

Childhood cat allergen exposure in three European countries: The AIRALLERG study

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Abstract

Introduction: Cat allergen is a major cause of morbidity among sensitised asthma patients, but little is known about distribution of cat allergen exposure and its determinants in homes.

Methods: We measured cat allergen and potential determinants of cat allergen levels in more than 1000 homes. House dust was collected from children's mattresses and living room floors in approximately 360 homes in The Netherlands, Sweden and Germany and analysed for Fel d 1 in one central laboratory. Exposure was expressed both in concentration (ng/g) and in loads (ng/m²).

Results: Levels on mattresses were similar in Sweden and Germany but higher on Dutch mattresses. Dutch floors had higher concentrations than Swedish floors, which had higher concentrations than German floors. The differences in load were less clear. Cat allergen on mattress and floor were moderately to highly correlated. The most important variable quantifying cat allergen variation was the presence of a cat. Floor cover type and last time that floor was vacuumed were important in all three countries. The ratio of cat allergen loads between mattresses from homes with and without cats was higher for Sweden and Germany than for The Netherlands. This is likely related to higher prevalence of cat ownership in The Netherlands which leads to more contamination of homes in which cats were never held. Dust samples from 27–35% of mattresses from homes without cats contained more than 1000 ng/g cat allergen.

Conclusion: With the exception of cat ownership and floor cover, questionnaire data on housing characteristics did not accurately predict cat allergen in the home.

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Keywords: Cat allergen; Home characteristics; Mattress; Living room floor

1. Introduction

The relationship between cat allergen exposure, sensitisation and asthma is complex (Wahn et al., 1997;

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Nelson et al., 1999; Lau et al., 2000; Melen et al., 2001; Platts-Mills et al., 2001; Almqvist et al., 2003a,b). Accurate assessment of exposure to cat allergen is important for further elucidation of these relations. The main allergen from cat is *Fel d 1*, a glycoprotein (Morgenstern et al., 1991) produced mainly in the sebaceous glands of the cat's skin and also found in lachrymal and salivary glands and particularly sebaceous glands of the face skin (Brown et al., 1984; Bartholome et al., 1985; Dabrowski et al., 1990; van Milligen et al., 1990; Mata et al., 1992; Carayol et al., 2000). Cat allergen is ubiquitous and has been found in indoor environment even if a cat has never been present. Exposure to low levels of cat allergen might still be sufficient for sensitisation and worsening of disease in children with established asthma (Chan-Yeung et al., 1999; Ichikawa et al., 1999; Perzanowski et al., 1999; Tunnicliffe et al., 1999; Almqvist et al., 2001; Ritz et al., 2002; Langley et al., 2003) which implies that cat allergen exposure is important in homes where cats were never held. It has been shown that as many as 75% of cat-allergic children have never lived in a house with a cat (Perzanowski et al., 2002).

Cat and dog allergens are to a large extent airborne and the allergen levels in air do not always correlate with those in dust (Bollinger et al., 1996). Reliable methods for collecting allergen, and sensitive assays for measuring low levels of allergen are essential to estimate dispersal of allergens, and to correctly assess personal exposure to airborne cat allergen in cat-free areas. Sampling with person-carried pumps is time-consuming and difficult in a large population (Almqvist et al., 1999). The correlation between Petri dish sampling, intranasal samplers and personal air samplers is generally poor (Karlsson et al., 2002). Cat allergens can be collected in dust samples by vacuuming dust reservoirs, and can be measured accurately with commercially available sensitive immunoassays (Chapman et al., 1988). Hence, it is important to know what factors may affect the allergen levels.

The aim of this report was to determine exposure of school children in three European countries to cat allergen in house dust. We also investigated which factors in the home best predict variation in cat allergen between homes.

2. Material and methods

Data were collected in the framework of a European collaboration, the AIRALLERG study. The AIRALLERG study combines four ongoing birth cohort studies of similar design: PIAMA in The Netherlands (Brunekreef et al., 2002), BAMSE in Sweden (Wickman et al., 2002) and GINI (von Berg et al., 2003) and LISA (Heinrich et al., 2002) in Germany. One objective was to

conduct a case-control study within the four cohorts using data on allergic sensitisation and disease collected at ages 2 (LISA) and 3 (GINI) in Germany and at age 4 in Sweden and The Netherlands. Cases were defined as children sensitised to common allergens (inhalant and/or food), controls as children who were not sensitised. Sensitisation was judged on the basis of serum IgE tests. In each country, data were collected from approximately 180 cases and 180 controls. This paper describes exposure to cat allergen in this large population of European children.

2.1. Dust sampling

Dust sampling was performed during January to mid-April of 2002 and mid-October to mid-May of 2002–2003 using previously published procedures (Schram et al., 2005). A field form concerning information relevant to dust sampling and a questionnaire about house characteristics was completed. A diary on smoking and ventilation habits was kept for the 2 weeks after dust sampling. Dust samples were collected with vacuum cleaners of 1200–1400 Watt equipped with sampling nozzles (Allergologisk Laboratorium København (ALK), Horsholm, Denmark). Glass fibre filters (70 mm glass fibre filter; Schleicher and Schuell; ref. No. 370104) were kept in tubes (Greiner, polypropylene 50 ml; no. 210296) and weighed before sampling with an analytical balance (Mettler). Samples from living room floor were taken from either 1 m² for 2 min of wall-to-wall carpets or large rugs of at least 4 m², or from 2 m² of smooth floor (when no carpets or rugs were present) at a rate of 2 min per m². Samples from a child's mattress were taken by vacuuming the entire top surface for 2 min of which area was measured. After sampling filters and dust from the filter holder were returned to the tube. Tubes were stored at –20 °C until post-sampling weighing and extraction.

2.2. Extraction of house dust samples

We were interested in analysing dust samples for several components so a sequential extraction method (Douwes et al., 1995) was used.

2.3. Dust extraction

Endotoxin and allergens were extracted sequentially from the dust-loaded filters as described previously (Schram et al., 2005). In short, a volume of 5 to 40 ml (depending on the net dust weight) pyrogen-free water with 0.05% (v/v) Tween-20 was added, and after 1 h incubation and centrifugation (15 min, 1000 ×g), the

upper 10% of supernatant was harvested and stored in four aliquots at -20°C for endotoxin analysis. For the allergen extraction, the removed supernatant was replaced with the same volume of 10×concentrated phosphate-buffered saline (PBS), thus changing the extraction medium into PBS-0.045% Tween-20. Tubes were incubated for another 1 h and centrifuged (15 min, $2000 \times g$) after re-suspension and thorough mixing of the pellet, after which most of the supernatant was harvested and stored in 6–10 aliquots at -20°C for analysis of mite and pet allergens.

Removal of 10% of the volume after the first extraction might have resulted in a maximal loss of 10% of the cat allergen present in the sample — if *Fel d 1* would be just as easily eluted from the dust in water-Tween as in PBS-Tween, but this possible loss should be practically the same for all samples, and thus only lead to underestimation of absolute levels by maximally 10%. In preliminary tests we had shown that indeed the yield of cat allergen in the second eluate highly correlates and is nearly identical to what would be found with a simple one-step extraction in PBS-Tween.

2.4. Cat Allergen EIA

A Sandwich Enzyme Immuno Assay (EIA) has been developed using monoclonal antibodies directed against the major cat allergen (Chapman et al., 1988) and is

commercially available (Indoor Biotechnologies; *Fel d 1* kit 6F9/3E4 batch 2622). One allergen specific antibody coats the microtitre plate and another biotinylated antibody is detecting antibody. The detecting antibody is labelled with Avidine-Horse Radish Peroxidase (DAKO P 0364), which is then coloured by means of OPD substrate (Sigma P1526 in citric acid sodium phosphate buffer pH 5.5) activated with hydrogen peroxide (Merck 822287). After 30 min the reaction is stopped by 2 M hydrochloric acid (Riedel de Haen 30721) and plates are read at 450 nm in a micro plate reader (Versamax Tuneable micro plate reader SNB02269). The limit of detection (LOD) of the assay was 0.3 mU/ml. Samples below this limit were given concentrations of 6.9 ng/g and 0.5 ng/m², which was 2/3 of the lowest concentrations measured; 10.4 ng/g, and 0.8 ng/m².

2.5. Statistical analyses

Dust weight and levels of *Fel d 1* had right-skewed distributions and were log-transformed before statistical analyses using SAS version 8.02, SAS Institute Inc, Cary, NC, USA. An analysis of field duplicate samples showed higher reproducibility of cat allergen expressed per m² than expressed per gram of dust (Giovannangelo et al., 2006) so we decided to focus our analysis on this particular expression. All home characteristics suggested to be associated with cat allergen levels were entered in

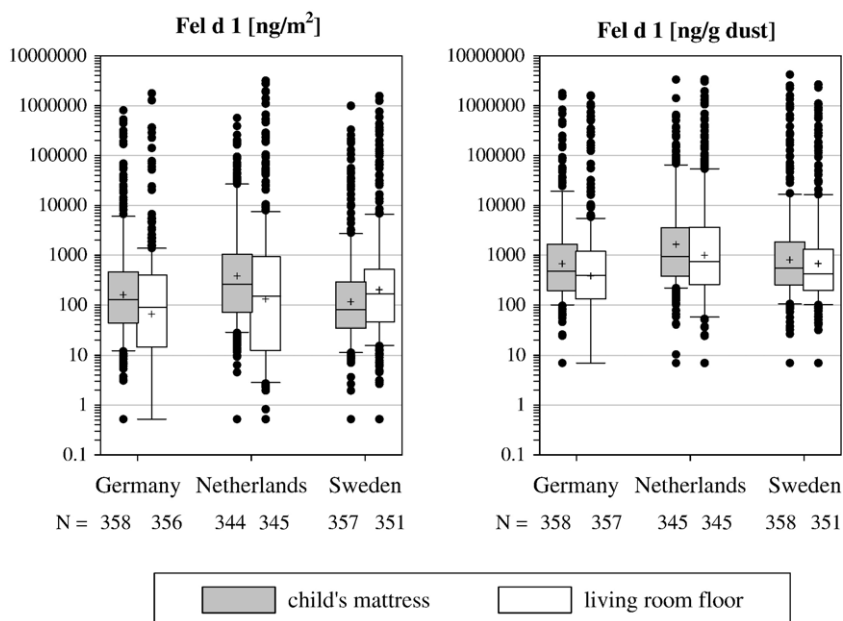


Fig. 1. Distribution of cat allergen on living room floors and child mattresses for Germany, The Netherlands and Sweden. The AIRALLERG study. The + denotes geometric means.

Table 1
Frequency distribution of potential predictors of cat allergen in house dust

Predictor	Germany		The Netherlands		Sweden	
	n/N	(%)	n/N	(%)	n/N	(%)
Pets in the child's home (current)						
Cat	27/357	(8)	68/346	(20)	35/358	(10)
Dog	23/357	(6)	38/346	(11)	13/361	(4)
Rabbit	17/357	(5)	16/346	(5)	17/361	(5)
Bird	13/357	(4)	63/346	(4)	9/361	(2)
Other pet	37/357	(10)	30/346	(9)	58/361	(16)
Cat ownership						
Never	117/133	(88)	233/344	(68)	303/358	(85)
Past but not current	7/133	(5)	43/344	(13)	20/358	(6)
Current	9/133	(7)	68/344	(20)	35/358	(10)
Season of dust sampling						
Autumn (Oct–Dec)	66/358	(18)	113/346	(33)	71/361	(20)
Winter (Jan–Mar)	163/358	(46)	200/346	(58)	279/361	(77)
Spring (Apr)	129/358	(36)	33/346	(10)	11/361	(3)
Type of mattress						
Foam rubber	121/358	(34)	224/346	(65)	229/361	(63)
Inner spring	99/358	(28)	1/346	(0)	130/361	(36)
Latex	88/358	(25)	3/346	(1)	0/361	(0)
Other/unknown	50/358	(14)	118/346	(34)	2/361	(1)
Mite impermeable mattress cover	62/340	(18)	63/316	(20)	0/361	(0)
Type of living room floor sampled						
Smooth floor	153/353	(43)	203/345	(59)	37/352	(11)
Rug	137/353	(39)	112/345	(32)	314/352	(89)
Wall-to-wall carpet	63/353	(18)	30/345	(9)	1/352	(0)
Living room floor last vacuumed						
Same day	71/355	(20)	81/312	(26)	19/345	(5)
≤ 1 day ago	111/355	(31)	104/312	(33)	50/345	(14)
> 1 day ago	173/355	(49)	127/312	(41)	274/345	(80)
Storey of living room						
Ground floor	212/358	(59)	313/338	(93)	195/360	(54)
1st floor	62/358	(17)	17/338	(5)	68/360	(19)
2nd floor and higher	84/358	(23)	8/338	(3)	97/360	(27)
Size of living room						
≤ 20 m ²	52/358/	(15)	10/345	(3)	107/359	(30)
20–40 m ²	259/358	(72)	193/345	(56)	220/359	(61)
> 40 m ²	47/358	(13)	142/345	(41)	32/359	(9)
Living room						
Mechanical ventilation used*	11/358	(3)	111/342	(32)	60/358	(17)
Air condition used*	1/357	(0)	1/344	(0)	1/358	(0)
Windows opened frequently*	239/358	(67)	179/344	(52)	102/358	(28)
Mould/damp spots in the living room†	6/358	(2)	3/337	(1)	9/355	(3)
Smoking*	46/358	(13)	83/338	(25)	14/360	(3.9)
Persons living in the child's home‡						
2–3	68/326	(23)	55/335	(15)	67/360	(19)

Table 1 (continued)

Predictor	Germany		The Netherlands		Sweden	
	n/N	(%)	n/N	(%)	n/N	(%)
Persons living in the child's home‡						
4	188/326	(58)	186/335	(56)	228/360	(63)
> 4	63/326	(19)	94/335	(28)	65/360	(18)

The AIRALLERG study.

Cat ownership never/current/past was defined by cat-ownership at birth, 4 years, and AIRALLERG home visit. Not available for GINI.

* Parent reported for 14 days following dust sampling.

† Assessed by fieldworker.

‡ Parental reported at the child's age of 4 years.

multiple linear regression models using SAS PROC REG for the child's mattress and living room floor. Associations were expressed as geometric means ratios (MR) compared to a reference category with 95% confidence intervals. We calculated country-specific models and an overall model in which all country data were combined. In the overall model adjusted for country to account for systematic differences between countries for which we did not have explicit information.

3. Results

Fig. 1 shows the cat allergen concentrations and loads as found in this study, for each country. Cat allergen concentrations were higher on Dutch mattresses and living room floors than on mattresses from Germany and Sweden. On living room floors, loads were highest in Sweden.

Pearson correlations between cat allergen concentrations found on the child's mattress and living room floors respectively ranged from 0.45 (Germany) to 0.72 (Sweden), correlations for loads were somewhat higher at 0.57 (Germany) to 0.79 (Sweden). Correlations between loads and concentrations were very high for each separate location, ranging from 0.88–0.97 which supports analysing determinants of just one of the two expressions. All of these correlations were highly significant ($p < 0.001$).

Table 1 lists potential predictors for cat allergen and their frequency of occurrence. Few houses had wall-to-wall carpeting. In The Netherlands, almost twice as many families had a cat compared to Sweden and Germany.

Predictive models for cat allergen loads on the child's mattresses explained 43 to 55 percent of measured Fel d 1 variation (Table 2). The variable most important in the models was the presence of a cat. In addition, only the presence of some other pets was significant. Predictive models for cat allergen loads on living room floors explained 55–77% of variance (Table 3). In addition to

Table 2

Associations between Fel d 1 load of mattress dust and potential predictors

Predictor	Germany ($R^2=42.3\%$)		The Netherlands ($R^2=54.9\%$)		Sweden ($R^2=45.6\%$)		Combined ^a ($R^2=46.7\%$)	
	MR ^b	(95% CI)	MR ^b	(95% CI)	MR ^b	(95% CI)	MR ^b	(95% CI)
Other pets in the child's home								
Cat (yes vs. no)	281	(122–650)	80.6	(49.58–131)	218	(111–428)	148	(102–214)
Dog (yes vs. no)	1.63	(0.67–3.98)	0.94	(0.50–1.75)	1.26	(0.44–3.58)	1.21	(0.76–1.93)
Rabbit (yes vs. no)	3.70	(1.19–11.59)	1.12	(0.46–2.72)	1.46	(0.58–3.67)	1.79	(1.02–3.14)
Bird (yes vs. no)	0.24	(0.08–0.76)	1.69	(0.64–4.42)	1.39	(0.36–5.34)	0.82	(0.43–1.57)
Other pet (yes vs. no)	1.53	(0.73–3.21)	1.83	(0.95–3.52)	1.56	(0.90–2.73)	1.54	(1.07–2.22)
Country								
Germany vs. Sweden	–		–		–		1.50	(1.06–2.12)
The Netherlands vs. Sweden	–		–		–		2.23	(1.58–3.14)

The AIRALLERG study.

Variable “cat” explained 36.7%, 52.2%, 42.6%, and 43.9% of the variability in the German, Dutch, Swedish, and combined model.

Variable “country” explained 1.3% of the variability in combined model.

All analyses adjusted for potential determinants of cat allergen listed in Table 3.

^a Adjusted for country.^b MR = ratio of geometric means.

the presence of cats, floor cover and vacuum cleaning contributed to the explained variance.

Table 4 shows a breakdown for homes where cats were never held, homes where cats were held in the past, and homes where cats are currently held. Even in homes where cats were no longer present, cat allergen on mat-

tresses and living room floors was 3–4 times higher than in homes where cats were never held. In homes with cats currently, ratios were 183 and 150, respectively. These ratios did not change much after adjustment for other housing characteristics, and they were all highly statistically significant. On mattresses the ratio between homes

Table 3

Associations between Fel d 1 load of living room floor dust and potential predictors

Predictor	Germany ($R^2=54.7\%$)		The Netherlands ($R^2=76.5\%$)		Sweden ($R^2=55.4\%$)		Combined ^a ($R^2=61.7\%$)	
	MR ^b	(95% CI)	MR ^b	(95% CI)	MR ^b	(95% CI)	MR ^b	(95% CI)
Other pets in the child's home								
Cat (yes vs. no)	250	(106–590)	150	(89.5–251)	524	(255–1078)	275	(187–404)
Dog (yes vs. no)	0.68	(0.27–1.75)	1.26	(0.64–2.50)	0.81	(0.28–2.38)	0.80	(0.49–1.30)
Rabbit (yes vs. no)	1.62	(0.51–5.18)	0.68	(0.27–1.69)	1.32	(0.50–3.45)	1.21	(0.68–2.14)
Bird (yes vs. no)	1.40	(0.43–4.53)	0.57	(0.19–1.75)	2.17	(0.55–8.58)	1.21	(0.60–2.42)
Other pet (yes vs. no)	1.86	(0.86–4.06)	1.50	(0.70–3.19)	1.47	(0.80–2.69)	1.68	(1.13–2.49)
Type of floor cover								
Wall-to-wall carpet vs. smooth floor	22.5	(13.6–37.3)	85.2	(54.8–132)	10.6	(5.33–21.1)	32.1	(23.8–43.4)
Rug vs. smooth floor	15.3	(7.96–29.4)	31.0	(14.5–66.0)	–		20.3	(12.6–32.7)
Living room floor last vacuumed								
≤ 1 day ago vs. same day	1.15	(0.59–2.23)	1.30	(0.74–2.27)	1.22	(0.41–3.59)	1.22	(0.82–1.81)
> 1 day ago vs. same day	1.75	(0.95–3.23)	2.69	(1.59–4.55)	2.12	(0.81–5.53)	2.10	(1.46–3.03)
Country								
Germany vs. Sweden	–		–		–		1.41	(0.97–2.05)
The Netherlands vs. Sweden	–		–		–		2.54	(1.68–3.85)

The AIRALLERG study.

Variable “cat” explained 25.0%, 33.9%, 45.4%, and 33.2% of the variability in the German, Dutch, Swedish, and combined model.

Variable “floor type” explained 27.4%, 39.9%, 7.7%, and 26.2% of the variability in German, Dutch, Swedish, and combined model.

Variable “country” explained 0.9% of the variability in combined model; All analyses adjusted for potential determinants of cat allergen listed in Table 3.

^a Adjusted for country.^b MR = ratio of geometric means.

Table 4

Geometric means (GM), geometric standard deviations (GSD) and ratios of geometric means (MR) of Fel d 1 loads in relation to past and current cat-ownership

	Germany			The Netherlands			Sweden			Combined		
	GM	GSD	MR ^a	GM	GSD	MR ^a	GM	GSD	MR ^a	GM	GSD	MR ^a
<i>Child's mattress</i>												
Cat in the child's home												
Never	97	8.6	1	150	4.2	1	63	5.2	1	93	5.2	1
Past	1677	5.9	17.3	256	6.4	1.7	510	22.6	8.1	376	10.4	4.0
Current	23,651	7.4	244	16,283	7.9	108	17,160	10.9	272	17,056	8.6	183
<i>Living room floor</i>												
Cat in the child's home												
Never	42	14.0	1	49	13.1	1	111	6.1	1	69	10.0	1
Past	722	35.3	17.3	107	20.9	2.2	363	48.2	3.3	182	28.9	2.6
Current	3204	11.8	76.7	5,524	23.0	112	50,294	11.3	452	10,397	21.2	150

The AIRALLERG study.

Cat ownership never/current/past was defined by cat-ownership at birth, 4 years, and AIRALLERG home visit. Not available for GINI.

^a MR = ratio of geometric means.

with and without cats in Sweden and Germany were 215 and 279, respectively (Table 4). In The Netherlands it was only 89. Swedish and German homes with cats had higher geometric mean mattress loads than The Netherlands (over 100,000 vs. 65,000 ng/g) whereas in homes without cats it was opposite (500 vs. 725 ng/g). A similar situation occurred on living room floors.

Predictive models were also developed for homes with and without current cats separately. For the child's mattresses, the percentage of explained variance was only 7% in homes without cats, and 14% in homes with cats. In homes without cats, homes with rabbits had 2.2 times higher cat allergen loads (95% CI 1.2–3.8), and homes with 'other' pets 1.6 times higher (95% CI 1.1–2.3). In homes with cats, no single variable contributed significantly to explanation of variance. For living room floors, the percentage of explained variance was 41% in homes without cats — of which 37% was explained by type of floor cover alone — 66% in homes with cats. In homes without cats, the effects of floor cover, vacuuming, presence of damp/mould and 'other' pets was very similar to the effects found in the population as a whole including the 'presence of cat' variable. In homes with cats, the effects of floor cover were much stronger with ratios of 82 and 92 for rugs and wall-to-wall carpets, respectively. Also the effects of vacuuming were greater, with ratios of 0.20 and 0.22 for vacuuming on the same day and the previous day before sampling, respectively. No other variables were found to be influential.

4. Discussion

This study has shown that the main determinant of cat allergen in homes is the presence of one or more cats.

Apart from this variable, little variation between cat allergen loads on mattresses could be explained. For living room floors, floor cover type and recent vacuuming were important. Correlations of cat allergen loads between living room floor and mattress were moderately high, so that it is reasonably possible to assess cat allergen exposure by measuring one of the two.

Child's mattresses in The Netherlands were found to contain almost twice as much cat allergen as in Sweden and Germany. These higher levels for The Netherlands are likely due to higher number of homes with a cat present, which was 20% for The Netherlands, 10% for Sweden and 8% in Germany. When stratifying for cat ownership, Dutch mattresses in homes with cats actually had lower levels of cat allergen than samples from the other two countries. In contrast, Dutch mattresses in homes without cats were higher in cat allergen content, possibly due to a wider diffusion of cat allergen in the environment in areas where more families own cats. Few samples were below limit of detection, which was likely due to the ubiquitous nature of cat allergen in the indoor environment. Cat allergen was higher on Swedish floors which may have been related to the observation that these had more often been vacuumed by the residents more than one day before the home visit.

A limitation of our study is that samples were taken in homes from a stratified sample of children participating in birth cohort studies on allergy and asthma in three countries. Whereas all four studies that served as sampling frame were population based, stratification by sensitisation may have somewhat affected the mean Fel d 1 concentrations and loads presented in this paper. However, sensitisation was measured at ages 2–4 in our

studies, and cat sensitisation was still rare at that age. This leads us to expect that the selection of children into the study has not had a major effect on Fel d 1 concentrations and loads. Surely, as children were selected in the same way in the three participating countries, this would not affect the comparisons within the study.

Many studies have detected cat allergen in homes even though a cat was never present or presence was a long time ago (Enberg et al., 1993; Egmar et al., 1998; Arbes et al., 2004). A study by Arbes et al. also showed that living in a community with high prevalence of cats increases cat allergen in homes even when no cats are being kept (Arbes et al., 2004). There are many other locations where cats have never been present or are not even allowed where significant amounts of cat allergen have been measured such as British hospitals (Custovic et al., 1998a,b), schools (Almqvist et al., 1999), public transport vehicles (Parti-Pellinen et al., 2000), newly built model homes, allergists' offices and shopping mall stores (Enberg et al., 1993). In our study, focused on children attending many different schools, it was not possible to include measurements of school cat allergen loads.

Cat allergen on the child's mattress was highly correlated to cat allergen on the living room floor (0.57–0.80) with little difference between countries. In the National Survey of Lead and Allergens in Housing (NSLAH) a correlation of 0.75 was found between concentrations of bed and living room floor (Arbes et al., 2004).

Cat allergen concentrations (ng/g) and loads (ng/m²) were highly correlated in our study, which implies they can be used interchangeably in epidemiological studies of cat allergen exposure.

Predictive models explained 40–64% of loads found on mattresses and floors. In a study from the metropolitan area of Boston, it was found that besides the presence of a cat, no other home characteristic was significant in predicting levels of cat allergens (Chew et al., 1998). In a comparison between the 2 cities of the former East and West of Germany, 69% of variance of cat allergen in carpet dust and 66% in mattress dust was explained by the presence of a cat and in addition, by size of dwelling, ventilation and frequency of vacuuming (Fahlbusch et al., 1999). Other studies were less well able to predict cat allergen levels. This was largely due to substantial amounts of cat allergen being found in homes without cats (Custovic et al., 1998a,b; Atkinson et al., 1999; Nafstad et al., 2001; Gehring et al., 2004).

Our study showed large differences in cat allergen levels between homes with and without cats. Cat allergen loads on living room floors were not as high as in studies in the United States (Arbes et al., 2004) and the United Kingdom (Custovic et al., 1998a,b, 1999) but similar to

farm homes on Gotland, Sweden (Parvaneh et al., 1999). The levels on mattresses in our study were similar to studies in Manchester (Custovic et al., 1998a,b), Munich and Leipzig (Fahlbusch et al., 1999).

An important question is how many homes have significant cat allergen levels without current presence of cats. It was found that 27, 28 and 35% of mattresses in Swedish, German and Dutch homes without cats, respectively, contained more than 1,000 ng/g cat allergen. This is the level that is sometimes suggested to be high enough to promote allergic sensitisation to Fel d 1 (Arbes et al., 2004). Similar percentages were found for living room floors. This illustrates that exposure to relatively high cat allergen loads is widespread, as was reported for US homes without cats (Arbes et al., 2004), for homes in various German cities without cats (Heissenhuber et al., 2003) and for Swedish homes without cats (Parvaneh et al., 1999). In a national sample of U.S. homes, 56% of floor dust samples from homes without cats had Fel d 1 concentrations above 1000 ng/g (Arbes et al., 2004). In Germany samples were taken in a birth cohort study. Geometric mean Fel d 1 was 120 ng/g in homes where a cat was never held, 470 ng/g in homes where a cat was held before the child was born, in the Swedish study, farm homes were sampled, and the Fel d 1 concentration in 26% of homes without cats was higher than 8000 ng/g. Samples were sieved in the U.S. and Swedish studies which may have increased Fel d 1 in comparison to our study and the German study.

In summary, the presence of a cat explained a large fraction of variability in cat allergen loads, supporting the use of cat presence as an exposure variable in epidemiological studies. Nevertheless, relatively high cat allergen levels were found in a sizeable percentage of homes without a cat, showing that measurement of cat allergen is still needed to improve the validity of exposure estimates.

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