

House dust mite and cat allergen in different indoor environments

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Summary

Allergy to house dust mites (HDM) and domestic pets is a major cause of asthma. People in developed countries spend more than 90% of their time indoors. We have measured levels of HDM allergen *Der p I* and cat allergen *Fel d I* in public buildings and public transport. Dust samples were collected by vacuuming a 1 m² area for 2 min from five schools, six hotels, four cinemas, six pubs, three buses, two trains and 12 domestic households without a cat. *Der p I* and *Fel d I* were assayed with monoclonal antibodies in a two-site immunometric ELISA. *Der p I* concentration was significantly higher in the private homes than in comparable sites in public places except for cinema seats (where high values were found) compared with domestic sofas. *Der p I* >2000 ng/g of fine dust was found in 30% of the upholstered seats, 9% having a concentration >10 000 ng/g. *Fel d I* levels were significantly higher in the dust from upholstered seats (geometric mean 14.88 µg/g) than in carpeted floors (geometric mean 0.73 µg/g), and in public places than in private homes. *Fel d I* >8 µg/g was found in 79% of the upholstered seats or furniture sampled in public buildings or public transport. In conclusion, upholstered seats from public buildings and public transport constitute an allergen reservoir for continuous contamination of the indoor environment which could compromise the effects of allergen avoidance employed at home.

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Introduction

Allergy to house dust mites (HDM) and pets is a major cause of ill health, and the diseases associated with those allergens are asthma, atopic dermatitis and allergic rhinitis [1]. Asthma is the most common chronic disease worldwide, and one of the few treatable conditions that have increased in prevalence and severity in recent years [2]. These variations seem to be related to a change in lifestyle and housing that has resulted in an increased exposure to indoor allergens [3]. Atopy is a major risk factor for the development of asthma, and the frequency of sensitization is related to the quantity of exposure to allergens [4]. It appears that the relationship between allergen exposure and asthma can be divided into two phases: exposure of genetically predisposed persons that

leads to sensitization and ongoing exposure of sensitized persons that contributes to chronic bronchial hyperreactivity [5]. Up to 90% of asthmatic children are sensitized to HDM, and 40% to allergens of cats [1].

It is well documented that the environment created by modern houses is ideal for the growth of mites [6], and significant levels of HDM allergens are found in a majority of domestic dwellings in UK. Cats are among the most common household pets in urban areas. Many homes that are without cats nonetheless contain high levels of the cat allergen *Fel d I* in dust [7]. Modern amenities (e.g. vacuum cleaners) have contributed to the increased allergen exposure in the domestic dwellings, and it is possible that the same occurred in a number of public buildings. The practice of installing wall to wall carpeting in schools, hospitals and offices is becoming widespread. It is therefore possible that significant exposure to domestic allergens can occur outside the home.

This study investigates the levels of HDM and cat allergens in the indoor environment of public buildings

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(schools, hotels, cinemas, pubs) and public transport (buses and trains) in Manchester.

Methods

Der p I and *Fel d I* were measured in the dust collected from carpeted floors and upholstered seats in five schools, six hotels, four cinemas, six pubs, three buses and two trains. In addition to this, allergen levels were determined in the dust samples from mattresses, living room carpets, bedroom carpets and sofas in 12 domestic households without a cat in the home. The study was carried out during winter and spring of 1993 in south Manchester.

Sample collection and extraction

Dust samples were collected using a Medivac vacuum cleaner (Medivac plc, Wilmslow, Cheshire, UK) with an air-flow rate of 45 l/s. A 1 m² area was sampled for 2 min.

Dust was sieved through a 355 µm diameter mesh screen (Endecotts Ltd, London, UK). One hundred milligram of fine dust was extracted by rotation for 2 h at room temperature with 2 ml of borate-buffered saline with 0.1% Tween 20, pH 8.0, and then centrifuged 20 min at 2500 rpm at 4°C. Supernatants were stored at -20°C for future analysis of allergen content.

Allergen assay

HDM (*Der p I*) and cat (*Fel d I*) allergen content was assayed by a two-site ELISA using monoclonal antibodies (MoAbs) [8,9]. Antibodies and standards were supplied courtesy of Professor Martin D. Chapman (UVA, Charlottesville, VA, USA).

Extracts were initially assayed in duplicate at 5-, 25-, and 125-fold dilution for *Der p I* and 100-, 400- and 1600-fold dilution for *Fel d I*. For concentrations lying off the sloping portion of the standard curve, the assays were repeated at an appropriate dilution. Paired samples were rejected if they differed by more than 5% (restricting intra-assay variation to this level).

Statistical methods

The *Der p I* and *Fel d I* data were found to follow a log-normal distribution; the results are thus reported as geometric means. Allergen levels in different sites were compared using log-transformed data and the Student's *t*-test. Statistical significance was set at a 5% level.

Results

Der p I and *Fel d I* concentrations were expressed as ng/g of fine dust.

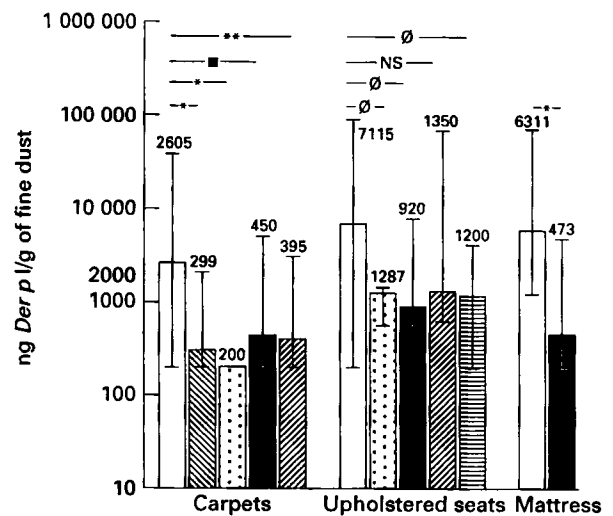


Fig. 1. Geometric means and ranges of *Der p I* levels (ng/g of fine dust) from different sampling sites in domestic households, public buildings and public transport. The numbers given are geometric means. * $P < 0.001$. ■ $P < 0.01$. Ø $P < 0.025$. ** $P < 0.05$. □. Home. ▨. School. ▤. Pub. ■. Hotel. ▩. Cinema. ▪. Public transport.

House dust mite allergen

Dust samples with *Der p I* level below the lower limit of detection of the assay (200 ng/g) were assigned a value of 200 ng/g for further analysis. The concentration of *Der p I* was below 200 ng/g in the carpet samples from all of the six pubs and two trains, 16/20 (80%) of the classrooms, 3/4 (75%) of the cinemas and 6/10 (60%) of the hotel rooms.

Figure 1 demonstrates the concentration of *Der p I* (geometric mean and range) in different sites in various public places. *Der p I* was greater than 2000 ng/g in 3/42 (7%) of the carpets sampled, but less than 10 000 ng/g in all of them. However, *Der p I* > 2000 ng/g was found in 10/33 (30%) of the upholstered seats, three of them (all cinema seats) having the concentrations greater than 10 000 ng/g.

The mean allergen levels of public places were compared with corresponding sites in domestic dwellings. *Der p I* concentration was significantly higher in the dust from home carpets (geometric mean 2605 ng/g, 95% CI 1394–4865) than in the carpeted floors from public places (geometric mean 284 ng/g, 95% CI 235–343) ($P < 0.0001$) and in the upholstered furniture in homes (geometric mean 7115 ng/g, 95% CI 2540–19330) than in upholstered seats from public places (geometric mean 1313 ng/g, 95% CI 1096–1556) ($P < 0.001$).

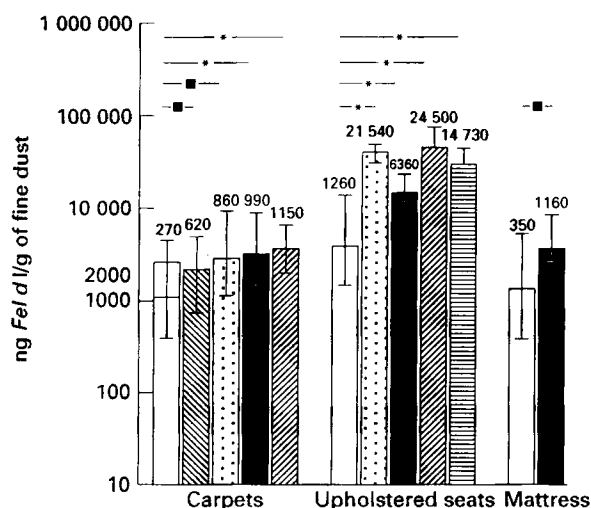


Fig. 2. Geometric means and ranges of *Fel d I* levels (ng/g of fine dust) from different sampling sites in domestic households, public buildings and public transport. The numbers given are geometric means. * $P < 0.001$. ■ $P < 0.01$. □. Home. □. School. □. Pub. ■. Hotel. □. Cinema. ▨. Public transport.

Cat allergen

Fel d I was present in all dust samples collected from public places and transport, ranging from 0.17 to 45.6 $\mu\text{g/g}$.

The concentrations of *Fel d I* in the dust samples from different sites (geometric mean and range) is shown in Figure 2.

Fel d I levels were higher in the dust from upholstered seats (geometric mean 14.88 $\mu\text{g/g}$, 95% CI 11.75–18.84) than in carpeted floors (geometric mean 0.75 $\mu\text{g/g}$, 95% CI 0.59–0.91) ($P < 0.001$). The same was found when comparison in *Fel d I* concentration was made between carpets and upholstered seats within each of the public buildings ($P < 0.001$). In hotels, the concentration in mattresses was lower than in soft furniture ($P < 0.001$).

Fel d I was greater than 8 $\mu\text{g/g}$ in 26/33 (79%) of the upholstered seats or furniture in public buildings and public transport. Levels lower than 8 $\mu\text{g/g}$ were only found in seven soft chairs or sofas in hotel rooms.

Allergen levels in public places was compared with corresponding sites in private homes. *Fel d I* was significantly higher in the carpets from public places (geometric mean 0.73 $\mu\text{g/g}$, 95% CI 0.59–0.91) than in carpets from the homes without a cat (geometric mean 0.27 $\mu\text{g/g}$, 95% CI 0.21–0.36) ($P < 0.001$) and in the upholstered seats from public places (geometric mean 14.88 $\mu\text{g/g}$, 95% CI 11.75–18.84) than in upholstered furniture from private homes (geometric mean 1.26 $\mu\text{g/g}$, 95% CI 0.97–1.63) ($P < 0.0001$).

Discussion

The benefit of allergen avoidance to patients with atopic disease already sensitized to the allergen has been clearly demonstrated, and is associated with symptomatic improvement and reduction in airway hyper-reactivity and medication [10–12]. When mite sensitive asthmatics move to altitude, or the mite free environment of a hospital, their asthma improves [13,14]. Allergen avoidance is therefore widely recommended for the treatment of established asthma where a particular causal allergen can be identified. There are a wide number of suggested methods of mite and cat allergen avoidance, summarized in a Position paper of The British Society of Allergy and Clinical Immunology [1], some being more effective [15] than others [16]. In general, those which are most successful are also the most inconvenient and cause most interference with lifestyle (particularly the changes in house design and removal of the family pet). Considerable effort is put into creating a low allergenic load at home, with the assumption that the exposure to domestic allergens occurs in domestic dwellings.

Most Americans spend more than 90% of their time inside a building of one kind or another, and an additional 5% in transport [17]. Children spend a large part of the day in school. This raises concern about the potential adverse health effects of indoor allergen levels not only within domestic dwellings, but also in public buildings and transport.

Green *et al.* reported recently that mite numbers and mite allergen levels in the dust from carpets or seats in public buildings are much lower than levels in carpets or beds in private houses [18]. The results of the current study are in accordance with this, although it is noteworthy that occasionally very high levels of *Der p I* were found (up to 72 500 ng/g) in cinema seats. The finding of high concentration raises the question of whether this is a significant trigger of asthma in mite sensitive asthmatics attending cinemas.

It is unclear why *Der p I* concentrations are significantly higher in homes than in comparable sites in public places. The indoor environment of public buildings differs significantly from the domestic environment. It is possible that the differences in relative humidity or the frequency of cleaning might play an important role in preventing mite population growth in public buildings [18]. It has been reported that 36% of the kindergarten schools in Germany had concentrations of *Der p I* in dust samples >2000 ng/g [19]. We collected samples from 20 carpeted classrooms in five schools, and only in one case did the *Der p I* level exceed the proposed level for sensitization of 2000 ng/g [4]. None of these

schools had upholstered furniture in the classrooms (it is, however, interesting that *Der p I* level in the upholstered chairs in the school staff rooms ranged between 3800–9750 ng/g). The upholstered furniture in the staff room was vacuum-cleaned considerably less often than classroom floors and chairs (personal communication, head teachers). Increased frequency of vacuum cleaning of the upholstered seats in cinemas, hotels and public transport would be desirable. The level of mite allergens in public places and transport may not be sufficient to result in a significant airborne exposure. With current techniques, it is not possible to assess the effect of such exposure on domestic allergen avoidance measures.

It has been previously reported that cat allergen can be found in virtually all homes, and although there were significant differences in allergen content in homes with and without cats, surprisingly high levels of *Fel d I* were found in many homes that were without a cat [7]. Measurable amounts of *Fel d I* were also found in the carpets of various types of public places [20]. In the current study, the amount of cat allergen in the dust from carpets in Manchester public places was similar to that found in Michigan [20]. *Fel d I* from the floors in five schools was comparable to the levels in four schools in Sweden [21]. We tried to monitor cat allergen level on the classroom chairs. However, the amount of dust collected was insufficient to prepare extracts, probably due to the fact that it was routine to clean the chairs, as well as the floors. It is unlikely that relatively low levels of *Fel d I* found in the dust from classroom carpets can result in a significant airborne exposure.

We found very high *Fel d I* levels in virtually all upholstered seats in hotels, cinemas, pubs and public transport. It has been suggested that cat allergen is transported into houses without cats on the clothes of inhabitants, or the cat owners who come to visit [7]. Higher levels of *Fel d I* were found on chairs than on floors in Swedish schools, probably as a result of children and teachers carrying it on their clothing [21]. Our data support this hypothesis. Significantly lower *Fel d I* levels were found on floors than on chairs, probably because the chairs were contaminated by the direct contact with clothing of cat owners. Poor cleaning of these sites contributed to the build-up of allergen. Mattresses are as good allergen reservoirs as upholstered furniture or seats. However, hotel mattresses had the same *Fel d I* concentrations as carpets, but significantly lower than the soft furniture. This is likely to be due to the fact that in comparison to sofas or chairs, mattresses are not in the direct contact with clothes which can be contaminated with cat allergen.

It is not known what level of cat allergen causes sensitization in susceptible individuals. Levels $>8 \mu\text{g}$ *Fel d I*/g of dust are associated with symptoms in

patients with asthma [22]. This proposed threshold was exceeded in all upholstered seats from cinemas, pubs and public transport. Particles that carry *Fel d I* are often less than $2.5 \mu\text{m}$ in diameter and are capable of penetrating deeply into the lung [23]. Only a modest level of disturbance is needed to dramatically increase the airborne concentration of cat allergen [17]. Upholstered seats in public buildings and transport may constitute a significant reservoir for the continuous contamination of the indoor environment. This can have a major implication for patients employing cat allergen avoidance, particularly if it involves the complete removal of the family pet. Significantly higher *Fel d I* levels were found in public places than in comparable sites in the homes without a cat. The effort spent on cat allergen avoidance measures could be compromised by the exposure in indoor environment of public buildings and public transport. It is impossible to prevent cat allergen being brought into public places. However, thorough cleaning not only of the floors, but of upholstered seats in particular, could reduce the build-up of *Fel d I*. Careful choice of vacuum cleaners is important, since those with single-thickness paper bags leak significant amounts of cat allergen, unlike those with double-thickness dust bags and an electrostatic filter over the exhaust [24].

In conclusion, although *Der p I* levels in the dust from public places and transport were lower than the levels in comparable sites in private households, occasionally very high values were found. In addition, high concentrations of *Fel d I* in upholstered seats from public buildings and transport suggest that they constitute a reservoir for continuous contamination of the indoor environment which could compromise the effects of allergen avoidance employed at home. The fact that *Fel d I* is significantly higher in seats than on floors would suggest that it is dispersed from the clothing of cat owners. It would be important to avoid the introduction of soft furnishing where possible (e.g. classrooms) to avoid creation of reservoirs for the build-up of domestic allergens, and to employ thorough cleaning procedures with appropriate equipment in order to reduce their concentration in the indoor environment of public buildings and public transport.

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