1	15	0.8	15	1.4	15	0.7	15	−0.2
Aarhus	17	134.1	17	0.1	17	0.7	17	1.6	17	0.9	17	0.3
Sweden												
Malmö	18	120.3	18	0.1	18	0.9	18	−2.7	18	0.3	18	1.5
Umeå	19	103.4	19	0.1	19	−0.6	19	−4.9	19	−2.0	19	−0.4
R^2	0.1117		0.1118		0.1120		0.1120		0.1136		0.1136	
F-test, *P*-value			$F = 0.43$	$P = 0.73$	$F = 1.10$	$P = 0.36$	$F = 1.48$	$P = 0.22$	$F = 17.3$	$P < 0.000$	$F = 3.15$	$P = 0.008$

BMI – body mass index, four categories; PA work – physical activity according to type of current job; PA recr. – physical activity, hours per week of recreational activities.

Table 6b Consumption of vegetables (g day^{-1}) in women in 27 centres of the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Influence of non-dietary variables. Baseline adjustment by: age, season and day of the week. Additional adjustment for other factors: difference (Diff.) from the baseline-adjusted mean and ranking of centres for each model

	Baseline-adjusted		Adjusted BMI		Adjusted PA work		Adjusted PA recr.		Adjusted smoke		Adjusted school	
Country and centre	Ranking	Mean	Ranking	Diff. (%)	Ranking	Diff. (%)	Ranking	Diff. (%)	Ranking	Diff. (%)	Ranking	Diff. (%)
Greece												
Greece	10	207.0	10	0.3	10	−0.5	12	−3.0	10	−0.2	7	0.9
Spain												
Granada	6	216.0	6	0.6	6	0.1	4	6.9	6	−0.1	5	−1.2
Murcia	2	253.3	2	0.2	2	−0.4	1	5.3	2	−0.1	1	3.5
Navarra	12	196.1	12	0.0	12	−0.4	10	6.0	12	−0.1	11	2.8
San Sebastian	8	212.7	7	1.7	7	1.2	5	7.1	7	1.3	4	5.2
Asturias	27	103.3	27	0.0	27	−0.9	26	12.5	27	−0.3	27	8.3
Italy												
Ragusa	20	138.3	20	0.0	20	−0.2	20	7.3	20	1.0	20	1.6
Naples	13	173.7	13	0.2	–	–	13	9.1	13	0.8	13	−0.5
Florence	11	197.2	11	0.0	11	0.1	11	3.4	11	0.0	12	−0.7
Turin	3	233.8	3	0.0	3	0.4	3	2.9	3	−0.1	3	0.2
Varese	17	160.0	17	0.0	17	0.4	17	2.2	17	−0.2	16	1.9
France												
South coast	1	260.9	1	0.0	1	−0.2	2	0.2	1	−0.8	2	−2.4
South	5	218.0	5	0.0	5	−0.3	7	0.2	5	−0.7	6	−4.0
North-west	9	208.7	9	−0.1	9	−0.3	9	0.3	9	−0.2	10	−1.9
North-east	7	215.1	8	−0.1	8	−0.4	8	0.7	8	−0.8	8	−3.0
Germany												
Heidelberg	15	165.4	15	0.1	15	−0.5	16	0.1	15	−0.3	14	2.2
Potsdam	14	167.0	14	0.1	14	−0.4	14	2.1	14	−0.5	15	0.7
The Netherlands												
Bilthoven	24	128.3	24	0.1	24	0.3	22	−1.5	24	1.3	24	−0.1
Utrecht	21	131.7	21	0.1	21	1.4	21	−1.9	21	0.4	22	−0.1
United Kingdom												
General population	16	163.7	16	−0.1	16	−0.1	15	2.4	16	−0.7	17	−1.0
'Health-conscious'	4	220.1	4	0.0	4	−0.2	6	1.2	4	−1.2	9	−6.1
Denmark												
Copenhagen	18	149.8	18	−0.2	18	−0.1	19	−0.3	18	0.8	18	2.2
Aarhus	19	149.2	19	−0.1	19	−0.4	18	0.5	19	0.8	19	2.5
Sweden												
Malmö	23	130.5	23	−0.1	23	−0.5	24	−5.0	23	0.9	21	3.4
Umeå	25	122.5	25	−0.1	25	0.6	25	−5.0	25	−0.1	25	−0.6
Norway												
South & East	22	130.7	22	−0.1	–	–	23	−4.3	22	0.8	23	−0.4
North & West	26	118.3	26	−0.1	–	–	27	−4.7	26	1.4	26	−0.5
R^2	0.0735		0.0737		0.0732		0.0759		0.0739		0.0779	
F-test, *P*-value			$F = 0.56$	$P = 0.64$	$F = 4.45$	$P = 0.0005$	$F = 19.63$	$P < 0.0000$	$F = 13.96$	$P < 0.0000$	$F = 20.48$	$P < 0.0000$

BMI – body mass index, four categories; PA work – physical activity according to type of current job; PA recr. – physical activity, hours per week of recreational activities.

Table 7a Consumption of fruits (g day^{-1}) in men in 19 centres of the European Prospective Investigation into Cancer and Nutrition (EPIC). Influence of non-dietary variables. Baseline adjustment by: age, season and day of the week. Additional adjustment for other factors: difference (Diff.) from the baseline-adjusted mean and ranking of centres for each model

	Baseline-adjusted		Adjusted BMI		Adjusted PA work		Adjusted PA recr.		Adjusted smoke		Adjusted school	
Country and centre	Ranking	Mean	Ranking	Diff. (%)	Ranking	Diff. (%)	Ranking	Diff. (%)	Ranking	Diff. (%)	Ranking	Diff. (%)
Greece												
Greece	10	273.0	10	0.6	10	0.3	11	−7.0	10	2.8	10	0.4
Spain												
Granada	6	360.4	6	0.6	6	0.2	6	6.2	6	−0.3	6	1.3
Murcia	1	453.6	1	0.2	1	0.2	1	5.0	1	1.5	1	3.7
Navarra	9	317.4	9	0.5	9	0.4	9	6.7	9	3.0	9	4.4
San Sebastian	5	386.1	5	0.2	5	0.3	4	5.2	4	1.6	4	3.5
Asturias	8	340.7	8	0.4	8	0.2	7	5.8	8	−0.3	7	4.2
Italy												
Ragusa	2	447.6	2	0.2	2	0.1	2	4.2	2	−0.8	2	0.2
Florence	4	396.1	4	−0.2	4	−0.2	5	1.9	5	−2.0	5	−0.7
Turin	3	421.5	3	−0.1	3	−0.2	3	1.6	3	−1.2	3	−0.3
Varese	7	348.2	7	−0.4	7	−0.3	8	2.2	7	−1.9	8	0.2
Germany												
Heidelberg	14	175.1	14	0.1	14	−0.9	14	1.5	15	−2.2	14	−0.3
Potsdam	12	239.3	12	0.2	12	−0.7	12	4.3	12	−0.3	12	−4.5
The Netherlands												
Bilthoven	15	167.8	15	0.2	15	0.6	15	−0.6	14	2.7	15	−2.1
United Kingdom												
General population	16	148.7	16	−0.5	16	−0.6	16	7.6	17	−4.4	16	−0.9
'Health-conscious'	11	264.2	11	−1.3	11	−0.3	10	3.6	11	−3.3	11	−2.1
Denmark												
Copenhagen	17	142.3	17	−0.2	17	0.6	17	3.7	16	2.1	17	−1.2
Aarhus	13	178.1	13	−0.3	13	0.4	13	5.2	13	2.5	13	0.4
Sweden												
Malmö	19	121.5	19	−0.7	19	0.1	18	−15.2	18	1.1	18	0.9
Umeå	18	121.9	18	−0.8	18	0.0	19	−17.1	19	−8.1	19	−2.1
R^2	0.1537		0.1541		0.1539		0.1569		0.1645		0.1578	
F-test, P-value			$F = 2.04$	$P = 0.11$	$F = 7.29$	$P < 0.0000$	$F = 16.17$	$P < 0.0000$	$F = 92.76$	$P < 0.0000$	$F = 13.62$	$P < 0.0000$

BMI – body mass index, four categories; PA work – physical activity according to type of current job; PA recr. – physical activity, hours per week of recreational activities.

Table 7b Consumption of fruits ($g\,day^{-1}$) in women in 27 centres of the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Influence of non-dietary variables. Baseline adjustment by: age, season and day of the week. Additional adjustment for other factors: difference (Diff.) from the baseline-adjusted mean and ranking of centres for each model

	Baseline-adjusted		Adjusted BMI		Adjusted PA work		Adjusted PA recr.		Adjusted smoke		Adjusted school	
Country and centre	Ranking	Mean	Ranking	Diff. (%)	Ranking	Diff. (%)	Ranking	Diff. (%)	Ranking	Diff. (%)	Ranking	Diff. (%)
Greece												
Greece	17	241.9	14	2.2	17	0.2	18	−6.7	17	−1.2	13	3.1
Spain												
Granada	5	353.3	5	1.5	5	0.5	5	5.5	5	−1.5	4	10.3
Murcia	2	378.9	2	1.2	2	0.3	2	4.7	2	−0.8	1	7.0
Navarra	8	332.4	8	0.8	8	0.3	7	5.0	9	−0.6	7	6.1
San Sebastian	3	372.8	3	0.3	3	0.2	3	4.3	3	−1.1	3	5.3
Asturias	6	336.4	6	0.9	6	0.3	6	5.3	6	−0.8	6	6.5
Italy												
Ragusa	1	399.9	1	0.5	1	0.3	1	3.8	1	1.1	2	0.5
Naples	10	292.7	10	1.4	–	–	10	7.1	10	1.6	10	–
Florence	9	328.1	9	0.1	9	0.4	9	3.5	7	1.5	9	−0.7
Turin	4	361.1	4	0.1	4	0.7	4	3.4	4	−0.3	5	−0.3
Varese	7	335.0	7	0.1	7	0.7	8	2.7	8	−0.7	8	1.0
France												
South coast	14	249.3	15	−1.7	14	0.2	14	2.2	15	−2.2	15	−4.6
South	13	257.7	13	−1.6	13	0.2	13	2.0	13	−3.1	14	−4.7
North-west	16	247.9	17	−1.7	15	0.3	16	2.2	14	−1.4	16	−4.6
North-east	15	248.0	16	−1.3	16	0.2	15	2.6	16	−1.8	17	−4.7
Germany												
Heidelberg	20	212.7	20	0.2	20	0.3	19	1.8	20	−0.4	19	2.3
Potsdam	12	259.9	12	0.8	12	0.2	12	3.0	12	−0.8	12	0.4
The Netherlands												
Bilthoven	24	169.8	23	1.4	23	2.4	23	0.1	22	4.2	24	−0.4
Utrecht	19	213.5	19	0.2	19	1.4	20	−0.6	19	1.4	20	−1.5
United Kingdom												
General population	23	171.7	24	0.1	24	0.7	22	4.9	24	−2.1	22	2.1
'Health-conscious'	11	274.1	11	−1.4	11	0.2	11	2.5	11	−2.7	11	−3.2
Denmark												
Copenhagen	21	181.4	21	0.0	21	0.6	21	1.7	21	2.4	21	1.1
Aarhus	18	231.2	18	−0.2	18	0.6	17	2.2	18	2.0	18	1.4
Sweden												
Malmö	27	151.0	27	−0.1	27	−0.5	27	−10.5	27	3.5	26	4.4
Umeå	26	159.4	26	0.4	26	1.7	26	−10.5	26	−0.4	27	−1.4
Norway												
South & East	22	173.7	22	−0.8	–	–	24	−9.3	23	1.8	23	–
North & West	25	162.7	25	−0.4	–	–	25	−9.9	25	2.5	25	–
R^2	0.0856		0.0869		0.0812		0.0874		0.0921		0.0911	
F-test, *P*-value			$F = 9.62$	$P < 0.0000$	$F = 24.04$	$P < 0.0000$	$F = 14.75$	$P < 0.0000$	$F = 75.74$	$P < 0.0000$	$F = 26.65$	$P < 0.0000$

BMI – body mass index, four categories; PA work – physical activity according to type of current job; PA recr. – physical activity, hours per week of recreational activities.

centres across Europe. This will provide a good opportunity to study relationships between vegetable and fruit intakes and cancer risk.

Acknowledgements

The work described in this paper was carried out with financial support of the 'Europe Against Cancer Programme' of the European Commission (SANCO); Ligue contre le Cancer (France); Société 3M (France); Mutuelle Générale de l'Education Nationale; Institut National de la Santé et de la Recherche Médicale (INSERM); Institute Gustave Roussy; German Cancer Aid; German Cancer Research Centre; German Federal Ministry of Education and Research; Danish Cancer Society; Health Research Fund (FIS) of the Spanish Ministry of Health; the Spanish Regional Governments of Andalucia, Asturias, Basque Country, Murcia and Navarra; Cancer Research UK; Medical Research Council, UK; Stroke Association, UK; British Heart Foundation; Department of Health, UK; Food Standards Agency, UK; Wellcome Trust, UK; Greek Ministry of Health; Greek Ministry of Education; Italian Association for Research on Cancer; Italian National Research Council; Dutch Ministry of Public Health, Welfare and Sports; Dutch Prevention Funds; LK Research Funds; Dutch ZON (Zorg Onderzoek Nederland); World Cancer Research Fund; Swedish Cancer Society; Swedish Scientific Council; Regional Government of Skane, Sweden; Norwegian Cancer Society; Norwegian Research Council. Partial support for the publication of this supplement was provided by the Centre de Recherche et d'Information Nutritionnelles (CERIN).

In addition, we wish to thank all study participants for their co-operation and all interviewers who participated in the fieldwork studies in each EPIC centre.

References

1 Van Duyn MA, Pivonka E. Overview of the health benefits of fruit and vegetable consumption for the dietetics professional: selected literature. *J. Am. Diet. Assoc.* 2000; **100**: 1511–21.
2 World Cancer Research Fund (WCRF)/American Institute for Cancer Research (AICR). *Food, Nutrition and the Prevention of Cancer: A Global Perspective*. Washington, DC: WCRF/AICR, 1997.
3 Greenwald P, Clifford CK, Milner JA. Diet and cancer prevention. *Eur. J. Cancer* 2001; **37**: 948–65.
4 Joshipura KJ, Hu FB, Manson JE, Stampfer MJ, Rimm EB, Speizer FE, *et al*. The effect of fruit and vegetable intake on risk for coronary heart disease. *Ann. Intern. Med.* 2001; **134**: 1106–14.
5 Ness AR, Powles JW. Fruit and vegetables, and cardiovascular disease: a review. *Int. J. Epidemiol.* 1997; **26**: 1–13.
6 Feldman EB. Fruits and vegetables and the risk of stroke. *Nutr. Rev.* 2001; **59**: 24–7.
7 Boyle P, Veronesi M, Tubiana M, Alexander FE, Calais da Silva F, Denis LJ, *et al*. European School of Oncology Advisory Report to the European Commission for the 'Europe Against Cancer Programme' European Code Against Cancer. *Eur. J. Cancer* 1995; **31A**: 1395–405.
8 US Department of Agriculture/US Department of Health and Human Services. *Nutrition and Your Health: Guidelines for the Americans*, 5th ed. Home and Garden Bulletin No. 232. Washington, DC: US Government Printing Office, 2000.
9 Hill MJ. Changing pattern of diet in Europe. *Eur. J. Cancer Prev.* 1997; **6**(Suppl.): S11–3.
10 Riboli E, Hunt KJ, Slimani N, Ferrari P, Norat T, Fahey M, *et al*. European Prospective Investigation into Cancer and Nutrition (EPIC): study populations and data collection. *Public Health Nutr.* 2002; **5**(6B): 1113–24.
11 Slimani N, Kaaks R, Ferrari P, Casagrande C, Clavel-Chapelon F, Lotze A, *et al*. European Prospective Investigation into Cancer and Nutrition (EPIC) calibration study: rationale, design and population characteristics. *Public Health Nutr.* 2002; **5**(6B): 1125–45.
12 Slimani S, Deharveng G, Charrondière R, van Kappel AL, Ocké MC, Welch A, *et al*. Structure of the standardized computerized 24-h diet recall interview used as reference method in the 22 centers participating in the EPIC project. *Comput. Meth. Programs Biomed.* 1999; **58**: 251–66.
13 Kleinbaum DG, Kupper LL, Muller KE. *Applied Regression Analysis and Other Multivariable Methods*, 2nd ed. Belmont, CA: Duxbury Press, 1988.
14 Agudo A, Amiano P, Barcos A, Barricarte A, Beguiristain JM, Chirlaque MD, *et al*. Dietary intake of vegetables and fruits among adults in five regions in Spain. *Eur. J. Clin. Nutr.* 1999; **53**: 174–80.
15 Bingham SA, Nelson M. Assessment of food composition and nutrient intake. In: Margetts BM, Nelson M, eds. *Design Concepts in Nutritional Epidemiology*. Oxford: Oxford University Press, 1991; 153–91.
16 Nestle M. Fruits and vegetables: protective or just fellow travelers. *Nutr. Rev.* 1996; **54**: 255–7.
17 Agudo A, Pera G, and the EPIC Group of Spain. Vegetable and fruit consumption associated with anthropometric, dietary and lifestyle factors in Spain. *Public Health Nutr.* 1999; **2**: 263–71.
18 Serdula MK, Byers T, Mokdad AH, Simoes E, Mendlein JM, Coates RJ. The association between fruit and vegetable intake and chronic disease risk factors. *Epidemiology* 1996; **7**: 161–5.
19 Roos G, Johansson L, Kasmel A, Kumbiené J, Prättälä R. Disparities in vegetable and fruit consumption: European cases from the north to the south. *Public Health Nutr.* 2000; **4**: 35–43.
20 Naska A, Vasdekis VGS, Trichopoulou A, Friel S, Leonhäuser IU, Moreiras O, *et al*. Fruit and vegetable availability among ten European countries: how does it compare with the 'five-a-day' recommendation? *Br. J. Nutr.* 2000; **84**: 549–56.
21 Collet-Ribbing C, Decloître F. Consommation alimentaire en France et dans quelques pays occidentaux. In: Riboli E, Decloître F, Collet-Ribbing C, eds. *Alimentation et Cancer. Évaluation des Données Scientifiques*. Centre National d'Études et de Recommandations sur la Nutrition et l'Alimentation (CNERNA). Paris: Tec & Doc-Lavoisier, 1996; 41–77.
22 Violan C, Stevens L, Molina F. *Encuesta de Alimentación en la Población Adulta de la Región de Murcia 1990*. Serie Informes 7. Murcia: Consejeria de Sanidad, Región de Murcia, 1991.
23 Krebs-Smith SM, Kantor LS. Choose a variety of fruits and vegetables daily: understanding the complexities. *J. Nutr.* 2001; **131**: 487S–501S.
24 Willett WC. Diet and cancer: one view at the start of the millennium. *Cancer Epidemiol. Biomark. Prev.* 2001; **10**: 3–8.