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Consumption and portion sizes of tree nuts, peanuts and seeds in the European Prospective Investigation into Cancer and Nutrition (EPIC) cohorts from 10 European countries

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Tree nuts, peanuts and seeds are nutrient dense foods whose intake has been shown to be associated with reduced risk of some chronic diseases. They are regularly consumed in European diets either as whole, in spreads or from hidden sources (e.g. commercial products). However, little is

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known about their intake profiles or differences in consumption between European countries or geographic regions. The objective of this study was to analyse the population mean intake and average portion sizes in subjects reporting intake of nuts and seeds consumed as whole, derived from hidden sources or from spreads. Data was obtained from standardised 24-hour dietary recalls collected from 36 994 subjects in 10 different countries that are part of the European Prospective Investigation into Cancer and Nutrition (EPIC). Overall, for nuts and seeds consumed as whole, the percentage of subjects reporting intake on the day of the recall was: tree nuts = 4·4%, peanuts = 2·3 % and seeds = 1·3 %. The data show a clear northern (Sweden: mean intake = 0·15 g/d, average portion size = 15·1 g/d) to southern (Spain: mean intake = 2·99 g/d, average portion size = 34·7 g/d) European gradient of whole tree nut intake. The three most popular tree nuts were walnuts, almonds and hazelnuts, respectively. In general, tree nuts were more widely consumed than peanuts or seeds. In subjects reporting intake, men consumed a significantly higher average portion size of tree nuts (28·5 *v.* 23·1 g/d, $P<0·01$) and peanuts (46·1 *v.* 35·1 g/d, $P<0·01$) per day than women. These data may be useful in devising research initiatives and health policy strategies based on the intake of this food group.

EPIC: Tree nuts: Peanuts: Seeds: Descriptive study: Intake: Portion size

Introduction

Nuts and seeds may be considered an important component of a healthy diet and are regularly consumed, either as snacks or part of a meal. In general, they are dense in a variety of nutrients and provide protein, fat (mostly unsaturated fatty acids), dietary fibre and many bioactive constituents such as vitamins (e.g. folic acid, niacin, vitamin E, vitamin B6), minerals (e.g. copper, magnesium, potassium, zinc), antioxidants, phytoestrogens and other phytochemicals (Dreher *et al.* 1996). By definition, tree nuts are dry fruits with one seed in which the ovary wall becomes hard at maturity. The family of the most popular edible tree nuts includes almonds, Brazil nuts, cashews, hazelnuts, macadamias, pecans, pine nuts, pistachios and walnuts, but the consumer definition also often includes peanuts, which are actually legumes but identified by consumers as part of the nuts food group. In addition, peanuts share a similar nutrient profile with tree nuts, as do many seeds. Although chestnuts are tree nuts by definition, they are different from other nuts because they are more starchy and have a different phytochemical profile.

To date, much research has focused on the potential healthy effects of high nut and seed consumption on the development of heart disease (Sabate *et al.* 1993; Hu *et al.* 1998; Curb *et al.* 2000; Zambon *et al.* 2000; Albert *et al.* 2002) and cancers of the prostate (Mills *et al.* 1989; Jain *et al.* 1999) and colorectum (Jenab *et al.* 2004). Due to their increasingly demonstrated beneficial health effects, nuts and seeds are now considered intrinsic to several dietary guidelines worldwide (Haddad *et al.* 1999; Johnson & Kennedy, 2000; Krauss *et al.* 2001; Health Canada, 2005).

Despite the growing visibility of and increasing consumer interest in this important food group, as well as greater availability of information on the healthy effects of higher nut and seed consumption, very little objective and reliable data exists on their intake profiles and qualitative and quantitative differences in their consumption patterns within and between populations or geographic regions. To date, most descriptive information about nut and seed consumption levels has been based on estimates derived from food disappearance or market data (Putnam & Allshouse, 1999), and less from data based on individual dietary intakes. Furthermore, in many dietary questionnaires used in nutrition surveys, questions on nut and seed intake have been either asked in insufficient detail or not at all. Accordingly, an important concern when comparing dietary intake data across various populations is the validity and standardisation of the dietary assessment instruments used. Since nuts and seeds are generally not consumed in very large amounts, minor differences in intake assessment may make comparability between different populations very difficult. Thus, in order to compare intake across different populations, the dietary assessment instruments should be as standardised as possible, with an open-ended structure to capture between subject variability in types and quantities of nuts and seeds consumed.

The European Prospective Investigation into Cancer and Nutrition (EPIC) is an ongoing multi-centre prospective cohort study with over 520 000 subjects from 23 centres in 10 Western European countries (Riboli *et al.* 2002). Within an 8 % (>36 000 subject) subset of the EPIC population, standardised information on the intake of nuts and seeds across various populations has been collected via computerised 24-hour recalls (Slimani *et al.* 2002).

The aim of the present study was to use the standardised data derived from the EPIC 24-hour recall subset to assess the population mean intake of nuts and seeds across the 10 European countries involved in EPIC. A second objective was to determine and compare the average portion size in subjects that reported consumption of this food group, by country. The diversity of the dietary and cultural patterns that exist within the EPIC study data will allow an understanding of the spectrum of nut and seed consumption in Western Europe. The results of this study may be useful both for the formulation of new scientific hypotheses related the intake of nuts and seeds and disease risk, and also for derivation of policy and intake recommendations for this food group.

Materials and methods

EPIC study design and dietary assessment

The rationale and methods of the EPIC study have been previously described in detail (Riboli & Kaaks, 1997; Riboli *et al.* 2002; Bingham & Riboli, 2004). The EPIC cohort consists of 23 centres representing heterogeneous groups that were either population based (Bilthoven centre of the Netherlands, Greece, Germany, Sweden, Denmark, Norway, Spain, Italy, Cambridge centre of the UK, and part of the Oxford centre of the UK), health conscious individuals (a majority of the Oxford centre of the UK) participants in breast screening groups (Utrecht centre of the Netherlands, Florence centre of Italy), or teachers and school workers (France). In France, Norway, the Utrecht centre of the Netherlands and the Florence centre of Italy all subjects were women.

Within the design of the EPIC study, a sub-sample of each study centre was randomly (age, sex stratified) chosen for the application of a standardized 24-hour dietary recall assessment

gathered by means of a computerised software (Slimani *et al.* 1999). By design, the sampling procedures of the 24-hour recall assessment sub-sample were defined to control for seasonal and day of the week variations in dietary intake (Slimani *et al.* 2002). In total, complete 24-hour dietary recall information exists from 36 994 subjects (13 486 men and 23 508 women). Using EPIC-Soft, information on the intake of all foods and beverages was collected, described, quantified, entered and coded according to common rules. Quantification of consumed amounts included pictures, household measures, and standardised units as well as cooking methods used and the edible part consumed.

All non-dietary variables were collected using self-administered questionnaires in most EPIC centres. Details on the presentation, definition and distribution of non-dietary variables are detailed elsewhere (Riboli *et al.* 2002).

Determination of nut and seed intake

The intake of nuts and seeds was determined using the EPIC 24-hour recall data described above and was divided into three separate categories:

(a) Consumed as whole: tree nuts, peanuts, non-specific nuts and seeds eaten as whole, as part of a meal or as a snack, (e.g. walnuts, ground almonds, pine nuts sprinkled on a salad, sunflower seeds, mixed nut snacks etc.),

(b) Consumed from hidden sources: tree nuts, peanuts, non-specific nuts and seeds eaten as ingredients in recipes or as part of commercial products, including breads, breakfast cereals, cakes, local products, sweets and confectionaries, and

(c) Consumed from spreads: tree nuts, peanuts, non-specific nuts and seeds eaten as spreads, includes intake from commercial spread products (e.g. peanut butter, hazelnut spread).

For nuts and seeds consumed from hidden sources, the content and amounts of specific nuts and seeds consumed from products and recipes were estimated from available information in dietary databases and with the assistance of research dieticians familiar with traditional recipes and commercial products of the individual countries. Since the estimation of nut and seed content of individual foods and products is associated with some degree of error, the focus of the present study was on the intake of nuts and seeds consumed as whole.

For the purposes of this analysis, the term 'nuts' refers to tree nuts, peanuts and non-specific nuts (type of nuts not specified by the subject or determination of the exact type of nut not possible; provided as a separate category since it may include mixed types of tree nuts and peanuts). Here, 'tree nuts' are defined as Almonds, Brazil nuts, Cashews, Hazelnuts, Macadamia nuts, Pecans, Pine nuts, Pistachios and Walnuts. Their combined total intake is represented by the variable 'all tree nuts'. Where necessary or appropriate, tree nuts with low intakes or low number of consumers (Brazil nuts, cashews, macadamias, pecans, pine nuts, pistachios) where combined into one variable ('all other tree nuts'), which represents a subset of the 'all tree nuts' variable. The variable 'total nuts' refers to all tree nuts, peanuts and non-specific nuts combined. Chestnuts and coconuts are not included as part of the present analysis. Seeds assessed from the 24-hour recall included pumpkin, sesame, sunflower, linseed, poppy and 'non-specific'. Due to low intakes of each type of seed, seeds were assessed collectively as a total sum variable ('seeds').

Subjects who reported an intake greater than 0 g of nuts and/or seeds on the day of the 24-hour recall are referred to as 'consumers' in the present study. Here, the term 'subjects who reported intake' is used interchangeably with the term 'consumers'. For the purposes of this study, the term 'population mean intakes' refers to the average intake across the entire 24-hour recall sub-sample (i.e. in both consumers and non-consumers, total $n = 36\,994$ subjects) and the term 'average portion size' refers to average intake in the 24-hour recall subjects who reported intake on the particular day of the recall (i.e. in consumers only). Since the UK centre includes two very different populations (a health conscious population and a general population) with potentially diverse nut and seed intake profiles, the nut and seed intake of these two populations was compared separately, where appropriate.

Statistical analyses

The adjusted population mean intakes and average daily portion sizes (± standard error) were calculated in each category as grams per day. All analyses were carried out for men and women combined. Men and women were assessed separately for comparison of average portion sizes, with all countries combined. All analyses were conducted using the SAS statistical software (version 8e, SAS Institute, Cary, NC, USA). For both population mean intakes and average daily portion sizes, adjusted data are presented by country and crude data for all countries combined. In order to further explore potential regional trends, adjusted data are also presented by European region (North = Denmark, Norway, Sweden; Central = Germany, the Netherlands, United Kingdom and the North of France; South = South of France, Greece, Italy, Spain). Differences in nut and seed intake between men and women in all EPIC countries combined and by categories of nuts and seeds with European region, were assessed by the general linear means model of SAS. In order to improve comparability between countries or by European region, population mean intakes and average portion sizes were adjusted by age and gender, using a set of weights to control for day of the week (Monday to Thursday; Friday to Sunday) and season (Spring, Summer, Autumn, Winter) of the 24-hour diet recall collection. When comparing men and women, analyses were adjusted for age and country using a set of weights to control for the day of the week and season of the 24-hour recall collection, as specified above. For the adjusted average portion sizes, differences between countries were assessed by least square means using general models procedure of SAS, with a Bonferroni adjustment for multiple comparisons. P values $< 0{\cdot}05$, according to the Bonferroni adjustment, were considered as statistically significant. Adjusted population mean intakes and average portion sizes were also compared by European region, and by gender, using the same methodology as above but without the Bonferroni adjustment. Here, two sided P values less than 0·05 were considered significant.

Results

Population mean intake of tree nuts, peanuts and seeds

Table 1 shows the adjusted mean population intakes of all tree nuts, peanuts, non-specific nuts, and total nuts, as well as seeds on the day of the 24-hour recall data, by country, for the

Table 1. Population means of intake of all tree nuts, peanuts, non-specific nuts and seeds, by country and all countries combined

	Population means of intake (g/d)					
Type of nuts or seeds	Denmark† *n* = 3918 Adjusted (S.E.)¶	France† *n* = 4735 Adjusted (S.E.)¶	Germany† *n* = 4418 Adjusted (S.E.)¶	Greece† *n* = 2930 Adjusted (S.E.) ¶	Italy† *n* = 3961 Adjusted (S.E.)¶	Netherlands† *n* = 4567 Adjusted (S.E.)¶
Consumed as whole						
All tree nuts	0·62 (0·12)	1·99 (0·12)	0·86 (0·11)	1·15 (0·14)	1·05 (0·12)	1·30 (0·11)
Peanuts	0·52 (0·13)	1·18 (0·12)	1·01 (0·12)	0·42 (0·15)	0·57 (0·13)	2·06 (0·12)
Non-specific nuts§	0·06 (0·06)	0·16 (0·05)	0·19 (0·05)	0·43 (0·06)	0·05 (0·06)	0·31 (0·05)
Total nuts	1·19 (0·19)	3·33 (0·18)	2·06 (0·18)	2·00 (0·22)	1·67 (0·19)	3·67 (0·18)
Seeds	0·11 (0·04)	0·01 (0·04)	0·36 (0·04)	0·28 (0·05)	0·04 (0·04)	0·13 (0·04)
Consumed from hidden sources						
All tree nuts	0·90 (0·06)	0·53 (0·05)	0·72 (0·05)	0·47 (0·06)	0·66 (0·06)	0·87 (0·05)
Peanuts	0·16 (0·04)	0·10 (0·04)	0·06 (0·04)	0·05 (0·04)	0·02 (0·04)	1·21 (0·04)
Non-specific nuts§	0·62 (0·05)	0·59 (0·05)	0·79 (0·05)	0·41 (0·06)	0·32 (0·05)	0·89 (0·05)
Total nuts	1·68 (0·09)	1·23 (0·08)	1·56 (0·08)	0·94 (0·10)	0·99 (0·08)	2·98 (0·08)
Seeds	0·04 (0·05)	0·41 (0·04)	1·53 (0·04)	0·61 (0·05)	0·05 (0·05)	3·97 (0·04)
Consumed from spreads						
All tree nuts	0·18 (0·02)	0·02 (0·02)	0·14 (0·02)	–	0·06 (0·02)	0·20 (0·02)
Peanuts	0·10 (0·05)	0·14 (0·05)	0·04 (0·05)	–	–	1·57 (0·05)
Non-specific nuts§	0·01 (0·01)	–	0·02 (0·01)	–	–	0·01 (0·01)
Total nuts	0·30 (0·06)	0·16 (0·05)	0·20 (0·05)	–	0·08 (0·06)	1·77 (0·05)
Seeds	–	–	–	0·09 (0·01)	–	0·08 (0·01)
Consumed as whole, from hidden sources and spreads						
All Tree Nuts	1·70 (0·14)	2·54 (0·13)	1·72 (0·13)	1·64 (0·16)	1·77 (0·13)	2·37 (0·13)
Peanuts	0·78 (0·14)	1·43 (0·13)	1·10 (0·13)	0·52 (0·16)	0·61 (0·14)	4·84 (0·13)
Non-specific nuts§	0·69 (0·08)	0·75 (0·07)	0·99 (0·07)	0·84 (0·09)	0·37 (0·08)	1·21 (0·07)
Total nuts	3·16 (0·22)	4·72 (0·21)	3·82 (0·20)	3·00 (0·25)	2·75 (0·21)	8·42 (0·20)
Seeds	0·15 (0·07)	0·38 (0·06)	1·89 (0·06)	0·98 (0·08)	0·10 (0·07)	4·17 (0·06)

	Population means of intake (g/d)						
						All Countries	
Type of nuts or seeds	Norway† *n* = 1798 Adjusted (S.E.)¶	Spain† *n* = 3220 Adjusted (S.E.)¶	Sweden† *n* = 6132 Adjusted (S.E.)¶	United Kingdom† *n* = 1315 Adjusted (S.E.)¶	All Countries† *n* = 36 994 Crude (S.E.)	Percentage consumers*	Average portion size** [g/d(S.E.)]
Consumed as whole							
All tree nuts	0·68 (0·18)	2·99 (0·13)	0·15 (0·10)	1·44 (0·21)	1·13 (0·04)	4·4	25·8 (0·6)
Peanuts	1·84 (0·19)	1·30 (0·14)	0·40 (0·10)	1·82 (0·22)	0·90 (0·04)	2·3	39·6 (1·2)
Nonspecific nuts§	0·28 (0·08)	0·53 (0·06)	0·06 (0·04)	0·34 (0·10)	0·19 (0·02)	0·5	37·5 (2·2)
Total nuts	2·80 (0·29)	4·83 (0·29)	0·61 (0·15)	3·60 (0·32)	2·23 (0·06)	6·9	30·8 (0·6)
Seeds	0·05 (0·02)	0·36 (0·05)	0·32 (0·04)	0·51 (0·08)	0·23 (0·01)	1·3	16·9 (0·8)
Consumed from hidden sources							
All tree nuts	0·74 (0·09)	0·46 (0·06)	0·81 (0·04)	0·28 (0·10)	0·68 (0·02)	12·6	5·4 (0·1)
Peanuts	–	–	0·16 (0·03)	0·17 (0·07)	0·21 (0·01)	1·2	17·5 (0·7)
Non-specific nuts§	0·37 (0·08)	0·07 (0·06)	0·34 (0·04)	0·65 (0·09)	0·53 (0·02)	8·2	6·4 (0·2)
Total nuts	1·07 (0·13)	0·48 (0·09)	1·32 (0·07)	1·10 (0·15)	1·43 (0·03)	20·7	7·7 (0·1)
Seeds	0·73 (0·07)	0·02 (0·05)	0·01 (0·01)	0·55 (0·08)	0·82 (0·02)	11·4	7·2 (0·1)
Consumed from spreads							
All tree nuts	0·38 (0·03)	0·01 (0·02)	0·03 (0·02)	0·02 (0·03)	0·10 (0·01)	1·3	7·8 (0·4)
Peanuts	0·13 (0·08)	–	0·09 (0·04)	0·70 (0·09)	0·24 (0·02)	1·0	25·1 (1·1)

Table 1. *Continued*

Type of nuts or seeds	Norway† $n = 1798$ Adjusted (S.E.)¶	Spain† $n = 3220$ Adjusted (S.E.)¶	Sweden† $n = 6132$ Adjusted (S.E.)¶	United Kingdom† $n = 1315$ Adjusted (S.E.)¶	All Countries† $n = 36\,994$ Crude (S.E.)	All Countries: Percentage consumers*	All Countries: Average portion size** [g/d(S.E.)]
Non-specific nuts§	–	–	–	0·01 (0·01)	0·01 (0·01)	0·04	15·0 (2·9)
Total nuts	0·51 (0·08)	0·01 (0·01)	0·12 (0·04)	0·73 (0·10)	0·34 (0·02)	2·2	15·8 (0·6)
Seeds	–	–	–	–	0·02 (0·01)	0·1	16·6 (2·5)
Consumed as whole, from hidden sources and spreads							
All tree nuts	1·80 (0·21)	3·46 (0·15)	0·99 (0·11)	1·74 (0·23)	1·92 (0·04)	17·5	11·0 (O·2)
Peanuts	1·94 (0·22)	1·20 (0·16)	0·65 (0·11)	2·70 (0·25)	1·36 (0·05)	4·2	32·1 (0·8)
Non-specific nuts§	0·64 (0·12)	0·60 (0·08)	0·40 (0·06)	0·99 (0·13)	0·73 (0·02)	8·7	8·4 (0·1)
Total nuts	4·38 (0·33)	5·27 (0·24)	2·04 (0·17)	2·04 (0·17)	4·00 (0·07)	27·3	14·6 (0·2)
Seeds	0·78 (0·10)	0·37 (0·07)	0·33 (0·05)	1·07 (0·11)	1·07 (0·02)	12·6	8·5 (0·1)

Population mean intake values are means (standard error) based on all the subjects with available data from 24-hour recalls in each country.
* Those reporting intake (also referred to as 'consumers') are defined as those eating any amount of the particular nut or seed on the day of the 24-hour recall assessment.
† Number of subjects in each country with available data from 24-hour dietary recalls.
§ Type of nut not specified by the subject, could include mixed nuts or peanuts.
¶ Means adjusted by age and gender, using weights to control for day and season of 24-hour recall (± standard error).
** Portion size values are crude means (standard error) and pertain to consumers only.

categories 'consumed as whole', 'consumed from hidden sources' and 'consumed from spreads'. The percentage of consumers and crude average portion sizes for all countries combined are also shown. For all tree nuts consumed as whole, the lowest adjusted mean population intake was in Sweden (0·15 g/d) and the highest in Spain (2·99 g/d). The percentage of consumers of all tree nuts, shows a similar intake trend with the percentage of consumers ranging from 1·0 % in Sweden to 8·3 % in Spain (Table 2).

The combination of geographically similar countries (described above) allowed a further exploration of regional trends and showed a clear gradient (lower in the north, moderate in central regions and higher in the south) of adjusted population mean intake of all tree nuts consumed as whole (Table 4). A clear trend in the percentage of subjects reporting intake of all tree nuts consumed as whole is also evident with 2·0 % in northern, 4·3 % in central and 6·3 % in southern European regions. Overall, in all countries combined, 4·4 % of subjects consumed tree nuts on the day of the 24-hour recall (Table 1).

For most countries, the percentage of consumers of peanuts consumed as whole was equal to or lower than that of tree nuts, with the highest in the Netherlands (4·7 %) and lowest in Denmark (0·9 %) (Table 2). A geographical gradient of adjusted population mean intakes was also apparent with peanuts consumed as whole, with central European regions (mean= 1·48 g/d) having a significantly higher intake than northern (mean = 0·66 g/d) or southern (mean = 0·79 g/d) regions (Table 4). In all countries combined, 2·3 % of subjects consumed peanuts on the day of the 24-hour recall (Table 1).

The percent of consumers of seeds consumed as whole was lower than that of all tree nuts or peanuts (Table 1). The percentage of seed consumers was highest in central (2·1 %) than northern (1·6 %) or southern (0·7 %) European regions (Table 4), but the population mean intake did not show any regional differences.

Although the percentage of consumers of nuts and seeds consumed from hidden sources was higher that those consumed as whole, the population mean intakes of the latter category were higher in most countries (Table 1). The population mean intake of tree nuts, peanuts and seeds from spreads was very minor.

For all analyses of mean population intake by country (Table 1) or European regions (Table 4), adjustments for age, gender, day and season of the 24-hour recall had only a minor effect on the results.

Average daily portion size of tree nuts, peanuts and seeds consumed as whole

Table 1 describes the crude average daily portion sizes of all tree nuts, peanuts, non-specific nuts, and seeds in all countries combined, while adjusted country specific average portion sizes for nuts and seeds consumed as whole only are shown in Table 2. The average daily portion size of tree nuts, peanuts and non-specific nuts consumed as whole was higher than those consumed from hidden sources or from spreads (Table 1). The most commonly consumed tree nuts were walnuts (average portion size: men:25·0, women:20·5 g/d), almonds (average portion size: men:20·7, women:19·2 g/d), and hazelnuts (average portion size:

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Table 2. Percentage of Subjects Reporting Intake* and Average daily portion size of tree nuts, peanuts and seeds consumed as whole in EPIC, by country

	Average portion size [g/d (S.E.)]									
	Denmark		France		Germany		Greece		Italy	
Type of nut consumed as whole**	*Percentage consumers	Adjusted (S.E.) ‡‡	*Percentage consumers	Adjusted (S.E.) ‡‡	*Percentage consumers	Adjusted (S.E.) ‡‡	*Percentage consumers	Adjusted (S.E.) ‡‡	*Percentage consumers	Adjusted (S.E.) ‡‡
Almond	1·0	18·1 (3·7)	1·3	22·9 (3·0)	0·6	19·4 (4·1)	1·1	22·4 (3·9)	0·6	24·4 (3·9)
Hazelnut	0·9	19·6 (3·8)	0·9	21·6 (3·4)	0·7	17·5 (3·6)	0·5	26·2 (5·8)	0·7	5·9 (3·6)
Walnut	1·2	9·9 (3·1)	3·7	25·5 (1·8)	1·4	22·4 (2·5)	2·3	28·0 (2·6)	2·8	23·9 (2·0)
All other tree nuts ††[a]	0·6	30·5 (4·3)	2·3	29·1 (2·5)	1·0	25·1 (3·3)	1·0	29·5 (4·8)	0·9	14·8 (3·7)
All tree nuts‡[a]	3·4	19·4 (2·2)	7·8	27·9 (1·5)	3·5	23·5 (1·9)	4·3	29·2 (2·3)	4·5	22·8 (1·8)
Peanuts[b]	0·9	46·0 (5·2)	2·5	39·4 (3·1)	1·7	50·4 (3·4)	1·1	34·3 (5·9)	1·9	29·3 (3·8)
Non-specific nuts§ [c]	0·2	23·3 (10·5)	0·3	38·0 (7·7)	0·4	39·8 (6·3)	1·3	30·2 (4·6)	0·1	43·4 (14·9)
Total nuts ‡[d]	4·5	26·6 (2·3)	10·2	33·4 (1·5)	5·5	34·7 (1·9)	6·5	31·4 (2·3)	6·0	27·3 (2·0)
Seeds[e]	1·2	9·6 (2·5)	0·4	9·7 (3·7)	2·6	13·2 (1·5)	1·3	24·9 (2·8)	0·4	18·1 (4·3)
Type of nut consumed as whole**	Netherlands		Norway		Spain		Sweden		United Kingdom	
	*Percentage consumers	Adjusted (S.E.) ‡‡	*Percentage consumers	Adjusted (S.E.) ‡‡	*Percentage consumers	Adjusted (S.E.) ‡‡	*Percentage consumers	Adjusted (S.E.) ‡‡	*Percentage consumers	Adjusted (S.E.) ‡‡
Almond	0·6	12·4 (4·2)	0·8	15·9 (5·8)	3·4	23·2 (2·0)	0·5	14·0 (3·8)	1·6	26·8 (4·5)
Hazelnut	0·4	15·9 (5·1)	0·6	39·0 (6·4)	1·1	39·0 (3·6)	0·3	16·1 (5·4)	1·6	31·2 (4·4)
Walnut	1·4	25·4 (2·6)	0·2	18·2 (9·5)	3·0	47·9 (2·0)	0·2	11·7 (5·3)	1·3	14·5 (5·2)
All other tree nuts ††	3·1	27·5 (2·1)	0·6	39·9 (6·7)	2·0	9·3 (2·9)	0·1	19·3 (12·3)	2·5	14·7 (4·2)
All tree nuts ‡[a]	4·7	28·7 (1·7)	2·2	30·5 (4·0)	8·3	34·7 (1·5)	1·0	15·1 (3·1)	5·9	26·1 (2·9)
Peanuts[b]	4·7	44·8 (2·2)	3·8	48·6 (4·1)	3·0	44·7 (3·3)	1·3	27·5 (3·8)	3·7	42·6 (4·3)
Non-specific nuts § [c]	0·7	41·5 (5·2)	0·6	47·3 (9·5)	1·2	44·4 (4·8)	0·1	30·4 (9·5)	1·0	29·8 (7·7)
Total nuts‡[d]	9·8	38·5 (1·5)	6·4	43·2 (2·9)	11·9	40·0 (16)	2·5	22·7 (2·5)	9·3	37·4 (2·7)
Seeds[e]	1·2	13·5 (2·2)	0·8	14·2 (4·0)	1·0	34·0 (3·0)	1·9	17·6 (1·5)	3·4	15·3 (2·4)

* Those reporting intake (also referred to as 'consumers') are defined as those eating any amount of the particular nut on the day of the 24-hour recall assessment; Values are means (standard error) for average portion sizes in consumers only.

‡ Those consuming two or more types of individual tree nuts were considered only once in the calculation of the percentage of consumers for the cumulative all tree nuts variable.

§ Type of nut not specified by the subject, could include mixed nuts or peanuts.

** Amount includes whole nuts only and not those eaten as part of hidden sources or spreads.

†† Variable expressing the combination of intake of Brazil nuts, cashews, macadamias, pecans, pine nuts and pistachios.

‡‡ Means adjusted by age and gender, using a set of weights to control for day and season of 24-hour recall (± standard error).

[a] Means of France, Greece, the Netherlands and Spain are significantly higher than those of Denmark and Sweden; Mean of Spain is significantly higher than that of Italy and Germany.

[b] Means of Germany, Norway and the Netherlands are significantly higher than those of Italy and Sweden; Mean of Spain is significantly higher than that of Sweden.

[c] There were no significant differences between any of the countries.

[d] Means of Denmark and Italy are significantly lower than those of the Netherlands, Norway and Spain; Mean of Sweden is significantly lower than France, Germany, the Netherlands, Norway, and Spain.

[e] Mean of Spain is significantly higher than that of all countries except for Italy and Greece, which is significantly higher than Denmark, France and Germany.

men:26·1, women:20·3 g/d) followed by the other tree nuts (Table 3). The number of consumers eating more than one type of whole tree nut was 168. For all tree nuts consumed as whole, the percentage of consumers was consistently higher in women than men, but the adjusted average daily portion size was higher in men than women for all individual whole tree nuts (except macadamias), with a significant difference ($P<0·05$) for cashews, walnuts and for all tree nuts combined (28·5 versus 23·1 g/d, P difference $<0·01$) (Table 3).

The average daily portion size of peanuts consumed as whole was higher than the average portion size of all tree nuts (Table 1), and was much higher in men than in women (46·5 versus 35·1 g/d, P difference $<0·01$) (Table 3). Eighty nine subjects consumed both a tree nut and peanuts on the same day.

For seeds consumed as whole, the adjusted average daily portion sizes were similar between men and women (16·7 versus 17·3 g/d, P difference$=0·71$). Sixty nine subjects consumed whole tree nuts and seeds on the same day, while only 4 consumed whole tree nuts, peanuts and seeds on the same day. The overall number of consumers of non-specific nuts (men: $n=81$, women: $n=109$) was low across all EPIC countries, but the adjusted average daily portion size per consumer was quite high in both men and women (40·9 versus 32·7 g/d, P difference$=0·06$) (Table 3).

In order to explore potential regional trends in daily adjusted average daily portion size, EPIC countries where combined by European region, as defined above. The adjusted average daily portion size of all tree nuts consumed as whole was significantly ($P<0·05$) lower in northern European countries than central or southern ones (Table 4).

The adjusted average daily portion size of peanuts consumed as whole was highest in Germany (50·4 g/d) and lowest in Sweden (27·5 g/d) (Table 2). Peanuts also showed differences in average daily portion size by European region (significantly higher in central countries than that in the southern region) (Table 4).

The adjusted average daily portion size of seeds consumed as whole was also much lower than all tree nuts or peanuts in all countries, except in Spain (34·0 g/d) and Greece (24·9 g/d), where it was quite high (Table 2). Because of this, the adjusted average daily portion size of seeds was significantly higher in southern European regions than in northern or central regions (Table 4). The percentage of consumers of non-specific nuts was quite low (Table 1), but the mean daily potion size was nonetheless high (Tables 1 and 3). Intake patterns by country and European region were not changed by adjustments for age and gender.

Relative proportion of nut and seed consumption in EPIC countries

Fig. 1 shows the relative percent consumption of individual tree nuts consumed as whole, by EPIC country and in all countries combined. In all countries combined, the percent relative consumption of walnuts (41·6 %) was higher than that of all the other tree nuts: almonds (18·3 %), hazelnuts (12·8 %), pistachios (12·9 %), cashews (11·9 %), pine nuts (1·6 %), pecans (0·8 %), Brazil nuts (0·4 %) and macadamias (0·2 %). Overall, in all countries combined, tree nuts represented 46·1 % of total whole nut and seed intake, peanuts 36·8 %, seeds 9·3 % and non-specific nuts 7·8 %.

Intake of nuts, seeds and peanuts from spreads and hidden sources in EPIC

Hidden sources of consumption accounted for a higher percentage of consumers than whole for all tree nuts (12·6 %), seeds (11·4 %) and non-specific nuts (8·2 %), but not peanuts (1·2 %) (Table 1). In all countries combined, the main tree nuts consumed from hidden sources were almonds ($n_{consumers}=4161$, mean portion $=4·9\pm0·1$ g/d), hazelnuts ($n_{consumers}=328$, mean portion $=9·2\pm0·9$ g/d) and walnuts ($n_{consumers}=207$, mean portion $=9·1\pm0·7$ g/d) (data not tabulated). In relative proportions, tree nuts represented 37·6 % of total consumption of nuts and seeds from hidden sources, followed by seeds (34·2 %) non-specific nuts (24·6 %) (data not tabulated).

The percent of consumers of spreads (all tree nuts $=1·3$ %, peanuts $=1·0$ %, seeds $=0·1$ %, non-specific nuts $=0·04$ %) and average daily portion sizes were lower than those consumed as whole (Table 1). The main tree nuts consumed as spreads were almond ($n_{consumers}=247$, mean portion $=8·8\pm0·5$ g/d) and hazelnut ($n_{consumers}=218$, mean portion $=6·7\pm0·7$ g/d) (data not tabulated). In relative proportions, all tree nuts represented 53·4 % of total intake of all spreads, followed by 40·7 % for peanuts (data not tabulated).

The combined average daily portion size (g/d) consumed as whole, from spreads and from hidden sources were 11·0 for all tree nuts, 32·1 for peanuts, 8·4 for seeds and 8·5 for non-specific nuts (Table 1). Comparison of these three separate categories of the intake of all tree nuts shows that 59·2 % of total consumption is from nuts eaten as whole, 35·7 % from hidden sources and 5·1 % from spreads (data not tabulated). For peanuts, the majority of the intake is consumed as whole (59·2 %), followed by hidden sources (35·7 %) and spreads (17·7 %) (data not tabulated). However, the intake of seeds was greatest from hidden sources (77·1 %) than for seeds consumed as whole (21·3 %) or as spreads (1·6 %).

Comparison of crude population mean intakes and portion sizes between 'Health Conscious' and 'General Population' cohorts in the United Kingdom

The UK sub-cohorts are composed of two different populations, one a health conscious (mostly vegetarian) population, and the other a general population. Due to the small number of consumers, the previously presented data do not separate out these two populations, but the difference between them is highlighted in Table 5. For all variables, the population mean intakes were much higher in the health conscious than the general populations. Compared to the general population, the health conscious have a much higher average daily portion size of all tree nuts (27·0 *v.* 13·3 g/d), seeds (17·9 *v.* 10·4 g/d) and non-specific nuts (31·0 *v.* 17·0 g/d) consumed as whole. However, the average daily portion size of peanuts consumed as whole was much higher in the general population than in the health conscious (44·7 *v.* 30·6 g/d respectively).

Discussion

This study presents an overview of the population mean intake and average daily portion sizes in subjects reporting intake of nuts and seeds consumed as whole, in spreads and from

Table 3. Average daily portion size of individual types of tree nuts, peanuts and seeds consumed as whole in all EPIC countries combined, by gender

	Men				Women				
	Consumers*		Average daily portion size g/d		Consumers*		Average daily portion size g/d		
Type of nut consumed as whole **	Number	Percentage	Adjusted mean (S.E.) ††	Median/Mode	Number	Percentage	Adjusted mean (S.E.) ††	Median/Mode	*P* value for difference in mean †
Almond	121	0·9	20·7 (2·2)	16·0/30·0	266	1·1	19·2 (1·4)	13·6/30·0	0·56
Brazil	4	0·03	7·5 (2·5)	5·6/3·7	19	0·1	9·2 (1·0)	7·4/3·7	0·52
Cashew	36	0·3	45·8 (6·3)	30·0/30·0	119	0·5	32·8 (4·7)	25·0 (30·0)	0·01
Hazelnut	87	0·7	26·1 (2·5)	15·0/30·0	161	0·7	20·3 (1·8)	15·0/15·0	0·06
Macadamia	0	0	–	–	3	0·01	24·8 (0·6)	25·0/–	–
Pecan	2	0·01	35·2 (14·3)	29·0/–	10	0·04	23·3 (5·4)	26·7/30·0	0·38
Pine	35	0·3	6·1 (1·6)	4·3/3·9	79	0·3	6·9 (1·1)	4·0/0·6	0·59
Pistachio	51	0·4	22·2 (4·8)	28·0/28·0	154	0·7	23·1 (4·0)	17·0/17·0	0·85
Walnut	219	1·6	25·0 (1·8)	24·8/30·0	439	1·9	20·5 (1·5)	20·0/20·0	0·02
All tree nuts‡	499	3·7	28·5 (1·3)	24·0/30·0	1125	4·8	23·1 (0·9)	18·0/30·0	<0·01
Peanuts	321	2·4	46·5 (2·0)	30·0/30·0	523	2·2	35·1 (1·6)	30·0/30·0	<0·01
Non-specific nuts §	81	0·6	40·9 (4·0)	30·0/30·0	109	0·5	32·7 (3·2)	30·0/30·0	0·08
Total nuts‡	860	6·4	38·3 (1·1)	30·0/30·0	1690	7·2	28·7 (0·8)	24·0/30·0	<0·01
Seeds	155	1·2	16·7 (1·5)	10·0/9·8	342	1·5	17·3 (1·0)	10·0/9·8	0·71

Portion size (consumers only) values are means (standard error).

* Those reporting intake (also referred to as consumers) defined as those eating any amount of the particular nut on the day of the 24-hour recall assessment.

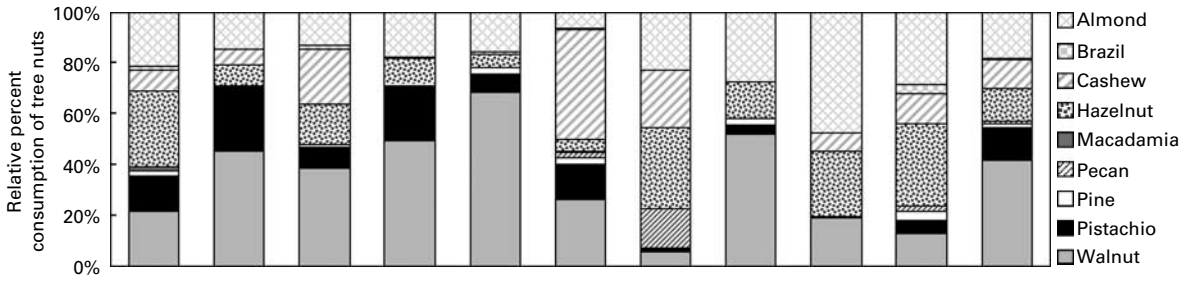
† *P* value for difference in the average daily portion size between men and women.

‡ Total number of subjects reporting intake differs from the sum of the number of subjects reporting intake of each individual type of nut or seeds since those consuming two or more types were only counted once in the cumulative variable and were considered only once in the calculation of the percentage of consumers.

§ Type of nut not specified by the subject, could include whole mixed nuts or whole peanuts.

** Amount includes whole nuts only and not those eaten as part of hidden sources or spreads.

†† Means adjusted by age and country, using a set of weights to control for day and season of 24-hour recall (± standard error).



	Denmark	France	Germany	Greece	Italy	Nether-lands	Norway	Spain	Sweden	United Kingdom	All EPIC Countries
All tree nuts*	48·7	67·7	38·2	52·2	59·9	34·6	23·7	54·9	16·5	36·4	46·1
Peanuts *	36·4	27·3	38·0	16·7	32·5	53·7	62·9	26·8	40·7	40·4	36·8
Non-specific nuts *§	5·3	3·6	7·5	17·3	3·4	7·4	8·9	10·8	5·6	7·7	7·8
Seeds *	9·6	1·4	16·3	13·8	4·2	4·3	4·5	7·5	37·2	15·5	9·3
Total	100	100	100	100	100	100	100	100	100	100	100

Values in the graph and table are percentages·
* amount includes whole nuts only and not those eaten as part of hidden sources or spreads.
§ type of nut not specified by the subject, could include whole mixed nuts or whole peanuts.

Fig. 1. Proportional percent consumption of individual tree nuts consumed as whole and the proportional percent consumption of all whole tree nuts, seeds, peanuts and non-specific nuts in EPIC countries in subjects reporting intake on the day of the 24-hour recalls.

hidden sources in select populations from 10 European countries participating in EPIC. Tree nuts, peanuts and seeds share some common characteristics, such as higher fat levels, rich content of antioxidants, various phytochemicals, and other nutrients (Dreher *et al.* 1996). As such, they are often placed together in one food group. This data from EPIC shows a high degree of heterogeneity in the intake of these foods, with the highest relative percent of consumption in most EPIC countries coming from tree nuts, followed by peanuts, seeds and non-specific nuts. This is in contrast to the population in the United States, where peanuts are more regularly consumed than tree nuts (Lino *et al.* 2000).

Some cultural trends are clearly observable from this data. Diets in southern European countries resemble the Mediterranean style diet, one of whose major characteristics is higher reliance on nuts and seeds as a source of food energy. From the present data, a north-south gradient is clearly apparent as the intake of all tree nuts consumed as whole in

Table 4. Adjusted population mean intake and portion size of all tree nuts, peanuts and seeds consumed as whole in the EPIC study, by European region

	European region					
	Northern ($n = 11\,848$)		Central ($n = 12\,990$)		Southern ($n = 12\,156$)	
	Denmark, Norway, Sweden		North of France, Germany, Netherlands, United Kingdom		South of France, Greece, Italy, Spain	
Type of nut consumed as whole**	Population mean intake ††		Population mean intake ††		Population mean intake ††	
All tree nuts	0·38 (0·07)	c	1·28 (0·07)	b	1·74 (0·07)	a
Peanuts	0·66 (0·07)	b	1·48 (0·07)	a	0·79 (0·07)	b
Non-specific nuts§	0·09 (0·03)	b	0·24 (0·03)	a	0·29 (0·03)	a
Total nuts	1·13 (0·11)	b	3·01 (0·11)	a	2·81 (0·11)	a
Seeds	0·22 (0·03)		0·23 (0·02)		0·18 (0·03)	
	Percent consumers *	Average portion size *††	Percent consumers *	Average portion size *††	Percent consumers *	Average portion size *††
All tree nuts	2·0	20·3 (1·7) b	4·3	27·2 (1·0) a	6·3	29·1 (0·9) a
Peanuts	1·1	39·6 (2·5) ab	3·3	44·9 (1·6) a	2·2	37·6 (2·1) b
Non-specific nuts§	0·2	34·4 (5·8)	0·6	38·3 (3·4)	0·7	37·4 (3·2)
Total nuts‡	3·7	29·8 (1·5) b	8·4	36·4 (1·0) a	8·4	33·8 (1·0) a
Seeds	1·6	15·6 (1·3) b	2·1	13·8 (1·1) b	0·7	24·2 (1·8) a

Population intake (both consumers and non-consumers) values and portion sizes (consumers only) are means (standard error).
* Those reporting intake (also referred to as 'consumers') are defined as those eating any amount of the particular nut on the day of the 24-hour recall assessment.
‡ Those consuming two or more types of nuts and seeds were considered only once in the calculation of the percentage of consumers for the cumulative all tree nuts variable.
§ Type of nut not specified by the subject, could include whole mixed nuts or whole peanuts.
** Amount includes whole nuts only and not those eaten as part of hidden sources or spreads.
†† Means adjusted by age and gender, using weight to control for day and season of 24-hour recall (± standard error).
Different *letters across a row* indicate a significant difference ($P < 0·05$) in adjusted population mean intake or average portion size by region.

northern European countries is significantly lower than that in southern countries in adjusted population mean intakes (0·38 versus 1·74 g/d) and average daily portion sizes (20·3 versus 29·1 g/d). A similar north-south gradient is apparent in the percent of consumers, which is lower in the northern European countries (2·0 %) than in the southern ones (6·3 %).

The most common tree nuts consumed were walnuts, almonds and hazelnuts, respectively, although some variation is observed between countries amongst the intake levels of the three types. These tree nuts are also the most commonly consumed in other Western populations (Fraser *et al.* 1992). The remaining tree nuts also present some variation of intake amongst countries. For example, according to this data, pistachios are well consumed in France and Greece, moderately consumed in Denmark, Germany, Italy and the Netherlands, and little consumed elsewhere (Fig. 1). Likewise, Brazil nuts are consumed much more in the United Kingdom than they are elsewhere and cashews are very popular in Germany, the Netherlands and Norway, and less so in the other countries (Fig. 1). However, it is unclear whether these differences are because of cultural aspects (e.g. use of nuts in local dishes or recipes) or as a result of marketing strategies (higher concentration of advertising), marketplace pressures (e.g. price) or relative un-availability of other types of tree nuts. At the population and individual levels, differences in the relative intakes of different nuts are also important because nuts may vary somewhat in their macro- and micro-nutrient contents (Dreher *et al.* 1996). It must be noted, however, that some nuts and nut products may be spiced, flavoured or salted, affecting their nutritional quality.

Regarding peanuts, the highest population mean intake level was in the Netherlands (Table 1), although the average daily portion size there was similar to that in many of the other countries (Table 2). Peanuts composed 54 % of all nut and seed intake in the Netherlands (Fig. 1), and although this percentage is higher in Norway (63 %), it is more due to lower consumption of tree nuts than high consumption of peanuts (Table 2). Only a small percentage of consumers consumed peanut spreads, and the average daily portion size of peanut spread consumption was lower than that of whole peanuts (25·1 versus 39·6 g/d). The intake of peanut spreads was specific to some countries (highest in the Netherlands and United Kingdom), and non-existent in others (Greece, Italy and Spain) on the 24-hour recall days.

In general, whole seeds were less consumed, both in terms of the number of consumers, population mean intakes and average daily portion sizes, than tree nuts or peanuts. The relative percent of whole seed consumption was highest in Germany and Sweden (16 and 37 %, respectively; Fig. 1). The types of seeds are likely varied, as all seeds were combined into one variable for the purposes of this study. In many countries, it is likely that hidden sources of seeds (e.g. flax, poppy, sesame in breads) may contribute extensively to seed intake. Indeed, from the present data, 11·4 % of subjects consumed an average of 7·2 g/d of seeds from hidden sources (Table 1).

In the present study, much effort was placed in identifying hidden sources (e.g. local products, commercial products, confectionaries, breads) of nut and seed intake, by analysing the various foods consumed by each subject within the 24-hour recall data, finding foods or products that may have contained nuts and seeds and estimating their content. However, some hidden sources may have been missed and so the present results may underestimate the actual intakes. Nonetheless, these results show that this category may be a major source of overall nut and seed intake.

The advantage of the 24-hour recall methodology used in this study is its standardization between countries, making diet measurements comparable between the different population groups (Slimani *et al.* 2002). They also provide high validity when addressing populations as a whole. This is of great benefit when assessing the intake nuts and seeds, since this food group may not be consumed regularly or in large amounts by all subjects. The drawback of using only a single 24-hour recall is that it does not account for day-to-day variations in intake (Bingham & Nelson, 1991). Thus, the data presented here represent a snapshot of total nut and seed intake on one particular day and do not allow the separation of habitual consumers from occasional ones. It is also for this reason that mean population intakes are presented alongside data on average daily portion sizes in subjects who reported intake on the day of the 24-hour recall.

The intake patterns of nuts and seeds, e.g. whether they are consumed more as snacks or as a main meal component, and differences between vegetarians and non-vegetarian populations, are also of great interest. But, for the most part, such data is unavailable in the EPIC database. However, the comparison of data from the United Kingdom cohorts, which is composed of both 'health conscious' (mostly vegetarian) and 'general' populations, allows some insight into potential differences of nut and seed intake patterns amongst sub-populations within a country. Since vegetarians have been previously shown to eat more nuts as part of their diet (Sabate, 1999), it was perceived that differences may also be observed between these two populations. The present data (Table 5) show that the health conscious sub-population in the United Kingdom had a higher daily average portion size of all tree nuts and seeds but not peanuts, than the general population. In addition, they had a higher population mean intake of total nuts than any other individual EPIC country. These observations are encouraging and require further research.

Gender may be a key factor affecting nut and seed intake patterns and levels. In the present study, an analysis of intake trends by gender in each country was not possible due to a low number of consumers. However, when considering all countries combined some important gender differences do emerge in the average daily portion sizes of all tree nuts and peanuts, which were significantly higher in men than in women, even though a greater percentage of all tree nut consumers were women.

Although in the EPIC study the participants in most centres were recruited independent of their dietary habits and so it may be assumed that their dietary habits are likely similar to those generally practiced in their respective regions (Agudo *et al.* 1999), it must still be noted that most subjects are not representative population samples, since EPIC centres were often selected based on priorities such as identification of cancer cases or were based on select groups such as blood donors (Spain, Italy) or school teachers (France). Nonetheless, it is felt that the data presented here are quite valid for comparisons of intake levels between countries, except for the UK, given the large number of vegetarians purposely enrolled.

Table 5. Comparison between the health conscious and general population cohorts of the United Kingdom: Population mean intakes and average daily portion sizes of tree nuts, peanuts, seeds and non-specific nuts consumed as whole

	United Kingdom					
	Health concious Cohort ($n = 322$)			General population Cohort ($n = 933$)		
		g/d (S.E.)			g/d (S.E.)	
Type of nut consumed as whole**	Percentage consumers*	Population mean intake	Average portion size	Percentage consumers *	Population mean intake	Average portion size
Almond	5·2	1·38 (0·46)	26·1 (6·3)	0·4	0·04 (0·02)	10·2 (3·8)
Hazelnut	5·9	1·57 (0·50)	26·6 (6·1)	0·2	0·05 (0·04)	24·2 (5·9)
Walnut	1·9	0·31 (0·13)	16·5 (2·4)	1·1	0·12 (0·05)	10·8 (3·4)
All other tree nuts ¶	6·5	0·93 (0·25)	14·2 (2·4)	1·2	0·15 (0·10)	12·6 (8·0)
All tree nuts ‡	15·5	4·18 (0·76)	27·0 (3·5)	2·7	0·36 (0·12)	13·3 (3·8)
Peanuts	6·5	1·99 (0·55)	30·6 (5·5)	2·8	1·26 (0·28)	44·7 (5·6)
Non-specific nuts §	3·1	0·96 (0·35)	31·0 (5·9)	0·3	0·05 (0·03)	17·0 (7·0)
Total nuts ‡	20·5	7·14 (1·21)	34·8 (4·5)	5·6	1·67 (0·31)	29·7 (3·9)
Seeds	10·6	1·90 (0·40)	17·9 (2·5)	1·1	0·12 (0·06)	10·4 (4·2)

Population intake (both consumers and non-consumers) values and portion sizes (consumers only) are means (standard error).
* Those reporting intake (also referred to as 'consumers') are defined as those eating any amount of the particular nut on the day of the 24-hour recall assessment.
** Amount includes whole nuts only and not those eaten as part of hidden sources or spreads.
‡ Those consuming two or more types of individual tree nuts were considered only once in the calculation of the percentage of consumers for the cumulative all tree nuts variable.
§ Type of nut not specified by the subject, could include whole mixed nuts or whole peanuts.
¶ Variable expresses the combination of intake of Brazil, cashew, macadamia, pecan, pine and pistachio nuts.

In summary, this study has described the population mean intake and average daily portion sizes of tree nuts, peanuts, seeds and non-specific nuts from about 37 000 24-hour recalls collected in 10 European countries as part of the EPIC study. The data show that on the day of the 24-hour recall, 4·4 % of all subjects consumed tree nuts, 2·3 % consumed peanuts, 1·5 % consumed non-specific nuts and 1·3 % consumed seeds. Out of all tree nuts consumed as whole, walnuts, almonds and hazelnuts were the most common. For all tree nuts consumed as whole, the highest population mean intakes and average daily portion sizes were in Spain and the lowest in Sweden. The data from this study may be of use in devising research and health policy strategies based on the intake of this important emerging food group.

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References

Agudo A, Amiano P, Barcos A, *et al.* (1999) Dietary intake of vegetables and fruits among adults in five regions of Spain. EPIC group of Spain. European Prospective Investigation into Cancer and Nutrition. *Eur J Clin Nutr* **53**, 174–180.

Albert CM, Gaziano JM, Wilett WC & Manson JE (2002) Nut consumption and decreased risk of sudden cardiac death in the Physicians' Health study. *Arch Intern Med* **162**, 1382–1387.

Bingham S & Riboli E (2004) Diet and cancer–the European Prospective Investigation into Cancer and Nutrition. *Nat Rev Cancer* **4**, 206–215.

Bingham SA & Nelson M (1991) Assessment of food composition and nutrient intake. In *Design concepts in nutritional epidemiology*, pp. 153–191 [BM Margetts and M Nelson, editors]. Oxford: Oxford University Press.

Curb JD, Wergowske G, Dobbs JC, Abbott RD & Huang B (2000) Serum lipid effects of a high-monounsaturated fat diet based on macadamia nuts. *Arch Intern Med* **160**, 1154–1158.

Dreher ML, Maher CV & Kearney P (1996) The traditional and emerging role of nuts in healthful diets. *Nutr Rev* **54**, 241–245.

Fraser GE, Sabate J, Beeson WL & Strahan TM (1992) A possible protective effect of nut consumption on risk of coronary heart disease. The Adventist Health Study. *Arch Intern Med* **152**, 1416–1424.

Haddad EH, Sabate J & Whitten CG (1999) Vegetarian food guide pyramid: a conceptual framework. *Am J Clin Nutr* **70**, 615S–619S.

Health Canada (2005) *Canada's Food Guide to Healthy Eating*: Public Works and Government Services Canada, Ottawa, Canada.

Hu FB, Stampfer MJ, Manson JE, Rimm EB, Colditz GA, Rosner BA, Speizer FE, Hennekens CH & Willett WC (1998) Frequent nut consumption and risk of coronary heart disease in women: prospective cohort study. *BMJ* **317**, 1341–1345.

Jain MG, Hislop GT, Howe GR & Ghadirian P (1999) Plant foods, antioxidants, and prostate cancer risk: findings from case-control studies in Canada. *Nutr Cancer* **34**, 173–184.

Jenab M, Ferrari P, Slimani N, *et al.* (2004) Association of nut and seed intake with colorectal cancer risk in the European Prospective Investigation into Cancer and Nutrition. *Cancer Epidemiol Biomarkers Prev* **13**, 1595–1603.

Johnson RK & Kennedy E (2000) The 2000 Dietary Guidelines for Americans: what are the changes and why were they made? The Dietary Guidelines Advisory Committee. *J Am Diet Assoc* **100**, 769–774.

Krauss RM, Eckel RH, Howard B, *et al.* (2001) Revision 2000: a statement for healthcare professionals from the Nutrition Committee of the American Heart Association. *J Nutr* **131**, 132–146.

Lino M, Marcoe K, Dinkins JM, Hiza H & Anad R (2000) The role of nuts in a healthy diet. *Insight: A Publication of the USDA Center for Nutrition Policy and Promotion* 23.

Mills PK, Beeson WL, Phillips RL & Fraser GE (1989) Cohort study of diet, lifestyle, and prostate cancer in Adventist men. *Cancer* **64**, 598–604.

Putnam JJ & Allshouse JE (1999) Food Consumption, Prices, and Expenditures, 1970-97. Food and Rural Economics Division, Economic Research Service. *U S Department of Agriculture Statistical Bulletin* **965**.

Riboli E, Hunt KJ, Slimani N, *et al.* (2002) European Prospective Investigation into Cancer and Nutrition (EPIC): study populations and data collection. *Public Health Nutr* **5**, 1113–1124.

Riboli E & Kaaks R (1997) The EPIC Project: rationale and study design. European Prospective Investigation into Cancer and Nutrition. *Int J Epidemiol* **26**, Suppl. 1, S6–S14.

Sabate J (1999) Nut consumption, vegetarian diets, ischemic heart disease risk, and all-cause mortality: evidence from epidemiologic studies. *Am J Clin Nutr* **70**, 500S–503S.

Sabate J, Fraser GE, Burke K, Knutsen SF, Bennett H & Lindsted KD (1993) Effects of walnuts on serum lipid levels and blood pressure in normal men. *N Engl J Med* **328**, 603–607.

Slimani N, Deharveng G, Charrondiere RU, *et al.* (1999) Structure of the standardized computerized 24-h diet recall interview used as reference method in the 22 centers participating in the EPIC project. European Prospective Investigation into Cancer and Nutrition. *Comput Methods Programs Biomed* **58**, 251–266.

Slimani N, Kaaks R, Ferrari P, *et al.* (2002) European Prospective Investigation into Cancer and Nutrition (EPIC) calibration study: rationale, design and population characteristics. *Public Health Nutr* **5**, 1125–1145.

Zambon D, Sabate J, Munoz S, Campero B, Casals E, Merlos M, Laguna JC & Ros E (2000) Substituting walnuts for monounsaturated fat improves the serum lipid profile of hypercholesterolemic men and women. A randomized crossover trial. *Ann Intern Med* **132**, 538–546.