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Validity of the interview on pets kept at home for predicting the actual domestic expsoure to their specific allergens. Krakow inner city area study

Research Article

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Abstract: The aim of the study was to describe the exposure to dog (Can f 1) and cat (Fel d 1) allergens within homes of very young children living with and without pets, and to assess the validity of the interview on pets for predicting the actual exposure to pet allergens in house dust. House dust samples were collected in 275 dwellings from the mattresses, children's bedroom and kitchen floors. In the laboratory, dust samples were analyzed for Can f 1 and Fel d 1 using monoclonal antibody enzyme-linked immunosorbent assays (ELISA). The majority of households (79.3%) had neither a dog nor a cat living in the home over the past 6 months preceding the survey. Dog allergen above 2 μg/g dust were found in 22.5% of homes and 14.2% of homes contained dog allergen above 10 μg/g of house dust. In the total study sample, cat allergen above 1 μg/g of dust were found in 12.7% of homes, and 3.3% of homes contained Fel d 1 levels greater than 8 μg/g of dust. The majority of children (75.0%) with reported ownership of dogs were exposed to Can f 1 levels above 2 μg/g of house dust, and 73.1% of children with cats at home were exposed to Fel d 1 concentrations above 1 μg/g house dust. The results of the study showed that post-test probability of the true exposure to Can f 1 above 2 μg/g dust in houses with positive interview on indoor dogs was 75.0% (95%CI: 61.7 – 84.8%). On the other hand, the prediction of exposure estimated from the interview data on indoor dogs produced 12.6% of false negatives (95% CI: 9.9 – 15.8%). Similarly, the post-test probability of the true exposure to Fel d 1 above 1 μg/g dust in houses with positive interview on indoor cats was 73.1% (95%CI: 55.1 – 85.7%). On the other hand, the interview data produced 6.4% false negatives (95% CI: 4.6 – 9.0%). In conclusion, the study demonstrated that homes in Poland with pet ownership are important reservoir of Can f 1 and Fel d 1 allergens with levels that might induce allergic symptoms. Even in homes of children without a dog or cat indoors, there was a higher prevalence of pet allergens at the levels above allergic sensitisation thresholds. This may have an important implication for epidemiologic studies on pet related allergy and prevention practice.

Keywords: *Dog and cat allergens • Prevalence of exposure at home • Children*

1. Introduction

Asthma is a chronic respiratory disease characterized by airway inflammation and episodic narrowing of bronchial tree. Although the nature of the disease is not yet well understood, it is generally accepted that asthma is the result of the interaction between genetic traits and environmental exposures, such as indoor or outdoor

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Table 1. Distribution of dog allergen by various sampling sites and reported ownership of the pet within Krakow homes.

Can f 1 (μg/g dust)	Children's contact with a dog			p
	Indoor N=44	Outdoor N=60	None N=171	
Bed:				
0	14 (31.8%)	44 (73.3%)	144 (84.2%)	
> 0 - 2	6 (13.6%)	6 (10.0%)	15 (8.8%)	0.000
> 2 - 10	3 (6.8%)	5 (8.3%)	5 (2.9%)	
> 10	21 (47.7%)	5 (8.3%)	7 (4.1%)	
Bedroom floor:				
0	9 (20.5%)	40 (66.7%)	134 (78.4%)	
> 0 - 2	2 (4.5%)	9 (15.0%)	22 (12.9%)	0.000
> 2 - 10	6 (13.6%)	4 (6.7%)	10 (5.8%)	
> 10	27 (61.4%)	7 (11.7%)	5 (2.9%)	
Kitchen floor:				
0	12 (27.3%)	50 (83.3%)	146 (85.4%)	
> 0 - 2	1 (2.3%)	6 (10.0%)	19 (11.1%)	0.000
> 2 - 10	8 (18.2%)	1 (1.7%)	5 (2.9%)	
> 10	23 (52.3%)	3 (5.0%)	1 (0.6%)	
Home mean:				
0	7 (15.9%)	35 (58.3%)	118 (69.0%)	
> 0 - 2	4 (9.1%)	12 (20.0%)	37 (21.6%)	0.000
> 2 - 10	6 (13.6%)	8 (13.3%)	9 (5.3%)	
> 10	27 (61.4%)	5 (8.3%)	7 (4.1%)	

allergens. Allergic sensitisation to dog or cat allergens is believed to be an important risk factor for asthma and asthma symptoms, [1-12] and many studies reported positive correlations between the ownerships of pets and the excess in the occurrence of asthma symptoms, asthma diagnosis or asthma medication treatment. It was also shown that asthmatics are more likely than non-asthmatics sensitised to pet allergens and exposures to Can f 1 and Fel d 1 as low as 2 μg/g of house dust and 1 μg/g of dust, respectively, have been assumed as clinically relevant risk thresholds [13-15]. Although an exposure to indoor allergens may be significant for the occurrence of allergic symptoms at any time, but the conditions under which exposure takes place early in life seem to be particularly important for sensitisation.

The primary aim of the study was to assess the prevalence of clinically potential allergic risk thresholds of pet allergens in Krakow inner city and describe the exposure and distribution of dog (Can f 1) and cat (Fel d 1) allergens within homes of 3 years-old children in families with and without ownership of pets. The secondary aim of the study was to examine the validity of the interview on pets kept in homes for predicting the actual exposure level to pet specific allergens measured in house dust. Up to now very little information on the concentrations of pet allergens in Polish houses is available and earlier studies were mainly based on reported ownership of pets.

2. Material and Methods

This study uses data from an earlier established Krakow birth cohort of children being the part of the collaborative study with Columbia University in New York on the vulnerability of foetus and child to environmental factors [16]. The enrolment (November 2000 - August 2003) included only non-smoking women with singleton pregnancies of the age of 18-35 years, without illicit drug use and HIV infection, free from chronic diseases such as diabetes or hypertension, and residing in Krakow for at least one year prior to pregnancy. In 2005 a total of 275 children completed 3 years of life and all of them were eligible for the present study. The Ethics Committee of the Jagiellonian University approved the study.

House dust samples were collected from the mattresses and from children's bedroom and kitchen's floors. Floors were sampled over a 2-minute period from a 2-m x 2-m frame; in bedrooms this was adjacent to the bed, and in kitchen where the child used to spend time. Parents of children were requested not to clean the mattresses or sweep or vacuum these floors for 48 hours before sampling. The same vacuum cleaner was used to collect dust samples from all household sites, and the trained staff performed the dust collection. To avoid cross-contamination between samples from different sites, vacuum cleaner parts were cleaned

Table 2. Distribution of cat allergen by various sampling sites and the reported ownership of pet within Krakow homes.

Fel d1 (μg/g dust)	Children's contact with a cat			p
	IndoorN=26	Outdoor N=36	None N=213	
Bed:				
0	3 (11.5%)	18 (50.0%)	159 (74.6%)	
> 0 - 1	6 (23.1%)	11 (30.6%)	38 (17.8%)	0.000
> 1 - 8	7 (26.9%)	7 (19.4%)	13 (6.1%)	
> 8	10 (38.5%)	0 (0.0%)	3 (1.4%)	
Bedroom floor:				
0	6 (23.1%)	14 (38.9%)	142 (66.7%)	
> 0 - 1	5 (19.2%)	17 (47.2%)	61 (28.6%)	0.000
> 1 - 8	10 (38.5%)	5 (13.9%)	10 (4.7%)	
> 8	5 (19.2%)	0 (0.0%)	0 (0.0%)	
Kitchen floor:				
0	5 (19.2%)	25 (69.4%)	180 (84.5%)	
> 0 - 1	7 (26.9%)	8 (22.2%)	31 (14.6%)	0.000
> 1 - 8	8 (30.8%)	3 (8.3%)	1 (0.5%)	
> 8	6 (23.1%)	0 (0.0%)	1 (0.5%)	
Home mean:				
0	3 (11.5%)	12 (33.3%)	112 (52.6%)	
> 0 - 1	4 (15.4%)	17 (47.2%)	92 (43.2%)	0.000
> 1 - 8	12 (46.2%)	7 (19.4%)	7 (3.3%)	
> 8	7 (26.9%)	0 (0.0%)	2 (0.9%)	

with wet cloths and dried after each sampling. All dust samples were sealed in plastic bags and sent to the laboratory of the Department of Clinical Immunology, the Polish-American Institute of Pediatrics.(Coll. Med. Jagiellonian University), where they were stored at 4°C, under desiccant, until they were extracted. Extracted dust samples were assayed for Can f 1 and Fel d 1 by ELISA (Indoor Biotechnologies, Chester, United Kingdom).

At the time of house dust collection trained field workers have carried out standardized interviews on the characteristics of the household and ownership of pets over the last 6 months and eventual child's contacts with dogs or cats outdoors over the same period. All interviews have been performed with the mothers of children.

2.1. Statistical analysis

The concentrations of pet allergens (micrograms per gram of dust) were compared between the household sites where the dust collection was done. Can f 1 exposure was categorized by the following levels: (0) undetected level, (1) >0 and ≤ 2 μg/g dust, (2) >2 and ≤ 10 μg/g dust; and (3) >10 μg/g dust; Fel d 1 exposure was divided in the following levels: (0) undetected level, (1) >0 or ≤1 μg/g dust, (2) >1 and ≤ 8 μg/g dust; and (3) >8 μg/g dust. In addition, an allergen-specific house mean exposure was created that was the mean of a given allergen in the sampled locations. Statistical bivariate models were used to analyze the association between levels of pet allergens, house sampling sites and ownership of pets in homes. Validity of interview on ownership of pets for predicting exposure to a given allergen concentration at home was appraised by the post-test probability of true exposure in cases with positive and negative interview results. For the validity analysis the PEPI software for Windows was used [17]. In all statistical analyses, the significance level was assumed as $p< 0.05$.

3. Results

The majority of households (79.3%) had neither a dog nor a cat living in the home over the past 6 months preceding the survey. Among all homes under study, 4.7% had both pets living in the home, 11.3% had at least 1 dog but not a cat living in the home, and 4.7% had at least 1 cat but not a dog living in the home. Besides, 21.8% of parents reported that in the past 6 months their child had contacts with a dog outdoors and 13.1% of children had such contacts with a cat. Majority of respondents (62.2%) denied the presence of an indoor dog or contacts of their children with an outdoor dog, and 77.5% of children had neither cats at home nor contacts with cats outdoors.

Figure 1. Concentration of dog allergen (Can f1) in μg/g of house dust in the Krakow survey.

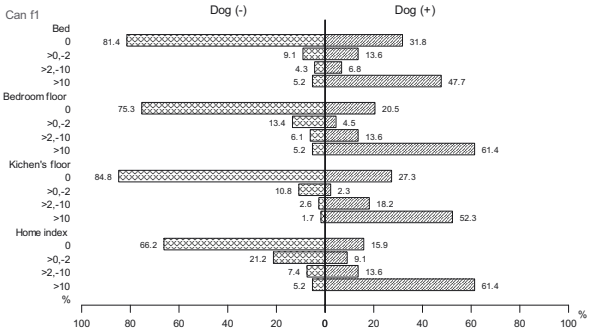
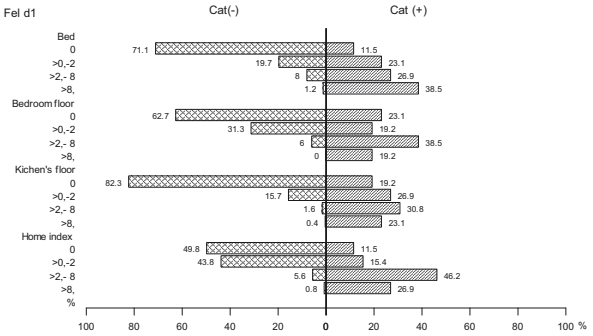


Figure 2. Concetration of cat allergen (Fel d1) in μg/g of house dust in the Krakow survey.



Exposure to dog allergens measured by the house dust survey was disclosed in 41.8% and that for cat allergen 53.8.5% of homes. Dog allergen level above 2 μg/g dust was found in 22.5% of homes and 14.2% of homes contained house allergen level above 10 μg/g dust. Cat allergen levels above 1 μg/g dust were found in 12.7% of homes, and 3.3% of homes contained Fel d 1 levels greater than 8 μg/g dust.

The majority of children (75.0%) with reported ownership of dogs were exposed to Can f 1 concentrations above 2.0 μg/g dust (Table 1) and 73.1% of children with ownership of cats were exposed to Fel d 1 concentrations above 1.0 μg/g dust wherever at home (Table 2).

In homes with ownership of dogs, concentrations of Can f 1 above 2 μg/g dust were found in 54.5% of children's beds, 75% of bedroom floors and 70.5% of kitchen floors. The corresponding prevalence rates in homes of children with reported dog contacts outdoors were 16.6%, 18.4% and 6.7%. Surprisingly, also in homes of children for whom dog's ownership and contacts with dogs outdoors were denied, higher concentrations of Can f 1 (above 2 μg/g dust) were found in 9.4% of homes; 7% of children's beds, 8.7% of bedroom floors and 3.5% of kitchen floors. Figure 1 presents the difference in the distribution curves of Can f 1 allergen in homes by the ownership of dogs.

Similarly, the majority of children (73.1%) with reported ownership of cats were exposed to Fel d 1 concentrations above 1.0 μg/g dust wherever at home. In this group, concentrations of Fel d 1 above 1.0 μg/g dust were found in 65.4% of children's beds, 57.7% of bedroom floors and 53.9% of kitchen floors. The corresponding prevalence of cat allergen in homes of children having only contacts with cats outdoors was 19.4%, 13.9% and 8.3%. In the group of children with neither indoor cats and nor cat contacts outdoors, the concentrations of Fel 1 d above 1.0 μg/g dust were found in 4.2% of homes; 7.5% of children's beds, 4.7% of bedroom floors and on 1.0% of kitchen floors. Figure 2 presents the difference in the distribution curves of the Fel 1 d allergen in homes by the ownership of cats. There was a high and significant correlation between concentrations of dog allergen in various house sampling sites within the homes where dogs lived. Spearmen correlation coefficients between Can f 1 concentrations on beds and bedroom floors and those on bedroom floor and kitchen floor was $r_s = 0.73$ and that between Can f 1 concentrations on bed and kitchen floor was 0.71. The correlation of Can f 1 between various sampling sites in the homes without indoor dog were much lower and ranged from 0.42 - 0.53. In houses with

Table 3. Validity of the interview on the ownership of dog over the past 6 months for the prediction of risk exposure level of Can f 1 allergens (concentration >2.0 μg/g house dust) at homes of children.

Interview results	Can f 1 >2.0 μg/g house dust (+)	Can f 1 <2.0 μg/g house dust (-)	Total
Dog ownership (+)	33 (TP)	11 (FP)	44
Dog ownership (-)	29 (FN)	202 (TN)	231
Total	62	213	275

TP: true positives; TN: true negatives; FN: false negatives; FP: false positives
Prevalence of dog's ownership = 16.2%
Prevalence of exposure to Can f 1 > 2 μg/g house dust = 22.5%
Sensitivity (33/62) = 53.2% (95%CI: 40.8 – 65.4%)
Specificity (202/213) = 94.8% (95%CI: 91.2 – 97.3%)
False Positives (11/213) = 5.2% (95%CI: 2.8 – 8.8%)
False Negatives (29/62) = 46.8% (95%CI: 34.6 - 59.2%)
Post-test probability of true exposure to Can f 1 allergen (> 2 μg/g house dust) at home
After positive results of interview (33/44) = 75.0% (95%CI: 61.7 – 84.8%)
After negative results of interview (29/231) = 12.6% (95%CI: 9.9 – 15.8%)

Table 4. Interview on the ownership of pets for prediction of risk of exposure to Fel d 1 allergen (concentration >1.0 μg/g house dust) at homes of children.

Interview	Fel d 1 >1.0 μg/g house dust (+)	Fel d 1 <1.0 μg/g house dust (-)	Total
Cat ownership (+)	19 (TP)	7 (FP)	26
Cat ownership (-)	16 (FN)	233 (TN)	249
Total	35	240	275

TP: true positives; TN: true negatives; FN: false negatives; FP: false positives
Prevalence of cat's ownership = 9.4%
Prevalence of exposure to Fel d 1 (> 1μg/g house dust) at home = 12.7%
Sensitivity (19/35) = 54.3% (95%CI: 37.8 – 70.1%)
Specificity (233/240) = 97.1% (95%CI: 94.3 – 98.7%)
False Positives(7/240) = 2.9% (95%CI: 1.3 – 5.7%)
False Negatives (16/35) = 45.7% (95%CI: 29.9 – 62.2%)
Post-test probability of true exposure to Fel d 1 (>1 μg/g house dust) at home
After positive results of interview (19/26) = 73.1% (95%CI: 55.1 – 85.7%)
After negative results of interview (16/249) = 6.4% (95%CI: 4.6 – 9.0%)

ownership of cats we also found high and significant correlation between concentration of cat allergen on bedroom floor and kitchen floor (r_s = 0.75), but lower coefficients were obtained for Fel d 1 concentrations on beds and on bedroom floors (r_s = 0.51) and between those on beds and kitchen floors (r_s = 0.38). In homes of children having only contact with cats outdoors, the correlation was highest between Fel d 1 level on beds and bedroom floors (r_s = 0.77). Association between Fel d 1 concentrations on beds and kitchen floors and between bedroom floors and kitchen floors were in the range 0.55 – 0.56. In homes where children did not have cats indoors or contacts with cats outdoors, correlation between allergen concentrations in various sampling sites within homes were in the range of 0.29 – 0.38.

Validity of the questionnaire data on the ownership of pets over the past 6 months for predicting the clinically relevant exposure levels was presented in tables 3 and 4. The cross-tabulation of exposure to Can f 1 above 2 μg/g dust and the questionnaire data showed that post-test probability of the true exposure was in 75.0% (95%CI: 61.7 – 84.8%). On the other hand, the prediction of exposure estimated from the interview data produced 12.6% of false negatives (95% CI: 9.9 – 15.8%). Similarly, the post-test probability of the true exposure to Fel 1 d above 1 μg/g dust in houses with positive interview on indoor cats was 73.1% (95%CI: 55.1 – 85.7%), however, the interview data produced 6.4% false negatives (95% CI: 4.6 – 9.0%).

4. Discussion

In our study sample most households had neither an indoor dog nor an indoor cat. House average dog allergen level above 2 μg/g dust were found in 22.5% of homes, and 14.2% of homes contained dog allergen above 10 μg/g dust. Cat allergen above 1 μg/g dust was found in 12.7% of homes, and 3.3% of homes contained Fel d 1 levels greater than 8.0 μg/g dust.

Distributions of Can f 1 and Fel d 1 in Krakow homes with and without pets living in the home at the time of the survey were significantly different. The dog allergens above 2 μg/g dust were found in 75% of homes keeping dogs indoors, while this level has been observed only in 12.6% of homes without dogs indoors. The cat allergens above 1 μg/g dust were found in 73.1% of houses with reported cats indoors and only in 6.4% of homes where cats were not kept indoors. High prevalence of increased levels of pet allergens observed in homes where pets lived indoors is well understood and is the result of intimate interactions between pets and family members and their constant contacts with household furniture.

The results of this survey on the prevalence of pet allergens in Krakow inner city area are important in the context of the recently published analysis, which showed the increasing hospitalisation rates from asthma among children in Poland over the last two decades [18]. On average, the rates increased annually by 12% among boys and 11% for girls, but the fastest increase has been noted in the youngest children aged less than 4 years. In addition, the prospective study over the period of three years in schoolchildren living in Krakow has shown in 6.2% of boys and 3.4% of girls allergic sensitisation to canine allergens while 17.4% of boys and 4.8% girls showed allergic sensitisation to cat allergens [19-20].

Out of total number of homes with mean Can f 1 level above 2 μg/g dust, only 53.2% kept dog indoors, 21.0% of children had contacts with a dog outdoors, but 25.8% had neither dog at home nor contacted a dog outdoors over the past six months. In the total number of homes with Fel d 1 level above 1 μg/g dust, the corresponding proportions of homes were 54.3%, 20.0% and 25.7%. These data draw our attention on how these allergens penetrate in high concentrations into homes from outdoors. The prevalence of pet allergens in houses without pets may be explained in several ways. First of all, pets could have been kept in the homes in the past

and the allergens could still be present during the house dust sampling. Since dog and cat allergens easily stick on rugs, furniture or clothing, this makes the elimination of the allergen from house environment not easy [21,22-24]. In homes without pets, the allergens could eventually be transmitted into the homes by the children or adult family members on clothing from allergen reservoirs in public places such as schools, means of public transportation, cinemas, or other places [25-28]. Our data suggest that children more frequently introduce into homes dog allergen than other family members (21.6% vs. 9.4%); the corresponding proportions for cat allergen are 19.4% and 4.2%.

Concentrations of the pet allergens were correlated between sampling sites within homes. The correlation between pet allergens collected from various house sites results from the fact that Can f 1 and Fel d 1 are associated with small dust house particles that remain airborne for long periods [29,30] and this helps the allergens circulate and settle on various places and domestic furniture throughout a house. Although the distributions of each allergen throughout the homes were not very much different, the highest concentrations of Can f 1 and Fel d 1 were usually found on the beds and bedroom floor. The bed was the most frequent site of higher exposure to cat allergens but the bedroom floor to dog allergens. This particular distribution of pet allergens may indicate preferred places where pets spend time in house. In homes with the ownership of pets, the higher levels of allergen on beds could reflect where pets prefer to spend time, but in homes without pets, it might suggest the site most likely to come into contact with clothes or garments worn outside the home. It could also result from the long persistence of allergen in bed mattresses, which are much more difficult to clean than house floors.

The results of the study also showed that predictions of the pet allergen level in homes based only on the ownership of pets might lead to exposure misclassification of subjects. This in turn may bias an estimated association between the exposure to pet allergen and the occurrence of asthmatic symptoms, specially if the misclassification of exposure is differential among cases and controls. In order to increase the validity of questionnaire data on exposure to pet allergens, more detailed information not only about the house characteristics and its hygienic standards, but also about the behaviour of household inhabitants, the behaviour of pets in homes, dog's pelage or cat's fur and more about type and duration of contacts of various family members with outdoor pets should be taken into consideration.

The limitation of our study may in part result from the fact that dust samples were collected at a single point in time and the measurements were not repeated in various seasons of the year. Since our main objective of the study was to estimate exposure of young children to pet allergens in Krakow inner city area, the cross-sectional approach was justified. It seems that the seasonality of exposure to pet allergens may be not relevant because we did not find a significant variability of the allergen measurements across seasons. Other possible weakness of the study is the fact that the questionnaire used in the study did not contain questions on pet contacts of adult family members, which could explain - at least to some extent - the presence of allergens in homes without pet ownership.

In conclusion, the study demonstrated that homes in Poland with pet ownership are important reservoir of Can f 1 and Fel d 1 allergens with levels above allergic sensitization thresholds and above levels that might induce allergic symptoms. Only in about half of homes the pet allergen levels above allergic sensitization threshold could be explained by the pet ownership. Therefore, for pet-allergic persons the allergen avoidance by removing pets from homes would be highly insufficient precaution. Developing environmental intervention programs that take into account modes of transmission of pet allergens into homes from the community potential reservoirs of these allergens should be an important new challenge for epidemiologic research and preventive practice.

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