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Original article

Geographical variation in the prevalence of positive skin tests to environmental aeroallergens in the European Community Respiratory Health Survey I

Background: Many studies have reported the prevalence of sensitization using skin prick tests. However, comparisons between studies and between regions are difficult because the number and the type of allergens tested vary widely. Using the European Community Health Respiratory Survey I data, the geographical variation of sensitization to environmental allergen as measured by skin tests was established.
Methods: Adults aged 20–44 years, living in 35 centres in 15 developed countries, underwent skin tests for allergy to nine common aeroallergens: *Dermatophagoides pteronyssinus*, timothy grass, cat, *Cladosporium herbarium*, *Alternaria alternata*, birch, *Olea europea*, common ragweed and *Parietaria judaica*. The age–sex standardized prevalence of sensitization was determined and centres with high (95% confidence interval above and excluding study median) and low prevalence (95% confidence interval below and excluding study median) of sensitization to each allergen and to any of the nine allergens were identified.
Results: There was substantial geographical variation in the prevalence of sensitization to each of the nine allergens tested and in the prevalence of sensitization to any allergen (lowest 17.1%, median 36.8% and highest 54.8%). Sensitization to *D. pteronyssinus*, grass pollen and cat were usually the most prevalent (median between centre 21.7%, 16.9% and 8.8%, respectively). Timothy grass sensitization was higher than that for any other pollen species.
Conclusions: As expected, geographical variations of sensitization to environmental allergen were observed across centres. These findings were compatible for those observed with serum-specific IgE. Skin tests can be used to assess the geographical distribution of allergens in a multicentric epidemiological survey.

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Key words: European Community Respiratory Health Survey; geographical variation; skin prick tests; standardized prevalence.

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Atopy is widely recognized as an important risk factor for asthma (1, 2), rhinitis (3, 4) and other allergic diseases. Many epidemiological studies have reported the prevalence of sensitization to the most common allergens. However, either the number of centres involved in each study was limited or the number of allergens tested was low (5).

The European Community Respiratory Health Survey (ECRHS) is a multicentre collaborative study that was established to measure (i) the variation in the prevalence of asthma, asthma-like symptoms and bronchial lability; (ii) the exposure to known and suspected risk factors for asthma, their association with asthma and the extent to which they explain variations in asthma prevalence and (iii) the variations in treatment for asthma (6, 7).

As part of the ECRHS, a standardized protocol was developed for assessment of atopy by measurement of specific IgE in serum to four allergens (plus a local one) and by skin prick testing to nine allergens. Skin tests have the advantage of being cheaper, thereby allowing more allergens to be tested. However, assessment of atopy by skin tests is subject to observer variation and may be difficult to standardize (8). Results from the blood tests have been presented elsewhere (9), but only four allergens were tested in all centres, and, to date, no paper has described the geographical variation in positive skin prick tests across all the participating centres.

In this article, the distribution of sensitization to environmental allergens is described as shown by the results of the skin tests in the participating centres of the ECRHS.

Abbreviations: ECRHS, European Community Respiratory Health Survey..

Methods

The methods used in the ECRHS are described in detail elsewhere (6, 10). Participating centres selected areas for study which had

populations of at least 150 000 people and where possible had up to date sampling frames of 20–44-year old men and women. In the first phase of the study a random sample of at least 1500 people of each sex in each centre were sent the ECRHS questionnaire. In the second phase a random sample of those responding to this postal questionnaire were invited to come for a more detailed interview, blood tests, skin tests, assessment of lung function by spirometry and airway challenge with methacholine.

Skin tests

Skin testing was performed using Phazets (Pharmacia Diagnostics, Uppsala, Sweden), which are stainless steel lancets precoated with lyophilized standardized allergen extracts (11–13). The following allergens were used: *Dermatophagoides pteronyssinus*, timothy grass, cat, *Cladosporium herbarium*, *Alternaria alternata*, birch, *Olea europea* (Olive), common ragweed, *Parietaria judaica* and a positive control (histamine) and negative control (uncoated Phazet). Skin testing was performed as described previously (6, 10) and presented in the supplementary file. A skin test was said to be positive if the mean wheal diameter (MWD) was greater than 0 mm (8). Subjects for whom the negative control was positive were omitted from the analysis (14). Atopy was defined as the presence of one or more positive skin tests.

The following procedure was adopted for skin testing. A skin test grid for application of Phazets was applied to the volar aspect of the forearm and taped. The lancet was held at 90° to the skin and pressed against the skin with the forefinger for at least 1 s. The lancet was withdrawn and the results were read 15 min later by drawing around the perimeter of the wheal with a ballpoint pen, placing transparent tape against the skin and transferring the prints to a data collection sheet. The transferred image of the wheal was measured at its widest point and at 90° to the diameter at its midpoint. Both diameters were recorded to the nearest whole millimetre and the mean of the two determined (MWD).

Two strategies were adopted to reduce measurement error:

1) Prior to starting the study, each fieldworker was required to perform at least two histamine tests on 20 volunteers and measure them following the protocol given above in order to achieve a coefficient of variability of less than 30%.
2) Each centre was visited during the study and five sample wheal images were measured by each fieldworker. Where the wrong method of measurement was being used (e.g. the two diameters not at right angles), fieldworkers were asked to review the records of all tests and remeasure the wheal images that had been kept on the transparent tape.

For each centre, the prevalence of sensitization to each allergen was determined for each of six age–sex groups (men and women aged 20–24, 25–34 and 35–44 years). In order to make valid comparisons between centres, these estimates were used to standardize the prevalence to a population with an even age distribution and equal numbers of men and women.

Comparison of prevalence between centres

The median value for the age–sex standardized prevalence of sensitization to each allergen across all centres was determined. Centres were then classified as having a significantly high (95% confidence interval around centre age–sex standardized prevalence above and excluding study median value) or low (95% confidence interval around centre age–sex standardized prevalence below and excluding study median value) or average value for sensitization (95% confidence interval includes study median).

Results

Patient population

Overall 18 102 participants from 35 centres in 15 countries were eligible for inclusion, but further exclusions were made if the participant refused skin prick testing (2702), the skin test data were likely to be incorrect (219, positive and negative controls) and the age was unavailable (21) (Fig. 1). Moreover, stringent research guidelines prevented skin prick testing of timothy grass, olive, *Parietaria* and common ragweed in Germany (two centres). In addition, common ragweed was not tested in Switzerland (one centre). Analyses for these allergens are therefore based on data from 33/32 centres.

The participation rate by centre from those selected for stage 2 of the ECRHS-I survey to those with valid skin prick tests is summarized in Table S1 given in a supplementary file. Of those accepting an invitation to take part in further tests following the postal survey, 84% agreed to skin prick testing.

Sensitization to allergens

There was a wide variation in the prevalence of sensitization to each allergen tested and a wide variation in the

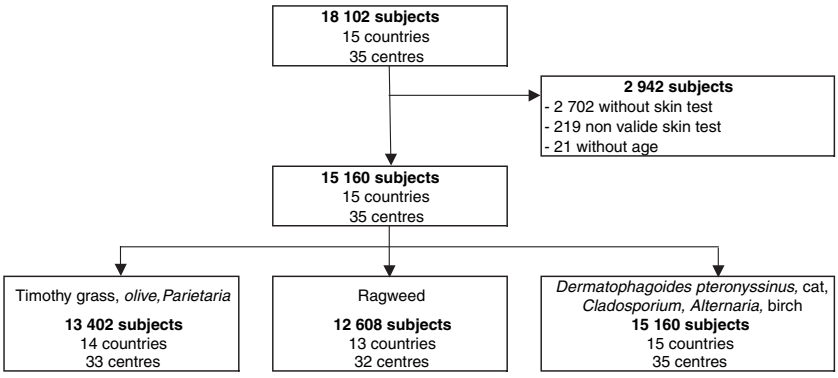

Figure 1. Flow chart.

prevalence of atopy (17.1–54.8%) (Fig. 2). Sensitization was most common for allergens *D. pteronyssinus* (median between centres: 21.7%), grass pollen (16.9%) and cat (8.8%) (Table 1). Other allergens were less common such as *Cladosporium* (1.7%), *Parietaria* (0.9%) and common ragweed (0.8%). There were substantial variations in the prevalence of sensitization between countries and also between centres within countries (Fig. 3).

Geleen (the Netherlands) was the only centre in which the prevalence of sensitization to each of the nine individual allergens tested was significantly higher than the study median. In the other centres in the Netherlands, a high prevalence was only seen for birch (in Bergen op Zoom).

In Table 2, the centres with high or low prevalence are shown, and in Table 3, prevalence for each centre is given.

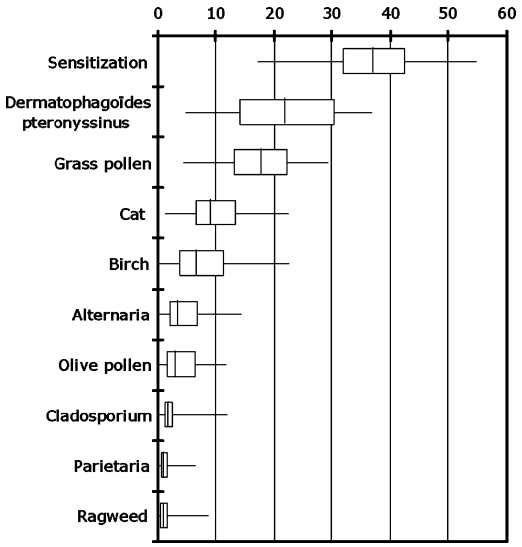

Figure 2. Geographical variation of sensitization to the main allergen. Minimum, 25 percentile; median, 75 percentile and maximum. *Dermatophagoides pteronyssinus*, cat, *Cladosporium*, *Alternaria* and birch: 35 centres; timothy grass, olive pollen, *Parietaria*: 33 centres; ragweed, sensitization: 32 centres.

Table 1. Highest, median and lowest age–sex standardized prevalence for sensitization to each allergen as assessed by skin tests

Allergen	Number of centres	Median (%)	Minimum (%)	Maximum (%)
Dermatophagoides pteronyssinus	35	21.7	4.8	36.8
Grass pollen	33	16.9	4.5	29.2
Cat	35	8.8	1.2	22.4
Birch	35	6.4	0	22.4
Alternaria	35	3.3	0.2	14.4
Olive pollen	33	2.9	0	11.7
Cladosporium	35	1.7	0	11.9
Parietaria	33	0.9	0	6.4
Common ragweed	32	0.8	0	8.7
Atopy (sensitized at least to one allergen)	32	36.8	17.1	54.8

Indoor allergens

The prevalence of sensitization to *D. pteronyssinus* was significantly higher than the study median (95% confidence interval around centre age–sex standardized prevalence above and excluding study median value) in centres in Australia, Belgium (Antwerp City), France (Bordeaux), Ireland, New Zealand, the Netherlands (Geleen), the UK (except Cambridge) and the USA. It was low (95% confidence interval around centre age–sex standardized prevalence below and excluding study median value) in Scandinavia, Spain (Albacete, Galdakao and Oviedo), Iceland, Italy and in one centre in Germany (Erfurt) and France (Montpellier). Centres in Spain (except Barcelona) and Italy (except Turin) also had a low prevalence of sensitization to cat, but in contrast to their low prevalence of sensitization to *D. pteronyssinus*, centres in Sweden showed a high prevalence of sensitization to cat.

Allergens associated with vegetation

The prevalence of sensitization to timothy grass was significantly higher than that of any other pollen species. A high prevalence was found in centres in Australia, France (Grenoble), New Zealand (except Hawkes Bay), the UK (except Caerphilly), Switzerland and Portland in the USA. The prevalence of positive skin tests to timothy grass was low in Iceland, Ireland, Norway and Spain, and in one centre in Italy (Pavia) and Belgium (South Antwerp). In the Netherlands, Geleen had a high prevalence, but the other two centres had a low prevalence.

Sensitization to the common ragweed was high in the USA (8.7%), one centre in the UK (Norwich), Sweden (Uppsala) and the Netherlands (Geleen).

The prevalence of sensitization to birch was generally high in northern and mid-Europe (Germany, the Netherlands, Norway, Sweden, Switzerland) and in some centres outside Europe (Christchurch and Hawkes Bay and Portland) and low in centres in the south of Europe (Montpellier, Paris, Pavia and Spanish centres).

Within Europe, the prevalence of sensitization to olive was high in some but not all centres in France, the Netherlands (Geleen) and Italy (Verona). However, there was a substantial variation within countries – for example, in Spain, the prevalence was 11.7% in Albacete and 7.6% in Barcelona when compared with 0% in Galdakao and 0.7% in Oviedo. In the Netherlands, Geleen had a high prevalence, but both other Dutch centres had a low prevalence. In one centre in the UK (Norwich), prevalence of sensitization to olive was high.

The prevalence of sensitization to *Parietaria* was high in all three centres in Italy and two other southern European centres (Barcelona, Montpellier). Substantial variation within Sweden was seen with the prevalence being 0.3% in Uppsala and 2.4% in Goteborg.

Figure 3. Prevalence of sensitization in Europe.

Moulds

Two centres in France (Bordeaux and Grenoble), Italy (Pavia) and Spain (Albacete, Galdakao and Oviedo) had a significantly lower prevalence of *Cladosporium* when compared with the study median. Two centres in the UK (Ipswich and Norwich), one centre in New Zealand (Wellington), the Netherlands (Geleen), Sweden (Umea) and the USA showed a high prevalence of sensitization.

Centres with a high prevalence for *Alternaria* included the single centres in Australia and the USA, one centre in France (Montpellier), Germany (Hamburg), New Zealand (Wellington), the Netherlands (Geleen) and centres in the UK (except Caerphilly). Centres with a low prevalence were scattered across both southern and northern Europe.

Atopy

The median standardized prevalence of sensitized subjects was 36.8% in the present study. It ranged from 17.1 in Oviedo (Spain) to 54.8% in Geleen (the Netherlands). This prevalence was high in all centres in Australia, New Zealand, the USA, two centres in the UK (Caerphilly and Norwich) and one centre in the Netherlands (Geleen). It was low in Belgium (South Antwerp), Iceland, Norway, Spain (all centres except Barcelona) and Italy (one centre in Pavia).

Discussion

This article has described the prevalence of sensitization to nine environmental aeroallergens – as determined by skin testing – in participating centres in the ECRHS. There is substantial variation between the centres in sensitization to most of the allergens and in the prevalence of atopy. The broad pattern of this geographical variation is similar to that observed for sensitization as assessed by measurement of serum-specific IgE for *D. pteronyssinus*, grass and cat. As more allergens were tested, the overall standardized prevalence of sensitized subjects was higher than that in the study of serum IgE.

Response rates varied between centres. The response to the second phase of the study among those who completed the postal questionnaire and who had been randomly selected for stage 2 varied from 12% in Montpellier to 90% in Umea. The response to skin testing among those who attended for further tests varied from 53% in Portland to 100% in Bordeaux and Verona. In the majority of centres, more people agreed to skin testing than to blood testing, and in some centres this difference was substantial (e.g. in Turin, 73% of people agreed to have blood tests, but 98% agreed to have skin tests). However, variation in response is unlikely to explain the geographical variations we have shown.

The size of a wheal generated following skin prick testing depends largely on the methods used for skin testing, the potency of the allergen extract used and the area of skin to which the test is applied, as well as the ability of the subject to mount an allergic response (15, 16). Standardization of the skin testing protocol, standardized fieldworker training and quality control visits have minimized the common sources of observer variation in our study. The commercial production of Phazet was abandoned in the mid-1990s, but several reports showed that it had good agreement with other skin prick testing methods (12, 17–19). The great advantage of

Table 2. High or low prevalence of sensitization to each allergen by centre as assessed by skin tests

Centre	d1	e1	g6	m2	m6	t3	t9	w1	w21	Sensitized
Australia										
Melbourne	High	High	High	–	High	–	–	–	–	High
Belgium										
South Antwerp	–	–	Low	–	–	–	Low	Low	–	Low
Antwerp City	High	High	–	–	Low	–	–	Low	Low	–
France										
Bordeaux	High	–	–	Low	–	–	High	Low	–	–
Grenoble	–	–	High	Low	–	–	High	–	–	–
Montpellier	Low	High	–	–	High	Low	High	–	High	–
Paris	–	–	–	–	–	Low	–	–	–	–
Germany										
Erfurt	Low	Low	ND	–	–	High	ND	ND	ND	ND
Hamburg	–	High	ND	–	High	High	ND	ND	ND	ND
Iceland										
Reykjavik	Low	–	Low	–	Low	Low	Low	–	Low	Low
Italy										
Pavia	Low	Low	Low	Low	–	Low	–	–	High	Low
Turin	Low	–	–	–	–	–	–	–	High	–
Verona	Low	Low	–	–	–	–	High	–	High	–
Ireland										
Dublin	High	–	Low	–	–	Low	–	–	–	–
New Zealand										
Christchurch	High	–	High	–	–	High	–	–	–	High
Hawkes Bay	High	–	–	–	–	High	Low	–	–	High
Wellington	High	–	High	High	High	–	Low	–	–	High
Norway										
Bergen	Low	–	Low	–	Low	High	Low	Low	Low	Low
Spain										
Albacete	Low	Low	Low	Low	Low	Low	High	Low	–	Low
Barcelona	–	–	Low	–	–	Low	High	–	High	–
Galdakao	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Huelva	–	Low	Low	–	Low	Low	–	–	–	Low
Oviedo	Low	Low	Low	Low	–	Low	Low	–	Low	Low
Sweden										
Goteborg	Low	High	–	–	Low	High	–	Low	High	–
Umea	Low	High	–	High	–	High	–	–	–	–
Uppsala	Low	High	–	–	–	High	Low	High	Low	–
Switzerland										
Basel	Low	–	High	–	–	High	High	ND	–	ND
The Netherlands										
Bergen op Zoom	–	Low	Low	–	–	High	Low	Low	–	–
Geleen	High	High	High	High	High	High	High	High	High	High
Groningen	–	–	Low	–	–	–	Low	Low	Low	–
UK										
Caerphilly	High	–	–	–	–	–	Low	–	–	High
Cambridge	–	–	High	–	High	–	–	–	–	–
Ipswich	High	High	High	High	High	–	–	–	–	–
Norwich	High	High	High	High	High	–	High	High	–	High
USA										
Portland	High	High	High	High	High	High	High	High	–	High

ND, not done (all nine allergens were not tested); d1, *Dermatophagoides pteronyssinus*; g6, grass; e1, cat; t3, birch; m6, *Alternaria*; t9, olive pollen; m2, *Cladosporium*; w21, *Parietaria*; w1, ragweed.

Phazet to the ECRHS was that in a multicentre setting, the precoating of the lancet with allergen was an ideal means of controlling the amount of allergen delivered to the skin. Notwithstanding the tight standardization, it is difficult to remove entirely variations between operators and this might explain, for instance, why Geleen shows a high prevalence to all allergens (unlike any other centre).

Perhaps, the most controversial part of the analysis is our decision to consider a skin test positive if the wheal was greater than 0 mm. Most practising allergists use a cut-off of 3 mm. For the purposes of this epidemiological study, we wanted to identify those with a measurable skin test response indicative of an immunological reaction (20), and therefore a lower cut-off was used. In addition, we have shown that even with the most well-standardized protocols, variation between fieldworkers may exist such that the relationship between wheal size and specific IgE is not constant between fieldworkers. This source of variation can be minimized using 0 mm as the cut-off (8). When we performed the same analysis using a 3 mm cut-off, the prevalence of sensitization was lower, but the same patterns of geographical variation remained [median 32.2% (16.5–47.1)].

Cross-reactivities that exist between some allergens may be important in the interpretation of our results (21). *Olea europea* is cross-reactive for all Oleaceae pollens including olive (southern centres) and ash (northern and some southern centres) (22). This is the likely explanation for the apparently high prevalence of olive sensitization in Norwich and Umea (where olive plants do not grow). Although nettle (*Urtica*) is from the same family as *Parietaria*, it does not cross-react (23, 24) and the high prevalence of positive skin tests to *Parietaria* in southern Sweden probably represents true sensitization to this species.

It is also well known that many grass pollens cross-react and sensitization to any of these can be studied with a single allergen. Timothy grass extract (*Phleum pratense*) is likely to identify most individuals sensitized to the common grass in Europe (northern pasture grass – Pooideae) and its subfamily members which all strongly cross-react (25). However, some exceptional participants only allergic to *Cynodon dactylon* in southern centres may not have reacted to the timothy grass extract (26).

Our report shows that sensitization to *Olea europea* and *P. judaica* is higher in southern Europe than northern Europe and sensitization to the silver birch is higher in northern Europe than southern Europe. These patterns could be predicted by the preferred habitat of each species. Wide variations in the prevalence of sensitization to some allergens were also observed *within* some countries (e.g. olive in Spain). While this may be due to variations in exposure in some large countries (e.g. Spain), it is also likely that other factors may be important determinants of sensitization. The prevalence of ragweed pollen was low (except in the USA), but this was expected as none of the centres (except Portland) was located in an area with elevated ragweed pollen counts (27, 28).

In summary, we have shown widespread geographical variation in the prevalence of sensitization to aeroallergens using skin prick tests. For allergens associated with plants and grasses, the prevalence of sensitization tends to

Table 3. Standardized (age, gender) prevalence of sensitization to nine allergens skin tested and standardized (age, gender) prevalence of sensitization each allergens skin tested

Centre	Sensitized	*D. pteronyssinus*	Cat	Grass pollen	*Cladosporium*
Australia					
Melbourne	49.2% (44.8–53.5)	36.6% (32.4–40.7)	14.6% (11.5–17.7)	29.2% (25.3–33.2)	1.9% (0.7–3.1)
Belgium					
Antwerp City	40.1% (34.7–45.5)	32.5% (27.3–37.8)	12.8% (9–16.6)	14.5% (10.5–18.6)	1% (−0.2–2.2)
South Antwerp	29.6% (24.9–34.3)	19.9% (15.8–24.1)	7.3% (4.5–10)	10.9% (7.6–14.2)	1% (0–2)
Overall	34.1% (30.5–37.7)	25.5% (22.2–28.8)	9.8% (7.5–12.1)	12.2% (9.7–14.7)	1% (0.3–1.8)
France					
Bordeaux	40.7% (36.7–44.8)	30.6% (26.8–34.4)	8.8% (6.5–11.2)	19.7% (16.4–22.9)	0.3% (−0.1–0.8)
Grenoble	40.4% (35.4–45.5)	20.5% (16.4–24.6)	9.5% (6.4–12.6)	22.2% (17.8–26.5)	0.5% (−0.1–1.1)
Montpellier	33.3% (28.5–38.1)	15.2% (11.3–19.1)	12.5% (8.9–16.2)	19.5% (15.3–23.6)	1.5% (−0.1–3.1)
Paris	35.8% (31.2–40.5)	21.7% (17.6–25.8)	8.8% (5.6–11.9)	16.1% (12.4–19.9)	1.8% (0.6–3)
Overall	38.1% (35.9–40.3)	23.4% (21.5–25.4)	9.6% (8.2–11)	19.2% (17.4–21.1)	1.1% (0.6–1.5)
Germany					
Erfurt	–	11.7% (9.4–14)	3.4% (2.1–4.7)	–	2.3% (1.2–3.3)
Hamburg	–	21.8% (19.2–24.4)	15.3% (13–17.5)	–	1.1% (0.4–1.8)
Overall	–	17.5% (15.7–19.2)	10.3% (8.9–11.7)	–	1.5% (1–2.1)
Iceland					
Reykjavik	21.6% (18–25.2)	8.2% (5.9–10.6)	8% (5.6–10.4)	10.8% (8–13.6)	1.3% (0.2–2.3)
Ireland					
Dublin	40.3% (34.7–45.9)	31.7% (26.4–36.9)	8.6% (5.4–11.7)	11.1% (7.6–14.6)	1% (−0.1–2)
Italy					
Pavia	19.4% (14.4–24.4)	7.7% (4.4–10.9)	3.3% (1.3–5.4)	8.9% (5.3–12.5)	0.5% (−0.2–1.2)
Turin	34.8% (28–41.5)	16.4% (11.2–21.5)	9% (5–13)	18.1% (12.7–23.5)	0.8% (−0.3–1.8)
Verona	32.6% (27.6–37.6)	12.3% (8.7–15.8)	5.3% (2.9–7.7)	15.4% (11.5–19.2)	1.1% (0–2.1)
Overall	29% (25.8–32.1)	12% (9.7–14.3)	5.7% (4.1–7.3)	14.2% (11.7–16.6)	0.9% (0.3–1.5)
New Zealand					
Christchurch	45.5% (40.2–50.8)	29.1% (24.2–33.9)	7% (4.2–9.7)	26.6% (21.8–31.3)	2.7% (1–4.4)
Hawkes Bay	47.4% (40–54.8)	36.8% (29.5–44.1)	5.9% (1.8–9.9)	21.9% (15.3–28.4)	1.1% (−0.1–2.3)
Wellington	47.3% (41.7–52.8)	35.4% (30–40.7)	8.6% (5.5–11.8)	26.6% (21.6–31.5)	5.2% (2.8–7.7)
Overall	46% (42.7–49.4)	32.4% (29.2–35.6)	7.1% (5.4–8.9)	25.1% (22.1–28.1)	3.3% (2.1–4.4)
Norway					
Bergen	29.3% (26–32.5)	12.7% (10.3–15.1)	8.6% (6.6–10.7)	14.2% (11.7–16.7)	1.7% (0.7–2.7)
Spain					
Albacete	17.8% (14.2–21.4)	4.8% (2.7–6.9)	3.8% (2.1–5.6)	7.6% (5.2–10)	0.2% (−0.2–0.7)
Barcelona	33.3% (26.8–39.8)	25% (19–30.9)	8.9% (4.8–12.9)	10% (5.8–14.2)	2% (0–3.9)
Galdakao	17.8% (14.3–21.3)	14.5% (11.2–17.7)	1.2% (0.3–2.2)	4.8% (2.8–6.7)	0% (0–0)
Huelva	29.5% (24–34.9)	17.5% (12.9–22.1)	3.3% (1.1–5.5)	13% (9–17.1)	0.9% (−0.3–2)
Oviedo	17.1% (12.4–21.8)	13.4% (9.1–17.6)	2.7% (0.7–4.7)	4.5% (1.9–7.1)	0% (0–0)
Overall	22.1% (20.1–24.2)	13.6% (11.9–15.3)	3.6% (2.7–4.5)	7.8% (6.5–9.1)	0.5% (0.1–0.8)
Sweden					
Goteborg	38.4% (34.4–42.3)	16.8% (13.7–19.8)	15.2% (12.3–18.2)	17.6% (14.5–20.6)	2% (0.9–3.1)
Umea	36.7% (32.3–41.2)	11.2% (8.3–14.1)	21.5% (17.6–25.3)	16.9% (13.5–20.4)	3.8% (2.1–5.6)
Uppsala	36.9% (32.8–41)	10.5% (7.9–13.1)	16.8% (13.6–19.9)	19.2% (15.9–22.5)	1.4% (0.4–2.4)
Overall	37.4% (35–39.8)	13% (11.3–14.6)	17.5% (15.6–19.4)	17.9% (16–19.8)	2.4% (1.6–3.1)
Switzerland					
Basel	–	17% (14.4–19.6)	8.3% (6.4–10.2)	26.3% (23.3–29.4)	1.7% (0.8–2.6)
The Netherlands					
Bergen op Zoom	32.9% (28.4–37.4)	21.9% (17.9–25.9)	5.4% (3.2–7.7)	13.1% (9.9–16.4)	2% (0.6–3.3)
Geleen	54.8% (49.4–60.2)	36.3% (31–41.5)	17.7% (13.5–22)	23% (18.4–27.6)	11.9% (8.3–15.4)
Groningen	33.9% (29.1–38.8)	25.7% (21.2–30.2)	11.5% (8.2–14.8)	13% (9.6–16.5)	1.8% (0.5–3.2)
Overall	39.8% (36.9–42.7)	27.4% (24.8–30.1)	11% (9.1–12.9)	16.2% (14–18.4)	4.8% (3.6–6.1)
UK					
Caerphilly	42.3% (36.9–47.7)	30.1% (25.1–35.2)	10.4% (6.8–13.9)	19.1% (14.7–23.6)	3.1% (1–5.3)
Cambridge	42.6% (36.1–49.1)	25.6% (19.8–31.3)	12% (7.7–16.2)	24.9% (19.2–30.7)	3.3% (1–5.6)
Ipswich	41.3% (36.5–46.0)	27.2% (22.8–31.6)	16% (12.4–19.7)	22.3% (18.1–26.4)	3.7% (1.8–5.7)
Norwich	44.2% (39.4–49.0)	32.2% (27.6–36.8)	14.1% (10.6–17.5)	22.3% (18.2–26.5)	3.7% (1.8–5.6)
Overall	42.6% (40.0–45.3)	29.1% (26.6–31.5)	13.3% (11.4–15.2)	21.8% (19.5–24)	3.5% (2.4–4.5)
USA					
Portland	52.1% (46.2–58.0)	32.5% (27–38)	22.4% (17.4–27.3)	28.1% (22.6–33.5)	9.8% (6.1–13.4)

Table 3. Continued

Centre	*Alternaria*	Olive pollen	Birch pollen	Parietaria	Ragweed
Australia					
Melbourne	11.3% (8.4–14.2)	2.8% (1.4–4.1)	6.4% (4.3–8.6)	0.8% (0–1.6)	0.5% (−0.1–1.1)
Belgium					
Antwerp City	1.8% (0.3–3.2)	2.5% (0.8–4.3)	4.5% (2.1–6.9)	0.3% (−0.3–0.8)	0% (0–0)
South Antwerp	2.6% (0.9–4.2)	0.5% (−0.2–1.2)	9.2% (6.2–12.2)	0.5% (−0.2–1.2)	0% (0–0)
Overall	2.2% (1.1–3.3)	1.4% (0.5–2.3)	6.9% (5–8.8)	0.4% (−0.1–0.9)	0% (0–0)
France					
Bordeaux	4.8% (3.1–6.6)	4.9% (3.1–6.7)	5.4% (3.5–7.2)	1.6% (0.5–2.6)	0.2% (−0.2–0.6)
Grenoble	6.1% (3.3–8.9)	10.9% (7.6–14.2)	6.4% (4.1–8.8)	0.9% (0.1–1.8)	1.1% (0.2–2)
Montpellier	7.6% (4.5–10.7)	10.2% (6.8–13.5)	2.3% (0.9–3.8)	4.1% (2–6.3)	1.8% (0.5–3.1)
Paris	4.2% (2.5–5.8)	5.3% (2.8–7.9)	3.6% (2–5.2)	1.2% (0.1–2.3)	0.8% (0.1–1.5)
Overall	5.6% (4.5–6.7)	7.2% (6–8.4)	4.7% (3.8–5.7)	1.9% (1.2–2.5)	0.9% (0.5–1.4)
Germany					
Erfurt	4.4% (2.9–5.9)	–	9.5% (7.4–11.6)	–	–
Hamburg	5.2% (3.8–6.6)	–	21.3% (18.8–23.9)	–	–
Overall	4.9% (3.8–5.9)	–	16.4% (14.6–18.1)	–	–
Iceland					
Reykjavik	1.5% (0.5–2.5)	1.1% (0.1–2.1)	3.2% (1.7–4.8)	0% (0–0)	1.4% (0.3–2.5)
Ireland					
Dublin	2.7% (0.7–4.7)	2.1% (0.4–3.8)	1.6% (0.2–2.9)	0.9% (−0.1–1.9)	1.5% (0–3)
Italy					
Pavia	1.8% (−0.2–3.7)	2% (−0.1–4.1)	3.7% (1.6–5.8)	4.4% (2–6.7)	1.5% (0.2–2.7)
Turin	2.5% (0–5.1)	4.7% (1.5–7.9)	6.5% (3.3–9.6)	6.1% (3–9.2)	2.6% (0.6–4.6)
Verona	5.5% (3.1–7.9)	6.4% (3.8–9)	6.8% (4.1–9.5)	6.4% (3.8–9)	2% (0.4–3.5)
Overall	3.6% (2.2–5)	4.5% (3–6)	5.9% (4.3–7.5)	5.7% (4.1–7.3)	2% (1.1–3)
New Zealand					
Christchurch	4.4% (2.2–6.6)	3.3% (1.4–5.3)	15.8% (11.9–19.7)	0.9% (−0.1–1.8)	0.7% (−0.3–1.7)
Hawkes Bay	7.6% (3.1–12.1)	0.6% (−0.5–1.7)	11.7% (6.6–16.8)	0.6% (−0.5–1.7)	0.6% (−0.5–1.7)
Wellington	7.8% (4.8–10.7)	1.5% (0.3–2.8)	6.1% (3.2–8.9)	1.6% (0.1–3)	1.4% (0–2.8)
Overall	6.4% (4.7–8.1)	2.2% (1.1–3.2)	11.2% (9–13.4)	1.1% (0.4–1.8)	0.9% (0.2–1.6)
Norway					
Bergen	1.6% (0.7–2.4)	0.7% (0.1–1.3)	11.1% (8.8–13.3)	0.3% (0–0.7)	0.2% (−0.1–0.6)
Spain					
Albacete	0.7% (0–1.4)	11.7% (8.7–14.7)	2.1% (0.7–3.4)	0.7% (−0.1–1.5)	0.3% (−0.2–0.8)
Barcelona	1.8% (0.1–3.6)	7.6% (3.9–11.3)	2.8% (0.6–4.9)	3.7% (1.2–6.3)	0.8% (−0.3–1.9)
Galdakao	0.2% (−0.2–0.6)	0% (0–0)	0.2% (−0.2–0.6)	0.2% (−0.2–0.6)	0% (0–0)
Huelva	0.7% (−0.3–1.6)	5.4% (2.7–8.1)	2.6% (0.7–4.4)	0.7% (−0.2–1.6)	0.3% (−0.3–1)
Oviedo	1.9% (0.2–3.5)	0.9% (−0.3–2.1)	0% (0–0)	0% (0–0)	0.3% (−0.3–1)
Overall	1% (0.5–1.5)	5.4% (4.3–6.6)	1.5% (0.9–2.1)	0.9% (0.4–1.4)	0.3% (0–0.6)
Sweden					
Goteborg	2% (0.9–3.2)	3.1% (1.7–4.5)	15.9% (13–18.9)	3.7% (2.2–5.2)	0.3% (−0.1–0.8)
Umea	3.3% (1.6–5)	3.2% (1.5–4.8)	17.8% (14.2–21.3)	1.1% (0.1–2.1)	2.1% (0.8–3.4)
Uppsala	3% (1.6–4.5)	1.7% (0.6–2.7)	17.3% (14.1–20.4)	0.3% (−0.1–0.8)	2.4% (1.1–3.7)
Overall	2.8% (1.9–3.6)	2.6% (1.8–3.4)	17% (15.2–18.9)	1.8% (1.2–2.5)	1.5% (0.9–2.1)
Switzerland					
Basel	2.9% (1.8–4.1)	7.5% (5.7–9.3)	17.5% (14.9–20.2)	1.5% (0.7–2.4)	–
The Netherlands					
Bergen op Zoom	3.5% (1.7–5.3)	1.2% (0.1–2.2)	10.5% (7.6–13.4)	0.5% (−0.2–1.3)	0.2% (−0.2–0.6)
Geleen	12.3% (8.8–15.9)	10.2% (6.8–13.6)	22.4% (17.9–27)	4.2% (2–6.5)	4.5% (2.2–6.8)
Groningen	2% (0.5–3.5)	0.5% (−0.2–1.1)	7.9% (5.2–10.7)	0% (0–0)	0% (0–0)
Overall	5.8% (4.4–7.2)	3.5% (2.4–4.6)	13.4% (11.4–15.4)	1.4% (0.7–2.2)	1.4% (0.7–2.1)
UK					
Caerphilly	3.3% (1.2–5.5)	1.6% (0.3–2.9)	4.6% (2.3–6.9)	0.6% (−0.2–1.3)	0.8% (0–1.6)
Cambridge	8.1% (4.5–11.7)	2.9% (0.6–5.3)	5.7% (2.8–8.6)	1% (−0.1–2.2)	0.7% (−0.3–1.7)
Ipswich	7.4% (4.8–10.1)	2.4% (0.8–3.9)	5.9% (3.5–8.3)	1.3% (0.2–2.4)	1.6% (0.3–2.8)
Norwich	10.2% (7.1–13.2)	6.4% (3.9–9)	7% (4.4–9.6)	0.9% (0–1.9)	2.5% (1–4.1)
Overall	7.3% (5.9–8.8)	3.5% (2.5–4.6)	5.9% (4.6–7.2)	1% (0.4–1.5)	1.6% (0.9–2.2)
USA					
Portland	14.4% (10.2–18.5)	7.8% (4.3–11.2)	15.9% (11.2–20.5)	0.7% (−0.3–1.6)	8.7% (5.2–12.1)

be high in areas where these plants and grasses are more common. For indoor allergens, the prevalence tends to be low in warmer parts of Europe. Our findings are broadly consistent with findings from earlier analyses of serum-specific IgE for the three allergens *D. pteronyssinus*, grass and cat, and show that similar variations exist for less common allergens.

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Supplementary Material

The following supplementary material is available for this article:

Table S1. Participation rates by centre.

This material is available as part of the online article from: http://www.blackwell-synergy.com/doi/abs/10.1111/j.1398-9995.2006.01293.x (This link will take you to the article abstract).

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