

B. Fahlbusch
J. Heinrich
I. Groß
L. Jäger
K. Richter
H.-E. Wichmann

Allergens in house-dust samples in Germany: results of an East–West German comparison

Authors' affiliations:

B. Fahlbusch, L. Jäger, Friedrich-Schiller-University, Institute of Clinical Immunology, Jena

J. Heinrich, I. Groß, H.-E. Wichmann, GSF-National Research Center for Environment and Health, Institute of Epidemiology, Neuherberg
K. Richter, Hospital Grosshansdorf, Center for Pneumology and Thoracic Surgery, Grosshansdorf, Germany

Correspondence to:

Dr B. Fahlbusch
Institute of Clinical Immunology
Friedrich-Schiller-University
Am Johannisfriedhof 3
07743 Jena
Germany

Key words: cat allergens; dwelling characteristics; East–West German comparison; house-dust-mite allergens; indoor allergen exposure.

The background of this study is the finding of several studies that the frequency of respiratory allergies was significantly higher in the former West Germany than the former East Germany. The present study investigated the levels of allergens of house-dust mite (Der p 1 and Der f 1), cat (Fel d 1), and cockroach (Bla g 2) in the household dust of 201 homes in Hamburg (West Germany) and 204 homes in Erfurt (East Germany), and examined the factors that affect these levels. The characteristics of homes were assessed by a questionnaire. The allergen levels were studied in dust from living rooms (LR), bedrooms (BR), and mattresses (MA). We detected in samples from Hamburg significantly higher allergen concentrations than in Erfurt: three times higher Der p 1, five times higher Der f 1, and three times higher Fel d 1. For Bla g 2, no comparison was possible because the concentrations were below the detection limit in 93% of the samples. Most of the differences could be explained by differences in housing and living characteristics between both cities. The mean ratio of Der p 1 levels in mattress dust between Hamburg and Erfurt decreased from 4.1 to 1.54 (NS) after adjustment for season, building material, age of the house, story of the dwelling, type of heating, age of carpet/mattress, presence of dogs, and indoor climate (temperature, humidity). The mean ratio of Der f 1 levels decreased from 6.9 to 2.78 ($P<0.05$) after adjustment for these factors. The mean ratio for Fel d 1 in mattress dust decreased from 4.03 to 1.65 ($P<0.05$) after adjustment for season, building material, story of dwelling, size of dwelling, ventilation, cleaning routines, and pets. A similar reduction was seen for floor dust (LR plus BR). Our results indicate that the differences between the concentrations of mite and cat allergens found in Hamburg

Date:

Accepted for publication 18 June 1999

To cite this article:

Fahlbusch B., Heinrich J., Groß I., Jäger L., Richter K. & Wichmann H.-E. Allergens in house-dust samples in Germany: results of an East–West German comparison. *Allergy* 1999; **54**: 1215–1222.

Copyright © Munksgaard 1999

ISSN 0105-4538

and Erfurt are explicable mainly, but not completely, by different building characteristics (age of houses, building material, story, and size of the dwelling) which affected the indoor climate, as well as by differences in other individual living habits (keeping of pets, age of carpets or mattresses, and cleaning routines).

In recent years, a continuous increase in IgE-mediated atopic disorders such as hay fever and asthma has been observed worldwide (1). The causes of this increase seem to be multifactorial in that genetic and environmental factors work together.

The reunification of Germany offered a unique opportunity to compare the prevalence of atopic diseases between the East and West German populations (2–7). All these studies yielded some unexpected results. Although there were much higher levels of ambient sulfur dioxide and total suspended particulates in East Germany, the frequencies of respiratory allergies and specific IgE levels were significantly higher in subjects from West German regions. The reasons for the lower prevalence of atopic sensitization in East Germany are still unknown. The genetic background in both parts is probably similar, and several suggestions regarding different living conditions over the last 40 years are rather speculative (8). Many East Germans live in multifamily concrete slab or brick houses in rather small and crowded apartments. Furthermore, the former East German homes were poorly insulated; often the heating could not be controlled in individual apartments; because heating costs were low, occupants controlled the temperature of their apartments by opening windows (8). In contrast, in West German homes, high energy costs caused home owners to insulate and seal buildings. Well-insulated, airtight homes are believed to create damp environments that augment the growth of molds, mildews, and mites (9).

Recently, Nowak et al. (10) observed a higher prevalence of atopic sensitization in Hamburg (West Germany) than in Erfurt (East Germany) and suggested that childhood factors and exposure to indoor allergens and irritants were probably responsible for the differences observed between the two cities. On the basis of these observations, a joint project has been established to investigate the influences of indoor factors and genetics in asthma (INGA) (11).

The purpose of this study, as part of the INGA project, was to analyze the concentration of indoor allergens (house-dust mites, cat, and cockroach) in dust from randomly selected homes in Hamburg and Erfurt, respectively. We report on

the influence of home conditions on allergen levels in these homes.

Material and methods

Homes and dwelling characteristics

From June 1995 to November 1996, 1175 dust samples were collected from 405 homes (Erfurt, $n=204$; Hamburg, $n=201$). These homes were selected from two population samples participating in the study on the prevalence of atopic sensitization in West and East Germany (10).

Interviewers collected information on housing conditions and living habits, and sampled reservoir dust. A questionnaire based on that of the EC Respiratory Health Survey study (12) was used to obtain detailed information on type and age of the home, story, size of the dwelling, type of heating, age of carpets and mattresses, pets, signs of dampness, tightness of the windows, ventilation, and cleaning habits in the home. Indoor climate (temperature and relative humidity) was measured for a period of 7 days after dust sampling.

Dust collection and processing

In each house, three dust samples from the living room (LR) floor and the bedroom (BR) floor and mattresses (MA) were collected from 1 m² in a standardized manner (13). The allergens were extracted from the sample dust plus filter paper with 0.125 M NH₄HCO₃ plus 0.05% Tween 20 (v/v) for 2 h at room temperature under constant shaking, with an extraction ratio of 1:10–1:100 (w/v), depending on the amount of sampled dust. The solution was clarified by centrifugation at 1000 g. The extracts were stored frozen at –20°C in separate aliquots until analyzed to avoid repeated freezing and thawing.

The allergen levels of Der p 1, Der f 1, Fel d 1, and Bla g 2 were assayed as described previously (13) by means of monoclonal antibodies and reference samples from Indoor Biotechnologies (Deeside, Clwyd, UK). The interassay variation for repeated assays was 10–16%, and the intra-assay variation was approximately 3.5–8%. The lower detection limits were 1 ng/ml for Der p 1 and Der f 1, 1.5 ng/ml for Fel d 1, and 0.04 U/ml for Bla g 2.

Because there is considerable potential variability in the sampling and assay of allergens (14), the questionnaires and dust sampling were carried out by the same fieldworkers

throughout our study, and the dust samples were processed by the same technician.

Statistical analysis

The allergen levels were transformed into logarithms and analyzed with SPSS (Version 6.12). The Mann–Whitney test was used to test the level of significance of differences between variables. The Spearman rank-order correlation was used to test possible association between variables. The limit of significance chosen was 0.05. The bivariate and multivariate analyses were performed with SAS (Version 6.08, Cary, NC, USA) by linear regression of the transformed allergen levels (15). The mean ratio of allergen concentrations was calculated by the ratio of adjusted geometric mean versus reference category.

Results

Content of allergens in dust samples

Dust sample weights varied widely from 0.019 to 11.95 g. Likewise, the physical appearance of the samples varied greatly, ranging from small amounts of fine dust to large

quantities of hair, fuzz, and debris. Therefore, we analyzed the allergen content as concentration per unit weight and per area sampled. Highly statistically significant correlations were found between the amounts of all four allergens expressed as $\mu\text{g/g}$ unsieved dust and those expressed as $\mu\text{g}/\text{m}^2$, ranging from 0.92 to 0.99.

Mite allergens (Der p 1 or Der f 1) were detected in 78%, Fel d 1 in 89.5%, and Bla g 2 in 7.1% of the samples analyzed ($n=1175$). We were unable to detect any of the allergens mentioned in only two (Erfurt) of 405 houses. By the proposed provisional guidelines on threshold levels, 52% of homes had at least one site with total levels of mite allergen (Der p 1 or Der f 1) over 2 $\mu\text{g/g}$, and 20.5% of homes had at least one site with Fel d 1 levels over the significant range ($\geq 8 \mu\text{g/g}$).

The distribution of allergens between Hamburg ($n=578$) and Erfurt ($n=597$) is summarized in Table 1. Although the collected dust amounts were not significantly different between the two cities, the allergen levels for Der p 1, Der f 1, and Fel d 1 were generally lower in Erfurt than in Hamburg. We detected in Hamburg three times higher Der p 1 levels and even five times higher Der f 1 levels. The Fel d 1 concentrations in dust from Hamburg were three times higher than in dust from homes in Erfurt. The number of Bla g 2-positive samples was too low for further statistical analysis.

Table 1. Statistical characteristics of allergen levels in dust samples from Hamburg (West Germany) and Erfurt (East Germany)

	Der p 1 ($\mu\text{g/g}$ dust)		Der f 1 ($\mu\text{g/g}$ dust)		Fel d 1 ($\mu\text{g/g}$ dust)		Bla g 2 (U/g dust)	
	Erfurt	Hamburg	Erfurt	Hamburg	Erfurt	Hamburg	Erfurt	Hamburg
<i>n</i>	597	578	597	578	597	578	597	578
<i>Dust samples (LR + BR + MA)</i>								
Geometric mean	0.036	0.111	0.087	0.414	0.273	0.879	<0.4	<0.4
Minimum	<0.01	<0.01	<0.01	<0.01	<0.015	<0.015	<0.4	<0.4
25th percentile	<0.01	<0.01	<0.01	62	0.054	0.118	<0.4	<0.4
Median	<0.01	0.087	0.059	0.475	0.120	0.367	<0.4	<0.4
75th percentile	0.177	1	0.667	2.999	0.535	5.780	<0.4	<0.4
Maximum	133	345	825	1255	7278	5274	7	54
<i>n</i>	204	201	204	201	204	201		
<i>Floor dust (LR + BR)</i>								
Geometric mean	0.024	0.064	0.062	0.252	0.314	0.897		
Median	<0.01	0.035	0.038	0.272	0.140	0.331		
<i>Mattress dust</i>								
Geometric mean	0.084	0.344	0.161	1.114	0.212	0.853		
Median	0.059	0.369	0.098	1.267	0.091	0.354		
LR: living room; BR: bedroom; MA: mattress.								

The proportion of Der f 1 over Der p 1 was also different in both cities. Geometric mean values in Hamburg were 0.414 and 0.111 µg/g dust for Der f 1 and Der p 1 (ratio: 3.7), respectively. The corresponding values in Erfurt were 0.087 and 0.036 µg/g dust (ratio: 2.4), respectively.

Furthermore, the frequency and the content of the three allergens in the different sampling locations were analyzed between the two cities (Table 1). As expected, the Der p 1 and Der f 1 concentrations in mattresses were higher than those of the floors of bedrooms and living rooms. In contrast, the concentrations of Fel d 1 allergen were higher in living room dust than in dust collected from bedrooms or mattresses, but only within samples from Erfurt. The Fel d 1 content of homes in Hamburg did not show statistically significant differences in the sampling locations. In general, we detected in all sampling locations in Hamburg significantly higher concentrations of Der p 1, Der f 1, and Fel d 1.

Association between allergen content and dwelling characteristics

Since the homes in Erfurt and Hamburg had different distributions of allergen levels, different housing factors were evaluated with regard to important factors associated with the presence of mite (15) or cat allergen (17) (Table 2).

In Hamburg, 77% (49% in Erfurt) of the subjects live in houses more than 25 years old, and 93% (47.5% in Erfurt) of the houses are made from bricks or from concrete. More of the dwellings were on the ground floor or the first floor (66% in Hamburg, in contrast to 44% in Erfurt); consequently, these characteristics could influence the indoor climate (temperature, relative humidity, and signs of dampness). Although no significant differences ($P=0.057$) were present in the heating systems either in Hamburg or in Erfurt, significant differences were found with respect to the indoor climate. Homes in Hamburg were damper than those of Erfurt. The greater tightness of the windows of houses in Hamburg has to be mentioned with regard to the findings ($P<0.001$). Likewise, potentially important specific factors, such as the age of carpets, and mattresses, were significantly different. In Erfurt homes, 58% (LR) and 64% (BR) of carpets were newer than 5 years, in contrast to Hamburg, where the figures were only 32% (LR) and 25% (BR), respectively. More people in Hamburg had cats ($P<0.001$) and/or dogs ($P=0.02$). For all appropriate characteristics, the bivariate association with the allergen concentration for Der p 1, Der f 1, and Fel d 1 was investigated on the floors and mattresses. Because many of the building and housing characteristics were found to be related, a multiple regression analysis was performed

separately for each allergen, in which initially all variables were entered which had at least a marginally significant ($P<0.10$) relationship to the allergen concentration in the dust (15).

For the mite allergens Der p 1 and Der f 1, the following factors were entered into all the models in addition to the *a priori* variables (city and season): building material, year of construction, story of the dwelling, type of heating system, age of carpet or mattress, presence of a dog during the last 12 months, additional humidity giving a measure for dampness of the house, indoor relative humidity, and indoor temperature. The mean ratio of Der p 1 concentration in floor or mattress dust was reduced, and no significant differences between Hamburg and Erfurt were found, when adjusted for these parameters, as shown in Table 3. In contrast, the mean ratio of Der f 1 levels remained significantly associated with the place of residence even after adjustment for these potential explanatory or confounding factors.

For the cat allergen Fel d 1, a multiple regression analysis was performed in which the *a priori* variables (city and season) and building material, story of dwelling, size of dwelling, ventilation, cleaning routines, and pets were included. The regression analyses explained 69% of the variance of Fel d 1 in carpet dust and 66% in mattress dust, respectively.

The amounts of Fel d 1 were significantly associated with the size of dwelling (higher in small homes), frequency of vacuuming (higher in case of low frequency), and the presence of a cat. After adjustment for the above mentioned factors, the Fel d 1 concentrations in floor dust were no longer significantly different between Hamburg and Erfurt. Although the mean ratio of Fel d 1 levels in mattress dust was reduced from 4.03 (crude data) to 1.65 (adjusted data), the differences remained significant for both cities (Table 3).

Discussion

Many factors may contribute to bronchial hyperreactivity; however, there is evidence that, with increased exposure to house-dust allergen, the risk of sensitization and development of allergic diseases has increased (18). While the level of indoor allergens in West German homes has been examined for some years (16, 19), allergen exposure in East Germany has only recently been reported for mite allergens (20). Understandably, a comparison between levels of allergens of different studies is limited because the dwellings were selected by different criteria, and different sampling methods and laboratory analyses were used. No

Table 2. Building characteristics of homes and individual occupant conditions in Erfurt ($n=204$) and Hamburg ($n=201$)

Characteristics	<i>P</i> value*	Erfurt (East Germany) <i>n</i>	Hamburg (West Germany) <i>n</i>
Age of home	<0.001		
Before 1945		77	70
1946–70		23	84
After 1970		104	47
Building material	<0.001		
Brick houses		88	135
Concrete slab houses		93	10
Concrete houses		7	49
Framework/clay houses		12	3
Story of dwelling	<0.001		
Ground floor		59	87
1st floor		31	46
2rd/3th floor		64	46
4th floor and higher		50	22
Size of dwelling	<0.001		
$\leq 50 \text{ m}^2$		29	20
$> 50\text{--}\leq 100 \text{ m}^2$		146	123
$> 100 \text{ m}^2$		29	58
Type of heating	0.0574		
Central		144	124
Not central		59	76
Median of relative humidity (LR)	0.004		
$\leq 45\%$		99	85
$> 45\text{--}\leq 60\%$		67	87
$> 60\%$		6	21
Median of temperature (LR)	0.001		
$\leq 20^\circ\text{C}$		35	41
$> 20\text{--}\leq 23^\circ\text{C}$		93	121
$> 23^\circ\text{C}$		58	29
Tightness of windows (LR)	<0.001		
Good		98	159
Bad		68	37
Age of carpet in LR	<0.001		
≤ 1 years		48	24
2–4 years		66	35
5–9 years		53	67
≥ 10 years		30	59
Age of mattress	0.0339		
≤ 1 years		40	29
2–4 years		69	56
5–9 years		40	64
≥ 10 years		51	49

Table 2. (continued)

Characteristics	P value*	Erfurt (East Germany) n	Hamburg (West Germany) n
Pets in home during last year			
Cat	<0.001		
Yes		17	46
No		187	155
Dog	0.0286		
Yes		39	57
No		164	143

*Differences between two cities were tested by chi-square test. NS: not significant; LR: living room.

valid data for comparison of indoor allergen exposure between East and West German homes are available. To our knowledge, this study is the first direct comparison of indoor allergen levels in East and West German homes by the same methods.

Dust samples were collected for more than 1 year to minimize seasonal influences. The data presented here demonstrated a high prevalence of mite and cat allergens, but not of cockroach allergen, in the dust of the homes. Cockroaches are a common source of indoor allergen in some parts of the world, particularly in the homes of subjects of lower socioeconomic status (21). The significance of exposure and sensitization to cockroach allergens in Germany is still unknown. We could detect the major cockroach allergen, Bla g 2, in 57 (14%) of the homes investigated. However, the level of cockroach allergen was below the detection limit in 93% of the total samples

studied. Pollart et al. (22) found up to 50 times more cockroach allergen in house dust from the kitchen floor than in that from the bedroom. But we detected Bla g 2 in only one dust sample from 25 kitchen floors in the pilot study (13).

Mite-allergen levels

Our results demonstrate that house-dust mites probably occur in most homes at any one time, but with a wide variation in both species and quantities. This is well known from previous studies performed in regions with a temperate climate (23). We were unable to detect mite allergens in only 38 homes (9.4%) (11 in Hamburg and 27 in Erfurt). We detected exclusively Der f 1 in 71 homes and in 25 only Der p 1.

Table 3. Relationship between place of residence and Der p 1, Der f 1, and Fel d 1 allergens in floor and mattress dust

Place of residence	Der p 1 level		Der f 1 level		Fel d 1 level	
	Mean ratio	95% CI	Mean ratio	95% CI	Mean ratio	95% CI
<i>Floor dust (LR + BR)</i>						
Erfurt as reference group	1		1		1	
vs Hamburg (crude, n=405)	3.43	(2.00; 5.86)	4.72	(2.81; 7.92)	2.93	(1.64; 5.21)
vs Hamburg (adjusted)	1.33 ^a	(0.67; 2.66)	2.24 ^a	(1.09; 4.63)	1.32 ^b	(0.86; 2.04)
	(n = 317)		(n = 317)		(n = 387)	
<i>Mattress dust</i>						
Erfurt as reference group	1		1		1	
vs Hamburg (crude, n=405)	4.1	(2.27; 7.40)	6.9	(3.72; 12.82)	4.03	(2.23; 7.29)
vs Hamburg (adjusted)	1.54 ^a	(0.71; 3.34)	2.78 ^a	(1.24; 6.23)	1.65 ^b	(1.03; 2.65)
	(n = 320)		(n = 320)		(n = 391)	

^aAfter adjustment for season, building material, age of house, story of dwelling, type of heating, age of carpet/mattress, dog, and indoor climate (temperature, relative humidity) (15).

^bAfter adjustment for season, building material, story of dwelling, size of dwelling, ventilation, cleaning routines, and pets.

A comparison of actual allergen levels with data from earlier studies is difficult because the sampling conditions (homes of atopic or nonatopic subjects, sampling time, sampling location, and sample handling) are different. Lau et al. (24) found median Der p 1 and Der f 1 concentrations in mattress dust in Berlin, West Germany, of 0.6 µg/g dust (133 atopics) and 0.4 µg/g dust (55 nonatopics, respectively). Higher Der p 1 (1.35–1.61 µg/g dust) and Der f 1 (2.48–2.93 µg/g dust) concentrations were found on the mattresses in southern Germany (16).

In keeping with most previous studies, the quantity of mite allergens was significantly higher on the mattresses than on the floors of bedrooms and living rooms in Hamburg and Erfurt.

An interesting finding was that *D. farinae* was the major mite species in both cities. Other investigators reported similar findings (16, 25, 26). Because *D. farinae* appears to be less sensitive to humidity loss (27), we suppose that the prevalence could be related to long periods of dry weather. The fact that the ratio of Der f 1 to Der p 1 was higher in Hamburg than Erfurt is difficult to explain. A possible influencing factor might be that Hamburg is an important transportation center, and it is not known how long *D. farinae* can survive in a semiarid environment when imported from mite-prevalent areas. Moyer & Nelson (28) examined dust samples from imported furniture and noted the presence of living mites after 2 years. Furthermore, another East German study showed the preponderance of *D. farinae* in urban homes and *D. pteronyssinus* in rural homes (20).

As stated in the literature, the number of mites in homes is related to humidity, building characteristics, and indoor lifestyle factors (29). In our study, a significant association of humidity (relative as well as absolute humidity), temperature, type of heating, story of the dwelling, age of the house, age of carpet or mattress, keeping of dogs, and Der p 1 concentration was obvious (15). These factors largely explained the different Der p 1 concentrations in Hamburg and Erfurt homes.

In contrast to Der p 1, the Der f 1 concentration was less affected by room temperature and humidity. However, the association of Der f 1 concentration and story, age of carpet or mattress, and dog explained only partially the difference between the cities. The difference in Der f 1 concentration in homes of both cities suggests that other, unidentified features of homes may have an influence on the dust-mite microenvironment. Our data exhibit both qualitative and quantitative variations in mite allergens in the two cities and may be also attributed to variation in geography and

climate, particularly the humidity of the regions, which varies significantly. Erfurt is considered to have lower humidity in the summer, autumn, and winter, while humidity in the coastal region of Hamburg is comparatively higher, a factor which helps house-dust mites to thrive.

Hirsch et al. studied the exposure to mite allergen in East German dwellings in Dresden, Halle, and Aue shortly after the German reunification (1992–6) and assumed that indoor conditions were not specifically disadvantageous for mite growth in East Germany (20). This supposition did not apply to Erfurt homes. The higher proportion of homes with central heating systems in Erfurt (71%) than in Dresden (45.8%) probably biased our data on exposure to mite allergen toward lower values.

Cat-allergen levels

Needless to say, the highest Fel d 1 levels were found in homes that had cats. The cat allergen Fel d 1 was found in 97.5% of homes, and this is in line with the common view that this allergen is ubiquitous in homes, as demonstrated by other studies. It is attached to wall surfaces (30) and can be introduced into the home by the occasional visit of a cat or a cat owner (31).

In accordance with other studies (31, 32) the concentrations of Fel d 1 were higher in dust from living rooms than in dust from bedrooms, but this was only so in Erfurt, where, presumably, either the cats had no access to the bedroom, or the bedrooms were more often or more efficiently cleaned than the living rooms. Similar levels of Fel d 1 were found on floors and mattresses in homes of Hamburg.

Indoor Fel d 1 levels are influenced by ventilation of the homes, but not by the humidity of the area (33), although damp homes have been reported to have higher cat-allergen levels (17). We found that different factors (ventilation, size of dwelling, and cleaning routines) influence the Fel d 1 levels in dust, but the most important factor was the cat itself. The size of dwelling, the cleaning routines, and cat presence appeared to be the major factors for the different Fel d 1 levels between Erfurt and Hamburg. The higher content of cat allergen in house dust in Hamburg reflects the fact that there are more cats in West Germany.

To summarize, our results are approximately representative of living conditions in Erfurt (East Germany) and Hamburg (West Germany) in the years 1996–7 with respect to main dwelling characteristics. It was found that the level of mite and cat allergens varies between both areas. The higher allergen levels found in Hamburg than Erfurt were mainly caused by different building characteristics (age of

home, building material, story, and size of the dwelling) which influenced in part the indoor climate, and other individual living habits (keeping of pets, age of carpets or mattresses, and cleaning routines). Thus, differing housing conditions persisted even 5–6 years after reunification. Since East Germans more and more accept the western lifestyle, we may expect an increase of the indoor allergen exposure in

East German homes. The future will show how long it takes the eastern allergen level to reach the western one.

Acknowledgment This study was supported by a grant from the Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie (BMBF/FKZ 01 EE 9301/6).

References

- Platts-Mills TAE, Carter MC. Asthma and indoor exposure to allergens. *N Engl J Med* 1997;**336**:1382–1384.
- von Mutius E, Fritzsche C, Weiland SK, Röhl G, Magnussen H. Prevalence of asthma and allergic disorders among children in united Germany: a descriptive comparison. *BMJ* 1992;**305**:1395–1399.
- Behrendt H, Krämer U, Dolgner R, et al. Elevated levels of total IgE in East German children: atopy, parasites or pollutants? *Allergo J* 1993;**2**:31–40.
- Schäfer T, Vieluf D, Behrendt H, Krämer U, Ring J. Atopic eczema and other manifestations of atopy: results of a study in East and West Germany. *Allergy* 1996;**51**:532–539.
- Trepka MJ, Heinrich J, Wichmann HE. The epidemiology of atopic diseases in Germany: an east–west comparison. *Rev Environ Health* 1996;**11**:119–131.
- Nicolai T, von Mutius E. Respiratory hypersensitivity and environmental factors: East and West Germany. *Toxicol Lett* 1996;**86**:105–113.
- Heinrich J, Richter K, Magnussen H, Wichmann HE. Is the prevalence of atopic diseases in East and West Germany already converging? *Eur J Epidemiol* 1998;**14**:239–245.
- Wichmann HE. Environment, life-style and allergy: the German answer. *Allergo J* 1995;**4**:315–316.
- Luczynska CM. Risk factors for indoor allergen exposure. *Respir Med* 1994;**88**:723–729.
- Nowak D, Heinrich J, Jörres R, et al. Prevalence of respiratory symptoms, bronchial hyperresponsiveness and atopy among adults: West and East Germany. *Eur Respir J* 1996;**9**:2541–2552.
- Richter K, Heinrich J, Bischof W, et al. Innenraumfaktoren und Asthma bronchiale in Hamburg und Erfurt als Teil der INGA-Studie: Studienziele und Methoden. *Allergologie* 1999;**22**:14–26.
- Burney PGJ, Luczynska C, Chinn S, Jarvis D. The European Community Respiratory Health Survey. *Eur Respir J* 1994;**7**:954–960.
- Fahlbusch B, Jäger L, Koch A, Heinrich J, Burge H. Erfassung und Analyse von Indoor-Allergenen. *Allergologie* 1995;**11**:495–500.
- Marks GB, Tovey ER, Peat JK, Salome CM, Woolcock AJ. Variability and repeatability of house dust mite allergen measurement: implications for study design and interpretation. *Clin Exp Allergy* 1995;**25**:1190–1197.
- Gross I, Heinrich J, Fahlbusch B, Jäger L, Bischof W, Wichmann HE. Indoor determinants of Der p 1 and Der f 1 concentration in house dust are different. *Clin Exp Allergy* (submitted).
- Kuehr J, Frischer T, Karmaus W, et al. Natural variation in mite antigen density in house dust and relationship to residential factors. *Clin Exp Allergy* 1994;**24**:229–237.
- Munir AK, Björkstén B, Einarsson R, et al. Cat (*Fel d 1*), dog (*Can f 1*), and cockroach allergens in homes of asthmatic children from three climatic zones in Sweden. *Allergy* 1994;**49**:508–516.
- Platts-Mills TAE, Sporik RB, Wheatley LM, Heymann PW. Is there a dose-response relationship between exposure to indoor allergens and symptoms of asthma? *J Allergy Clin Immunol* 1995;**96**:435–440.
- Lau-Schadendorf S, Ehnert B, Weber A, et al. Determinants for indoor allergens in atopic and nonatopic families in Germany. *Allergo J* 1992;**2**:28–33.
- Hirsch TH, Range U, Walther KU, et al. Prevalence and determinants of house dust mite allergen in East German homes. *Clin Exp Allergy* 1998;**28**:956–964.
- Sarpong SB, Hamilton RG, Eggleston PA, Adkinson NF. Socioeconomic status and race as risk factors for cockroach allergen exposure and sensitization in children with asthma. *Allergy Clin Immunol* 1996;**97**:1393–1401.
- Pollart SM, Mullins DE, Vailes LD, et al. Identification, quantitation, and purification of cockroach allergens using monoclonal antibodies. *J Allergy Clin Immunol* 1991;**87**:511–521.
- Wickman M, Nordvall SL, Pershagen G, Sundell J, Schwartz B. House dust mite sensitization in children and residential characteristics in a temperate region. *J Allergy Clin Immunol* 1991;**88**:89–95.
- Lau S, Falkenhorst G, Weber A, et al. High mite-allergen exposure increases the risk of sensitization in atopic children and young adults. *J Allergy Clin Immunol* 1989;**84**:718–725.
- Arlian LG, Bernstein IL, Gallagher JS. The prevalence of house dust mites, *Dermatophagoides* spp, and associated environmental conditions in homes in Ohio. *J Allergy Clin Immunol* 1982;**69**:527–532.
- Hannaway PJ, Roundy C. Distribution of *Dermatophagoides* spp., *D. farinae* and *D. pteronyssinus*, antigen in homes of patients with asthma in eastern Massachusetts. *Allergy Asthma Proc* 1997;**18**:177–180.
- Brandt RL, Arlian LG. Mortality of house dust mites, *Dermatophagoides farinae* and *D. pteronyssinus*, exposed to selected pesticides or dehydrating conditions. *J Med Entomol* 1976;**13**:327.
- Moyer DB, Nelson HS, Arlian LG. House dust mites in Colorado. *Ann Allergy* 1985;**55**:680–682.
- Wickman M, Nordvall SL, Pershagen G, Korsgaard J, Johansen N. Sensitization to domestic mites in a cold temperature region. *Am Rev Respir Dis* 1993;**148**:58–62.
- Wood RA, Mudd KE, Eggleston PA. The distribution of cat and dust mite allergens on wall surfaces. *J Allergy Clin Immunol* 1992;**89**:126–130.
- Munir AKM, Einarsson R, Dreborg SKG. Indirect contacts with pets can confound the effect of cleaning procedures for reduction of animal allergen levels in house dust. *Pediatr Allergy Immunol* 1994;**5**:32–39.
- van der Brempt X, Charpin D, Haddi E, da Mata P, Vervloet D. Cat removal and *Fel d 1* levels in mattresses. *J Allergy Clin Immunol* 1991;**87**:595–596.
- Woodfolk JA, Luczynska CM, de Blay F, Chapman MD, Platts-Mills TA. Cat allergy. *Ann Allergy* 1992;**69**:273–275.