

International prevalences of reported food allergies and intolerances. Comparisons arising from the European Community Respiratory Health Survey (ECRHS) 1991–1994

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Objective: The aim of this study was to report the prevalence, type and reported symptoms associated with food intolerance.

Design: A cross-sectional epidemiological study involving 15 countries using standardized methodology. Participants answered a detailed interviewer-administered questionnaire and took part in blood, lung function and skin prick tests to common aeroallergens.

Setting: Randomly selected adults who took part in the second phase of the European Community Respiratory Health Survey (ECRHS).

Subjects: The subjects were 17 280 adults aged 20–44 y.

Results: Twelve percent of respondents reported food allergy/intolerance (range 4.6% in Spain to 19.1% in Australia). Atopic females who had wheezed in the past 12 months, ever had asthma or were currently taking oral asthma medications were significantly more likely to report food allergy/intolerance. Participants from Scandinavia or Germany were significantly more likely than those from Spain to report food allergy/intolerance. Respondents who reported breathlessness as a food-related symptom were more likely to have wheezed in the past 12 months, to have asthma, use oral asthma medications, be atopic, have bronchial hyperreactivity, be older and reside in Scandinavia.

Conclusion: Self-reported food allergy/intolerance differed significantly across multiple countries. The reasons for these differences were not explored in this study, but are likely to be largely due to cultural differences.

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Introduction

Community-based studies have previously been conducted to determine the prevalence of reported food allergy and intolerance in the UK, Holland and the USA (Young *et al*,

1994; Jansen *et al*, 1994; Altman & Chiaramonte, 1996). These studies have reported food intolerance levels of 14.7%, 12% and 16%, respectively. However it is difficult to compare these values as the studies were conducted independently and used different methodologies. To date no study has been conducted with the aim of reporting between-country comparisons of reported prevalence rates of food allergy and food intolerance using standardized questions. Furthermore, there is little information relating to the inter-country variation in characteristics of those who report food-related respiratory symptoms.

The European Community Respiratory Health Survey (ECRHS) was a multicentre study which aimed to compare the prevalence of adult asthma between countries, using standardized epidemiological methods and to identify the risk factors associated with the international variation in asthma prevalence throughout Europe and elsewhere (Burney *et al*, 1994). Some dietary information was also collected as part of the ECRHS. Two previous publications,

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which involved only single countries involved in the ECRHS, found that 17% and 25% of respondents in Australia and Sweden, respectively, reported food allergy or intolerance (Woods *et al*, 1998a; Bjornsson *et al*, 1996). This analysis presents the prevalence, type and reported symptoms associated with food ingestion among young adults participating throughout the ECRHS. Results are reported here from 34 centres in 15 countries that provided usable data.

Methods

Study subjects

The subjects were participants in the second phase of the ECRHS. The full details of the sampling protocol for the ECRHS has been described elsewhere (Burney *et al*, 1994; Abramson *et al*, 1996). Briefly, participating centres selected an area for study defined by pre-existing administrative boundaries with at least 150 000 inhabitants and up-to-date sampling frames for subjects aged 20–44 y of age. In the first phase, subjects were sent a brief questionnaire about respiratory symptoms and attacks of asthma in the preceding 12 months, current use of asthma medication and nasal allergies including hayfever. A random sample of subjects, who had responded to phase one, were then selected to take part in phase two.

In this second phase, subjects were invited to answer a more detailed interviewer administered questionnaire, and to take part in blood tests, skin prick tests, height and weight measurements, assessment of lung function by spirometry and airway challenge with methacholine. The questionnaire collected information on respiratory symptoms (including wheeze, shortness of breath, cough and phlegm production) during the previous 12 months, history of asthma, home and work environment, allergic symptoms, smoking, demographic information, medications and dietary information. The background and validity of this questionnaire has been described elsewhere (Burney *et al*, 1994).

Dietary questions

There were four questions relating to diet in the questionnaire. The first three questions gathered information on the amount of convenience-type foods and drink that participants consumed and between-meal snack patterns, but these responses will not be considered further in this analysis. The fourth question asked: 'Have you ever had an illness or trouble caused by eating a particular food or foods?' and if so, 'have you nearly always had the same illness or trouble after eating this type of food?'. Respondents were then asked to list the food(s) and symptoms in order to distinguish between symptoms of indigestion/food poisoning and food allergy or intolerance.

Objective Tests

Lung function was measured with a rolling seal spirometer (Biomedin, Italy) in most centres or equivalent equipment

elsewhere. Initial FEV₁ was recorded as the best of five blows which met the American Thoracic Society (ATS) criteria. Methacholine (MCh; Provocholine, Hoffman La Roche, Basel, Switzerland) was delivered by a Mefar 3B dosimeter (Mefar srl, Bovezzi, Italy) until FEV₁ fell by 20% from the initial value or up to a cumulative dose of 2 mg (10 µmol). Subjects who were pregnant, breast-feeding, taking specific medications, whose initial FEV₁ was < 70% predicted and those who did not consent to the test were not challenged with MCh.

Skin prick testing for allergies was performed on the volar surface of the forearm using Phazets (Kabi-Pharmacia, Uppsala, Sweden), which were lancets precoated with a standard amount of allergen. The ECRHS allergy panel consisted of *Dermatophagoides pteronyssinus*, cat, Timothy grass, birch, olive, *Parietaria*, ragweed, *Cladosporium*, *Alternaria*, positive (histamine) and negative (uncoated lancet) controls. In addition each centre applied up to three local allergens using standardized extracts (eg Hollister-Stier, Spokane, Washington, USA). Wheals were measured after 15 min.

Further details of these tests can be found elsewhere (Burney *et al*, 1994). All persons gave informed consent. The protocol of the study was approved by the Institutional Ethics Committees associated with each participating centre.

Definitions

Atopy was defined as a positive skin reaction (a wheal $\geq$ 3 mm diameter) to any allergen on skin prick test. Bronchial hyperreactivity (BHR) was defined as a provocative dose of inhaled methacholine causing a 20% fall in FEV₁ (PD₂₀) < 1 mg MCh. Current asthma was defined as the combination of wheezing in the past 12 months and BHR (Toelle *et al*, 1992).

Statistical analysis

Data from the questionnaires, lung function tests and skin prick tests were externally entered and verified. Range and logic tests were performed to confirm the validity of the data. Association between categorical variables was assessed by the chi-squared test and comparison of continuous variables by Student's *t*-test. Analyses were conducted using the Statistical Package for the Social Sciences (SPSS; Norusis, 1997). Multivariate models of illness from food and symptoms were fitted using stepwise multiple logistic regression. A *P*-value < 0.05 was accepted as statistically significant.

Results

Data from some 17 280 young adults form the basis of this analysis. Table 1 details the characteristics of the participants. The mean age was 33.2 y, with little variation between participating countries. There was a slight female preponderance in all countries except Germany, Switzerland and Ireland. The mean body mass index was 24 kg/m², which is within the normal range. However most participants were overweight in Ireland, New Zealand, Australia and the USA (mean BMI > 25 kg/m²). The pre-

Table 1 Subject characteristics

Country	n	Mean age (y) (s.d.)	Males (%)	Mean body mass index (kg/m ²) (s.d.)	Atopic (%)	BHR positive (%)	Current asthma (%)	Ever smoked (%)	Current smokers (%)
Iceland	559	32.9 (6.9)	48.5	24.0 (3.5)	24.0	6.8	2.5	62.3	39.4
Norway	833	32.7 (6.7)	49.1	24.1 (3.6)	29.3	7.7	2.5	58.7	43.6
Sweden	1850	32.8 (7.3)	48.8	23.4 (3.3)	39.0	9.6	4.4	51.4	28.5
Netherlands	1210	33.6 (7.3)	48.4	24.1 (3.4)	40.8	12.5	4.5	62.7	41.2
Belgium	1119	32.5 (7.0)	43.7	23.1 (3.5)	37.1	13.1	4.2	57.0	35.4
Germany	1967	33.1 (7.3)	50.4	23.9 (3.8)	32.1	15.0	3.9	66.3	43.7
Switzerland	842	32.4 (7.1)	50.4	23.1 (3.8)	41.5	9.6	3.0	59.1	40.5
France	2362	34.2 (7.3)	49.7	22.8 (3.4)	43.7	17.1	5.9	58.7	34.8
UK	1148	32.9 (6.9)	42.9	24.1 (3.9)	42.8	19.1	7.4	47.8	27.1
Ireland	435	32.1 (6.6)	50.1	25.1 (4.1)	40.8	15.8	6.0	60.7	45.1
Italy	644	33.3 (7.0)	49.7	23.7 (3.7)	43.2	10.1	2.8	56.8	37.6
Spain	1939	32.1 (7.3)	48.2	25.0 (4.0)	23.6	10.8	3.8	65.5	51.2
New Zealand	1148	34.0 (7.2)	47.5	25.8 (4.5)	38.2	25.7	9.6	47.3	22.5
Australia	669	34.3 (6.8)	48.1	25.3 (3.8)	51.6	21.2	10.0	51.0	24.4
USA	555	35.0 (6.7)	40.2	26.5 (5.5)	52.8	17.6	4.3	41.4	20.2
Total	17280	33.2 (7.2)	48.0	24.0 (3.9)	37.5	14.1	5.0	57.5	36.5

valence of atopy ranged from 23.6% in Spain to 52.8% in the USA, whilst the prevalence of current asthma ranged from 2.5% in Iceland and Norway to 10% in Australia. The prevalence of bronchial hyperreactivity ranged from 6.8% in Iceland to 25.7% in New Zealand. The prevalence of current smoking ranged from 20.2% in the USA to 51.2% in Spain.

Reported illness from food

Nineteen percent ($n = 3334$; 95% CI: 18.7–19.9%) of all respondents indicated that they had experienced ‘illness or trouble’ caused by eating a particular food or foods, whilst

12.2% ($n = 3311$, 95% CI: 12.0–13.0%) reported that they nearly always experienced this illness following particular food ingestion, presumably due to food allergy or intolerance. Figure 1 details the reported food allergy/intolerance prevalence rates for each country. The rates were lowest in Spain and highest in Australia.

The food items that were reported as causing ‘illness or trouble’ when eaten are listed in Table 2. Some 87 different items were cited as causing illness from food. No particular food group stood out as a major cause of symptoms, although fruits, dairy products, nuts and chocolate featured several times.

Of those who reported food allergy/intolerance, 10% (95% CI: 8.8–11.4%) experienced breathlessness as a symptom. The prevalence ranged from 2.8% in Belgium to 17.0% in Norway. Table 3 outlines the type of symptoms that were reported by eating particular foods and the most common foods cited as being responsible for each symptom. Of the 17 280 subjects surveyed, 217 (1.3%, 95% CI: 1.1–1.4%) respondents experienced breathlessness as a symptom following food ingestion, whilst 26 respondents reported that a particular food caused only breathlessness.

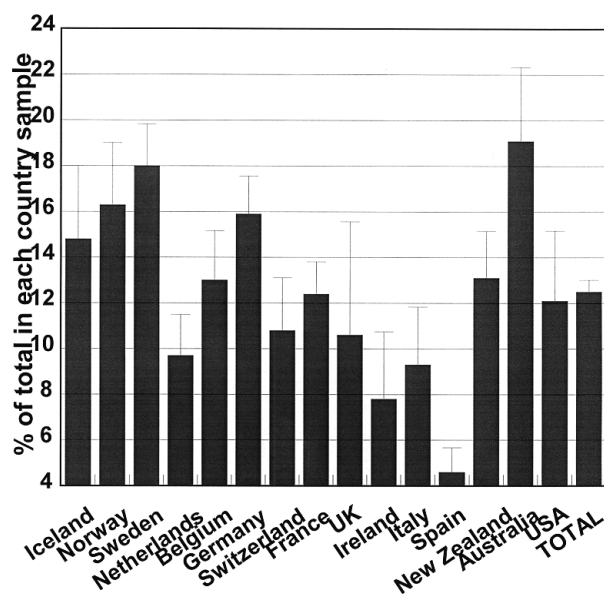

Figure 1 Reported food allergy/intolerance prevalence rates and 95% Confidence Intervals by country.

Table 2 Percentage of individuals reporting given foods as causing ‘illness or trouble’ nearly always when eaten ($n = 1992$)

Food item	Responses %
Chocolate	4.8
Apple, hazelnut	4.7
Strawberry	4.6
Cow's milk	4.3
Orange, tomato	3.0
Shrimp (prawn), egg	2.8
Oyster	2.3
Fish (white, cod, plaice)	2.2
Other (76 items)	36.1
	(range: 0.05–1.9)
Not coded	25.1

Table 3 Reported symptoms that occur nearly every time following eating particular food(s) ($n = 2162$)

Symptom type	n (percentage of responses)	Items cited (n)	Most commonly reported food items responsible for symptom (percentage of responses)
Rash/itchy skin	800 (37.0%)	76	Strawberries (10.1%), apple (7.0%), hazelnut (6.7%), not coded (15.7%)
Diarrhoea/vomiting	797 (36.9%)	73	Cow's milk (6.9%), oyster (6.0%), chocolate (4.2%), not coded (32.3%)
Runny/stuffy nose	207 (9.6%)	57	Apple (9.2%), hazelnut (8.4%), cow's milk (6.9%), not coded (13.8%)
Severe headaches	326 (15.1%)	65	Chocolate (10.7%), hard cheese (4.3%), cow's milk (4.1%), not coded (26.8%)
Breathlessness	217 (10.0%)	53	Hazelnut (12.8%), apple (7.0%), peach (4.3%), not coded (16.8%)
Other	878 (40.6%)	78	Apple (7.0%), hazelnut (6.8%), cow's milk (4.7%), not coded (24.5%)

A total of 53 different food items were reported as being associated with the reporting of breathlessness from food. The most commonly reported foods were hazelnut (12.8%), apple (7.0%), peach (4.3%), cow's milk (3.7%), egg and orange (2.9% each), fish (white, cod, plaice, 2.7%) and 16.8% of responses were not coded.

Table 4 lists the most commonly reported foods associated with breathlessness and the percentage of each sample reporting breathlessness as a symptom following food ingestion for each country. Again no single food stood out, but fruits, nuts, dairy products, seafoods and chocolate featured in several countries.

Risk factors for reporting illness and breathlessness from food (Table 5)

The significant independent risk factors for reporting food allergy or intolerance were: atopy; wheeze in the past 12 months; having ever had asthma; use of oral asthma medications within the past 12 months; females; and residence in Iceland, Norway, Sweden or Germany. Residing in Spain was found to be a significant protective factor. Current asthma, doctor diagnosed asthma, BHR, current use of inhaled asthma medications, smoking status, BMI, age, previous allergy vaccination (immunotherapy) or other country of residence were not associated with food allergy or intolerance.

Using a similar logistic regression model, the significant independent risk factors for reporting of *breathlessness* as a symptom for food allergy or intolerance were rather different: atopy; wheeze in the past 12 months, having ever had asthma; doctor diagnosed asthma; oral asthma medication usage within the past 12 months; BHR, current asthma; older respondents; and residence in Norway or Sweden.

Discussion

This is the first published study to our knowledge that has gathered community-based data on the self-reported prevalence of food allergy/intolerance across multiple countries using standardized methodology. The international variations in atopy, bronchial hyperreactivity and asthma among young adults, which roughly parallel each other, have been reported previously (European Community Respiratory Health Survey, 1996).

The major limitation of this study is that 'food allergy or intolerance' was determined by self-report only. It is important to confirm these self-reported food related problems. The true diagnosis of food allergy requires double-blind, placebo-controlled food challenges (DBPCFC). If the self-reported problem cannot be confirmed by DBPCFC, individuals would then be able to reintroduce the perceived 'problem food' into their diet and thus free them from the

Table 4 Breathlessness as reported symptom following consumption of particular foods by country ($n = 217$)

Country	Percentage of sample who reported illness from food	Number food items cited	Most commonly reported foods (percentage responses)
Iceland	7.2	3	Cherry/corn/kiwi (14.3%), not coded (57.1%)
Norway	17.0	16	Hazelnut (36.6%), egg (9.8%), crab/shrimp/not coded (7.3%)
Sweden	16.1	31	Hazelnut (19.8%), apple (12.3%), peach/not coded (7.5%)
Netherlands	14.5	23	Cow's milk (8.1%), not coded (13.5%)
Belgium	2.8	5	Apple/not coded (25%)
Germany	8.0	20	Hazelnut (15.1%), apple (11.3%), not coded (13.2%)
Switzerland	7.7	1	Celery/not coded (50%)
France	6.2	12	Not coded (47.8%)
United Kingdom	6.9	8	Not coded (27.3%)
Ireland	8.8	4	Banana/egg/hard cheese/cow's milk (25%)
Italy	6.7	5	Strawberry (33.3%)
Spain	7.8	10	Lobster (14.3%), not coded (21.4%)
New Zealand	11.4	14	Cow's milk (18.2%), hard cheese (13.6%)
Australia	10.9	8	Chocolate/apricot (10.5%), not coded (47.4%)
United States of America	16.9	11	Peanut (14.3%), not coded (33.3%)

Table 5 Significant independent risk factors for the reporting of food related illness ($n = 12\,249$)

Outcome/Predictor	Adjusted odds ratio	95% confidence interval
<i>Reported food allergy/intolerance nearly always after eating particular food</i>		
Wheeze in past 12 months	1.37	1.16–1.60
Ever had asthma	1.71	1.09–2.66
Current oral asthma medication use	1.44	1.21–1.70
Atopy	1.38	1.23–1.55
Gender (female)	1.47	1.24–1.74
Residence in Iceland	1.72	1.12–2.67
Residence in Norway	2.00	1.33–3.04
Residence in Sweden	1.98	1.37–2.88
Residence in Germany	1.76	1.22–2.26
Residence in Spain	0.53	0.35–0.82
<i>Breathlessness as a symptom nearly always reported after eating food</i>		
Wheeze in past 12 months	2.51	1.64–3.80
Ever had asthma	7.04	3.72–13.16
Doctor diagnosed asthma	3.57	1.83–7.06
Current oral asthma medication use	2.00	1.34–2.95
Atopy	2.84	1.98–4.10
BHR positive	2.69	1.61–4.52
Current asthma	2.46	1.26–4.76
Age (older)	1.03	1.00–1.05
Residence in Norway	4.76	1.88–12.27
Residence in Sweden	3.32	1.41–7.95

extra burdens associated with carrying the diagnosis of having a food allergy. This was not feasible in such a large epidemiological study and therefore these results must be interpreted with caution.

Previous independent studies conducted in the UK, Netherlands and the USA found self-reported food intolerance levels of 14.7%, 12% and 16%, respectively (Young *et al*, 1994; Jansen *et al*, 1994; Altman & Chiaramonte, 1996). Whilst the absolute values from the present study are lower than those of previous studies, the ranking of self-reported food intolerance levels is consistent across all of these studies. Logistic regression showed that there was indeed a relationship between atopy, history of asthma, BHR and reported food intolerance levels, but no such relationship existed with current asthma. One of these previous studies has also shown that there is indeed a wide gap between self-reported food allergy/intolerance and the true prevalence of food allergy as defined by double-blind, placebo-controlled food challenge testing (Young *et al*, 1994).

A wide range of foods and beverages were reported to precipitate food-related symptoms. This suggests individual idiosyncrasies rather than a consistent problem with specific foods. Although dairy products have often been reported as triggers of asthma, double-blind randomized controlled trials of milk have not confirmed clinically important changes in asthma symptoms, lung function, bronchial hyperreactivity or soluble inflammatory mediators (Woods *et al*, 1998b). The gastrointestinal symptoms probably represent lactose intolerance, as true allergy to cows' milk is uncommon in adults. Double-blind placebo-controlled studies in adults have not supported fruit being a common cause of food intolerance (Sampson & Metcalfe,

1991; Young *et al*, 1994). However, Kivity *et al* have reported that when sensitization to food allergens occurs after the age of 10 y, fruits and vegetables appear to be the main causative agents (Kivity *et al*, 1994). Although immunological cross-reactivity of plant aeroallergens with fruits are well-documented (Calkhoven *et al*, 1987; Eriksson *et al*, 1982), the clinical relevance of this remains unclear (Bock, 1991).

The coding of food substances perceived to be causing food allergy/intolerance created major difficulties in this analysis because of the large number of responses that did not fit into the coding system and were simply recorded as 'not coded'. Similar problems were also encountered with the coding system used for reporting symptoms that people experienced following food ingestion. For example, those reporting 'cough or wheeze' were coded in the 'other' category and not in the breathlessness category. Thus, the reporting of asthma symptoms following food ingestion is likely to have been underestimated in the present analysis. We have highlighted these difficulties previously (Woods *et al*, 1998a). As the ECRHS is currently being repeated, improvements in the coding systems to be used in the repeat study have been made to avoid these problems in the future.

Only 10% of people who reported food allergy/intolerance had breathlessness as a symptom following food ingestion. However there was quite a range in the prevalence of breathlessness between countries. Prevalence levels were generally high in the Nordic countries, Australasia and the USA with lower levels in Iceland and continental Europe. This pattern of prevalence levels is not consistent with the international pattern of asthma prevalence rates.

It is thought that the prevalence of food allergy is dependent on geographical area. This is due in part to differences in cross-sensitivity between pollen and aero-allergens and also due to the differences in dietary intakes between countries (Bousquet *et al*, 1997). For example, peanut allergy is common in the USA due to its extensive use in a range of food products. Similarly, fruit, vegetable and nut sensitivities are common in the Nordic countries due to birch pollen, which is known to cross-react with fruits, vegetables and nuts, being a very common aeroallergen.

The results of our analysis are consistent with this theory as indeed the prevalence of reporting food allergy/intolerance was significantly higher in Norway and Sweden. The reasons for residence in Spain being a protective factor against the reporting of food allergy/intolerance remain unclear. Perhaps the consumption of the 'Mediterranean diet' offers protection against food allergy/intolerance similar to that hypothesized about this type of diet being a protective factor for heart disease (De Lorgeril *et al*, 1994). However, the same did not apply to Italy, where there are many dietary similarities. Alternatively, perhaps these differences are due to undefined cultural factors. This survey did not collect data that enabled these interesting geographical differences to be fully explored. Future studies, which assess the dietary intakes of those in different geographical regions, are required to clarify these issues.

The analysis by Bjornsson *et al* (1996) is consistent with the results obtained in our study insofar as a large proportion (25%) of people from Sweden reported food allergy/intolerance. They also found that females were more likely to report food allergy/intolerance. Furthermore the Swedish study collected data on specific IgE antibodies to common food allergens and found that only 6% of the study population had specific IgE antibodies. This suggests that the prevalence of food allergies/intolerance is over-estimated by self-report. Interestingly they also found that sensitization to food allergens was uncommon in subjects without positive skin prick tests to at least two inhalant allergens. Unfortunately the current analysis was unable to verify or refute this finding.

In conclusion, we found that self-reported food allergy/intolerance was relatively common across multiple countries using a standardized methodology. The prevalence rate of reported food allergy/intolerance ranged from 4.6% in Spain to 19.1% in Australia. A wide range of foods and beverages were reported to precipitate food-related symptoms. Double-blind, placebo-controlled food challenges are required to confirm these self-reported food related problems. Atopy, wheeze in the past 12 months, being female, having ever had asthma, currently using oral asthma medications and residing in Iceland, Norway, Sweden and Germany were all found to be independent risk factors for the reporting of food allergy and intolerance, while living in Spain is apparently protective. Improved coding systems for the types of foods and symptoms associated with reported food allergy/intolerance are required in

future studies to more confidently identify the foods responsible.

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