

Mite (*Der p I*, *Der f I*), cat (*Fel d I*) and dog (*Can f I*) allergens in dust from Swedish day-care centres

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Summary

Early exposure to allergens is important for sensitization to inhalant allergens and it has been reported that there is a causal relationship between allergen exposure and bronchial asthma. We investigated the levels of major mite (*Der p I*/*Der f I*), cat (*Fel d I*) and dog (*Can f I*) allergen levels in dust collected from various locations in seven day-care centres (22 sections). The allergen levels were related to the characteristics of the day-care centres. Children and staff were questioned about contacts with animals, and cleaning personnel were asked about methods and frequency of cleaning. Mite allergen was found in nine of the 22 sections. The concentrations varied between < 16 ng/g and 106 ng/g dust (median < 16 ng/g). Mite allergen was not detected in any floor dust sample. Cat and dog allergen was detected in all centres and sections. The concentrations of dog allergen (median $4.3 \mu\text{g/g}$; range < 60 ng– $21 \mu\text{g/g}$) were significantly higher ($P < 0.05$) than that of cat allergen (median $1.6 \mu\text{g/g}$; range < 16 ng– $22.8 \mu\text{g/g}$). Higher amounts of both *Fel d I* and *Can f I* were observed on mattresses/sofas/cushion like toys and curtains than on tables/chairs and floors. The levels of cat or dog allergen on floors significantly correlated with the total number of children and staff with either a cat or a dog at home and or frequent contacts with them. Neither cleaning methods nor the frequency of cleaning influenced the allergen concentrations. The concentration of *Fel d I* was significantly lower ($P < 0.05$) in washed than in never washed curtains. We conclude that *Fel d I* and *Can f I* allergens are ubiquitous in day-care centres. The allergens are probably carried there in the clothes of children and staff. Day-care centres should be considered a cause of exposure to indoor allergens. Curtains, toys and upholstery were the most important reservoirs. We suggest that the concentration of allergen in curtains reflects long-term exposure to airborne indoor allergens, since they are mainly exposed to airborne allergens.

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Introduction

Many studies have shown that exposure to indoor allergens and particularly early exposure to house dust mites is a major cause of allergic sensitization and asthma [1–6]. The predominant sensitizing allergens in Swedish asthmatic children are furry pet animals, causing sensitization twice as often as house-dust mites [7,8]. In several previous studies we observed that the major allergens derived from cats (*Fel d I*) and dogs (*Can f I*) are the dominating dust allergens in homes of

newborn babies [9], in homes of allergic children [10], in homes of asthmatics [11] and in Swedish schools [12].

The risk level of mite allergen exposure for both sensitization and development of asthma has been suggested to be $2 \mu\text{g/g}$ dust [13]. No exact standards exist regarding the clinical significance of *Fel d I* or *Can f I* allergen levels in dust. However, it has been suggested that $\geq 8 \mu\text{g}$ of the major allergen from cat, *Fel d I/g* of fine dust, should be regarded as risk level for both sensitization and acute asthma [14,15]. Later, lower levels have been shown to be sensitizing [6,9]. For *Can f I*, levels for sensitization and triggering of asthma have not been identified or suggested so far. Our hypothesis is

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that concentrations much lower than the levels proposed might also cause at least low grade clinical asthma in most mite/cat or dog sensitive asthmatic children [9,12, 16–18].

It has been reported that asthmatic symptoms improve in patients removed from allergen exposure at home [19]. However, exposure to indoor allergens in public places is also of importance [12,16,20–22].

School children are exposed to high levels of allergens at school [12,16]. In a previous study we found the levels of mite and pet allergens in dust from homes of high-risk newborn babies to be low [9]. However, many small children stay in day-care centres. Therefore, we investigated the levels of the major mite (*Der p I/Der f I*), cat (*Fel d I*) and dog (*Can f I*) allergens in Swedish day-care centres.

Materials and methods

Twenty-two sections in seven day-care centres were randomly selected from suburban areas of Linköping. All centres had one or two infant sections (age: 1 month–3 years) and one or two sections for older children (age: 3–6 years).

Characteristics of day-care centres, sections, staff and children

Administrators and staff of the day-care centres were

asked to respond to a questionnaire regarding the technical characteristics of the buildings, and sections and also about the number of children and staff. Some technical characteristics of the centres and sections are given in Table 1. All centres were built between 1970 and 1990, floor materials were linoleum and during the winter season central heating was used. In all sections table and chair surfaces were made of wood. All but one section was located on the ground floor. No section had visible mould growth either on walls, floors or in ceilings. One section had damp spots on the walls and roofs and in another one there was condensation of water inside the window glass during the winter season.

Questionnaires regarding the children's exposure to cats and dogs were supplied to the parents of the children. All the staff were interviewed regarding exposure to pets. Some characteristics of children and staff members are given in Table 2.

Cleaning routine in day-care centres

The personnel responsible for cleaning of day-care centres were given a questionnaire about the cleaning methods used. In all sections, table surfaces and floors were cleaned daily by wet sweeping and/or dry sweeping, but chair surfaces were not cleaned regularly (Table 2). There was

Table 1. Technical characteristics of day-care centres and sections investigated

	Centre 1	Centre 2	Centre 3	Centre 4	Centre 5	Centre 6	Centre 7
<i>Number per day-care centre</i>							
Location:							
Suburban bungalows	Yes	No	No	No	Yes	Yes	Yes
Suburban apartments	No	Yes	Yes	Yes	No	No	No
Number of sections	3	2	5	5	6	6	3
Number of after school (free time) sections	0	0	1	1	1	1	1
Number of infant sections	2	1	2	2	3	3	1
Number of older children sections	1	1	2	2	2	2	1
Number of sections investigated	3	2	3	4	4	4	2
Number of children	38	43	79	68	94	104	56
Number of staff	9	9	17	16	21	18	12
Ventilation system:							
Window + passive outblowing by fan	Yes	No	No	No	No	No	No
Window + active in- and out-blowing	No	Yes	Yes	Yes	Yes	Yes	Yes
Working duration:							
daytime (not weekends)	Yes	Yes	Yes	Yes	Yes	No	No
day and night + weekends	No	No	No	No	No	Yes	Yes
<i>Number per investigated section</i>							
Number of children, mean (range)	13 (10–18)	22 (19–24)	15 (10–18)	12 (8–17)	15 (12–19)	15 (12–18)	18 (14–21)
Number of staff, mean (range)	3 (3–3)	5 (4–5)	3 (3–4)	3 (3–4)	4 (3–4)	4 (3–4)	4 (3–5)

Table 2. Characteristics of children and nurses and cleaning frequency in different sections

	Centre 1	Centre 2	Centre 3	Centre 4	Centre 5	Centre 6	Centre 7
<i>Number per investigated children sections</i>							
Cat at home	4	9	8	8	6	7	8
Dog at home	1	4	0	10	3	3	6
Frequent contacts with cat	3	11	4	7	4	8	4
Frequent contacts with dog	5	14	8	8	9	3	8
Cat at home & frequent contacts (total)	7/47	20/52	12/56	15/62	10/74	15/74	12/43
Dog at home & frequent contacts (total)	6/47	18/52	8/56	18/62	12/74	6/74	14/43
<i>Cleaning frequency (times/week, month or year)</i>							
Tables	5/w	5/w	5/w	5/w	5/w	5/w	5/w
Chairs	5/w	5/w	1/w	5/w	§	5/w	5/w, §
Floors	5/w	5/w	5/w	5/w	5/w	5/w	5/w
Curtains	2/y	*	○	○	1/y	○	2/y
Mattress cover	2/m	1/m	○	1/w, ○	○	○	1/m
Pillow cover	2/y	1/m, ○	○	2/y	1/y	1/m	1/m
Sofas or sofa cover	2/y	2/y	1/w	2/y	1/y	1/m	○
Cushion like toys	2/y	1/m, ○	○	§	2/y	1/y	○

w. Week. m. Month. y. Year. § When necessary. ○ Very seldom. * Never.

no regular schedule for cleaning or washing of curtains. In some sections curtains were never cleaned (centre 2). In all sections bed sheets were washed regularly in hot water and detergents, but sofa covers (if any) and cushion like toys were cleaned very seldom or only if necessary.

Collection, sieving and extraction of dust

Dust was collected from all 22 sections from 1 January to 15 January 1993. No changes in the cleaning procedures or cleaning routines were performed prior to the dust collection. All dust samples were collected by the same type (series D780, 1100 kW; Electrolux, Stockholm, Sweden) of two vacuum cleaners equipped with a special device that contained a Millipore filter (pore size, 6 µm) (ALK, Copenhagen, Denmark). Samples were collected by the same team between 06.00 and 08.00 h. Dust was sampled from table and chair surfaces, floors, curtains, mattresses and cushions like toys in infants sections, and sofas and cushion like toys in sections for older children. Mattresses were present only in infant sections ($n = 11$) and sofas only in section for older children ($n = 11$). Table and chair surfaces were vacuumed together, since the amount of dust on these surfaces was very low, floor surfaces and curtains were vacuumed for 1 min/m² (total 8 min/8 m²). Mattresses and geometric formed cushion like toys or sofas and cushion like toys were vacuumed together for 2 min/m² (total 8 min/4 m²). Dust samples were stored at -20°C until analysed.

Dust samples collected on filters were passed through a sieve (pore size, 300 µm) to obtain fine dust. The amount of dust collected from table/chair surfaces (median, 54 mg, 95% confidence intervals 48–126 mg) and curtains (median, 71 mg, 95% c.i. 17–298 mg) were low compared with dust collected from floors (median, 282 mg, 95% c.i. 179–580 mg), mattresses/cushion like toys (median, 572 mg, 95% c.i. 442–1029 mg) and sofas/cushion-like toys (median, 802 mg, 95% c.i. 637–1051 mg).

Extracts of dust samples were prepared in phosphate-buffered saline, pH 7.6, as described earlier [12].

Determination of dust allergen content

The concentration of major mite, cat and dog allergens in dust was determined by sandwich ELISA according to the method described by Luczynska *et al.* [23] for *Der p I*/*Der f I*, Chapman *et al.* [24] for *Fel d I* and Schou *et al.* [25] for *Can f I*.

The ELISA test kits for *Der p I*/*Der f I* and *Fel d I* were kindly supplied by Dr M. D. Chapman (Charlottesville, VA, USA) and the ELISA test kit for *Can f I* was supplied by Dr C. Schou (ALK Laboratories, Hørsholm, Denmark).

For all ELISA the interassay variation for repeated assays was < 15% and the intra-assay variation was < 10%. The cut off limit for *Der p I*, *Der f I* and *Fel d I* assay was set at 1.6 ng/ml and for *Can f I* assay 6 ng/ml, which equivalents to 16 ng/g and 60 ng/g of fine dust, respectively.

Statistical analysis

Allergen concentrations were transformed into decimal logarithms. Mann-Whitney test and Kruskal-Wallis test were utilized to test the level of significance between variables in sections. Wilcoxon signed rank test was used to observe any variation between sampling locations. Spearman rank-order correlation coefficient (r_s) was employed to test a possible association between variables, sources and allergen concentrations. In the case of mite allergen, the total mite allergen content (*Der p I* + *Der f I*) was used for statistical calculations. The peak mite, cat and dog allergen concentrations, i.e. the highest concentration of allergen in each section regardless the site of allergen source, was also considered for analysis of any association between allergen level and section characteristics.

Results

Mite allergen

Mite allergen was detected in four of seven centres or nine of 22 sections (41%) and 11 of 88 (13%) samples. No mite allergen was detected in any of the floor samples. The concentration of total mite allergen varied from < 16 ng/g to 106 ng/g dust (median, < 16 ng/g, 95% c.i. < 16 ng–24 ng/g). *D. pteronyssinus* and *D. farinae* were equally common (9/88 samples each).

Of the positive samples, four were detected in dust from tables/chair surfaces (median, 68 ng/g), five from curtains (median, 32 ng/g) and two from mattresses or sofas/cushion like toys. Mite allergen was not detected in any sample from centres 1, 2 and 5 (Fig. 1).

In centres with a ventilation system working day and night, the concentration of mite allergen (peak values)

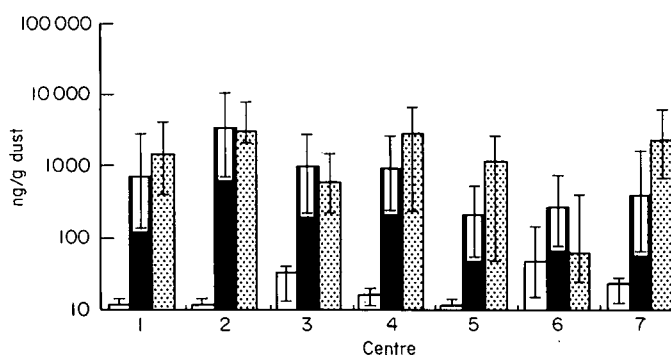


Fig. 1. The concentration of mite (*Der p I* + *Der f I*, □), cat (*Fel d I*, ■) and dog (*Can f I*, ▨) allergens in dust from various locations (tables and chairs, floors, curtains, mattress + soft toys or sofas + soft toys) from seven day-care centres. Median and 95% confidence intervals are given.

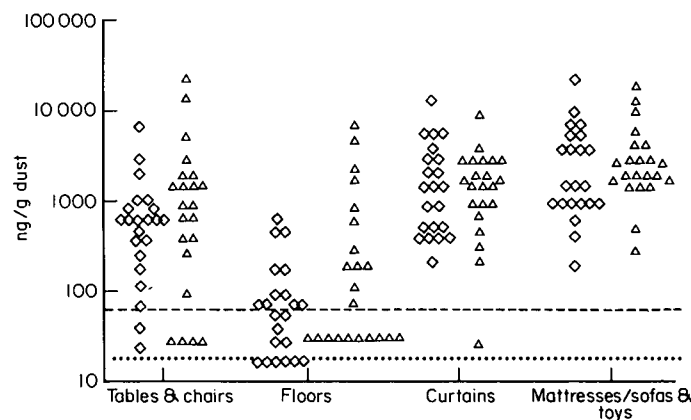


Fig. 2. The concentration of cat (◇, *Fel d I*) and dog (△, *Can f I*) allergens in dust from different sampling locations from 22 sections in seven day-care centres. Cut-off limit for *Fel d I* (.....) and *Can f I* (----) allergen.

was significantly higher ($P < 0.05$, Mann-Whitney test) than in centres with a ventilation system working only during daytime. Cleaning methods and the frequency of cleaning had no influence on the concentration of mite allergen (peak levels) in dust.

Cat allergen

Cat allergen was detected in all sections and 93% of the samples and not detected in six samples from floors (Fig. 2). The concentration of cat allergen varied from < 16 ng to 22.8 µg/g dust (median, 1.6 µg, 95% c.i. 1.2 µg–3.1 µg/g). Nine samples (10%) contained *Fel d I* levels between 16 ng and 60 ng/g dust. Seventeen sections had *Fel d I* levels between 1 µg and 8 µg/g dust and three samples from two sections contained *Fel d I* levels ≥ 8 µg/g dust. Of these three samples, two were from mattresses/cushion like toys and one from curtains.

The *Fel d I* allergen concentration in dust from floors was significantly lower ($P < 0.001$, Kruskal-Wallis and Wilcoxon signed rank test) than in those from other locations (Fig. 2). The concentration in dust collected from tables/chairs was significantly lower ($P < 0.01$) than that from curtains and mattresses/sofas/cushion like toys, which showed similar levels.

The highest *Fel d I* level was observed in centre 2, which had the highest number of persons with cats at home (17%) and frequent contacts with cats (21%) (Table 2).

The levels of cat allergen were similar in sections with infants and sections with older children. Dust from centres located in apartment buildings contained significantly higher ($P < 0.05$) concentrations of *Fel d I* than did dust from centres in isolated, bungalow type buildings.

Type of ventilation system and the working duration of active in- and out-blowing ventilation system had no influence on the concentration of cat allergen in dust. However, in sections with a ventilation system working during day and night, the concentration in curtains tended to be lower ($P = 0.05$) than in sections with a ventilation system working only during daytime.

In centres in which chair surfaces were cleaned regularly, i.e. daily or weekly, dust from chair surfaces contained significantly higher ($P < 0.01$, Kruskal-Wallis and Mann-Whitney test) concentrations of *Fel d I* in dust than in centres where chair surfaces were cleaned very seldom or only when necessary. In all but four sections tables, chairs and floors were cleaned by wet sweeping. In these four sections (Centre 5), chairs and floors were cleaned by both dry and wet sweeping. The concentration of *Fel d I* on tables, chairs and floors was significantly lower ($P < 0.05$) compared with sections where only wet sweeping was used.

Dust from curtains which were never washed contained significantly higher ($P < 0.05$, Mann-Whitney test) concentrations of *Fel d I* compared with curtains cleaned often or once or twice in a year. Dust from mattresses/cushion like toys contained significantly higher ($P < 0.05$, Kruskal-Wallis and Mann-Whitney test) *Fel d I* levels in centres where mattress covers were cleaned regularly, i.e. weekly or monthly, compared with centres where mattress covers were washed very seldom. The frequency of cleaning on other surfaces did not influence the concentration of *Fel d I* in dust. The number of staff members and children with cat at home and with frequent contacts with cats significantly correlated ($r_s = 0.5$, $P < 0.05$) with the concentration of *Fel d I* on floors.

Dog allergen

Can f I allergen was detected in all sections and 83% of the samples (Fig. 2). Peak levels of dog allergen were significantly higher ($P < 0.05$, Wilcoxon signed rank test) than those of cat allergen in dust. The *Can f I* concentrations varied between < 60 ng/g and 21 µg/g of dust (median, 4.3 µg/g, 95% c.i. 3.1 µg– 6.1 µg/g). Five sections contained *Can f I* concentrations ≥ 8 µg/g dust. Seventeen (77%) sections and 33% of the samples contained *Can f I* levels ≥ 2 µg/g dust. All but two samples from mattresses/sofas/cushion like toys and five samples from curtains contained *Can f I* levels > 1 µg/g of dust.

The *Can f I* allergen concentration in floor dust was significantly lower ($P < 0.01$, Kruskal-Wallis and Wilcoxon signed rank test) than in dust collected from the other locations (Fig. 2). Dust from mattresses/sofas/cushion like toys contained significantly higher ($P < 0.01$) *Can f I* than dust collected from curtains,

which in turn contained significantly higher ($P < 0.01$) levels than dust from tables/chairs.

Dust from centre 6, which had the lowest number of persons in contact with dogs (Table 2), contained lower concentrations of *Can f I* allergen than the other centres. The levels of dog allergen were similar in sections for infants and for older children and in apartment and bungalow type of centres, respectively. Dust from centres with an active in- and out-blowing ventilation system working day and night, contained significantly lower ($P < 0.05$, Kruskal-Wallis and Mann-Whitney test) concentrations of dog allergen on tables/chairs than dust from centres with a ventilation system working only during daytime.

The concentrations of dog allergen on any surface was neither influenced by a combination of dry and wet cleaning or only wet cleaning nor by the frequency of cleaning. The total number of staff and children with a dog at home in each section significantly correlated ($r_s = 0.7$, $P < 0.01$) with the concentration of *Can f I* on curtains. When the number of staff members and children in each section with dog at home and frequent contacts with dogs were grouped together, then a significant correlation was observed with the concentration of *Can f I* on floors and curtains ($r_s = 0.5$, $P < 0.05$).

Discussion

The levels of mite allergen in dust from day-care centres were low and even lower than those found in homes [9,17,26] and in schools [16] in the same area. This was probably due to the fact that the cleaning schedule used in all centres was more frequent than that in schools [12]. In no centre was mould growth observed and in almost no section signs of dampness was observed. Indication of dampness were found in schools [12] and in homes [9,17,26].

Dust from chairs and tables were pooled, because the amount of dust collected from table or chair surfaces separately was not enough for analysis of four allergens. The concentration of mite allergen on table/chair surfaces was higher than on floors and other locations. In schools we observed that dust from table surfaces contained higher levels of mite allergens than that from chair or floor surfaces and we suggested that students and teachers probably transport mite allergens to schools in their hair and when sitting at the table mites/mite allergens fall down on the table [16]. In this study the higher levels on tables/chairs than on floors might be due to influence of the concentration of tables only. It is also possible that daily wet sweeping might cause increased moisture and might influence the microclimate on table surfaces which favours survival of mites.

In contrast to the effect of ventilation on cat and dog allergens, active ventilation working during daytime reduced mite allergen levels significantly compared with active ventilation working day and night. The effect of ventilation systems on humidity depends not on for how long the ventilation system runs but, on the efficiency of the ventilation system, i.e. the rate of air exchange, the number of humans in the house, the amount of water used by the household members and the area of the dwelling [27,28]. Therefore, the lack of significant effect on mite allergen levels of active ventilation working during day and night is probably due to that day care centres are not inhabited during nights, i.e. opposite to homes, no human beings were present. Furthermore, mite allergens are associated with larger particles and fall rapidly [13] and therefore, after disturbance during the day, mite allergens become airborne but fall on the ground before there is any influence of night time ventilation. On the other hand, unlike mite allergens after disturbance, cat allergens remain airborne for long periods of time [15]. Thus, airborne cat allergen can be removed by continuous ventilation during nights, because they are associated with small particles [29].

The concentrations of cat or dog allergens in day-care centres were higher than those found in homes of allergy-risk babies [9], in homes of allergic children [10] and in schools [12] but similar to those found in homes of asthmatic children [11]. Thus at least high risk infants are exposed to low levels of cat or dog allergen at home, but to relatively high levels of cat or dog allergen in day-care centres and in schools. We also confirmed previous finding [12], that cat and dog allergens are present in places not visited by these animals.

The concentration of both cat and dog allergens were significantly higher in dust from curtains and mattresses/sofas/cushion like toys than in dust from floors. Several previous studies have reported cat allergen in dust from mattresses [10,30,31], carpets [9,22,30], carpets and upholstered furniture [10], tables [12], chairs [12], floors [9,12,22,31] and on wall surfaces [32]. In addition to previous findings, we demonstrated that curtains should also be considered a reservoir of indoor allergens. Furthermore, we confirm our previous findings in schools, that floor dust contains less allergen than other sources. We propose, this is due to the fact that floors are regularly cleaned, whereas other surfaces are not cleaned regularly.

The highest concentration of cat allergen in centre 2 and the lowest concentration of dog allergen in centre 6 were related to the highest and the lowest number of persons with a cat and dog at home and/or with frequent contacts with cats or dogs, respectively. The number of staff and children in direct/indirect contact with cats or

dogs were correlated with the concentration of cat or dog allergen in dust from floors and curtains. In a recent study in schools [12] we also observed this correlation with cat allergen levels on tables or chairs.

The findings support previous suggestions, that pet allergens are brought to schools [12] and homes with no pets [10] in the clothes of individuals in contact with pets, i.e. pet allergens are probably brought to day-care centres in the clothes of staff and children in contact with pets. In day-care centres children play in all rooms. Thus, pet allergens were probably distributed to all surfaces. Especially tables but also chairs are probably cleaned often in day-care centres since children eat and paint at the tables, that is why they need regular cleaning by the staff, not the cleaning personnel.

The number children and staff members in contact with pets were similar between apartment buildings and bungalow type centres. Higher *Fel d I* but not *Can f I* allergen levels were observed in dust from apartment buildings than in dust from bungalows. The difference in frequency in contacts with cats or dogs between apartment buildings and bungalows might explain this difference. However, we could not confirm this hypothesis in our study.

The frequency of cleaning or the method used for cleaning of different sampling locations did not affect the concentration of *Fel d I* or *Can f I* allergen in dust. In a recent study in homes of allergic children without a resident cat or dog [10], we observed that regular efficient vacuum cleaning of mattresses or living rooms with a modern vacuum cleaner equipped with a HEPA (High Efficiency Particulate Air)- or micro-filter did not reduce cat allergen levels, if the sampling area was contaminated by cats or cat owners. This observation suggests that direct and indirect contacts with pets should be avoided to reduce indoor cat and dog allergen exposure. In several previous studies [31,33] other authors have suggested that after elimination of cats, cat allergen levels remain high, since it is not eliminated. We suggest that cat allergen is continuously brought to the homes by visitors [10]. Further studies must be performed to investigate this matter.

We have previously reported that in our area the prevalence of sensitization to cats and dogs among asthmatic children was higher than to mites [7,8]. In several previous studies [9-12] we found significantly higher levels of cat and dog allergens than mite allergens in homes and schools. The present study confirms that pet allergens are more important than mite allergens in Sweden [7-12].

We found influence of cleaning and ventilation in some locations. This influence in some cases is probably due to covariation with other factors, e.g., contacts with

pets. Since, the sample size was too small it did not allow us to analysing confounding factors.

In conclusion, our study demonstrates that mite, cat and dog allergens are found in day-care centres. The major cat (*Fel d I*) and dog (*Can f I*) allergens were more commonly found than the major mite (*Der p I*/*Der f I*) allergens. Curtains, mattresses/sofas/cushion like toys were the most important reservoirs for cat and dog allergens. Finally, our results suggest that the day-care centres should be considered as a cause of indoor cat or dog allergen exposure. In addition to previously known reservoirs of pet allergens such as carpets, upholstery and chairs, curtains should also be considered when measures are taken to reduce indoor mite, cat and dog allergen exposure.

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