

House dust mites (Der p 1, Der f 1), cat (Fel d 1) and cockroach (Bla g 2) allergens in indoor work-places (offices and archives)

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Abstract

Background: Exposure to indoor allergens has already been shown to occur in many public places, including workplaces, in several countries. Aim of this study was to measure the levels of house dust mites, cat and cockroach allergens in indoor workplaces (offices and archives) in Italy and to evaluate the possible relationships between allergen levels and building characteristics, type of ventilation, indoor relative humidity and temperature. **Methods:** Der f 1 and Der p 1, Fel d 1, Bla g 2 were measured by ELISA in dust samples collected from floors or upholstered seats of 160 workplaces. **Results:** Detectable Der p 1 levels were found in 86 (54%) workplaces Der f 1 in 87 (55%), Fel d 1 in 86 (54%) and Bla g 2 in 3 (1.9%). Der p 1 allergen concentrations expressed per weight were higher than the proposed sensitization thresholds in 7 samples, Der f 1 in 5, Fel d 1 in 6 and Bla g 2 in 3. The highest allergen levels were detected in samples from upholstered seats. A significant correlation was found between Der f 1 level on floors, expressed per surface, and indoor temperature ($r=0.39$; $P<0.01$). **Conclusions:** In our study we found that upholstered seats in workplaces in Italy may constitute a significant reservoir both of house dust mites and cat allergens. Exposure to these allergens in workplaces may represent a risk factor for elicitation of symptoms and/or induction/maintenance of inflammation in allergic individuals and might also constitute a risk factor for sensitization.

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1. Introduction

Exposure to indoor allergens, such as house dust mites (HDM), pets and cockroach is an important risk factor for sensitization and respiratory allergy in most part of the world. This is particularly relevant in Westernized countries where people spend most of their time, on average 20–22 h a day, indoor (Platts-Mills, 1994) and where exposure levels are thought to have increased with the modernization of housing design (warm houses with extensive furnishing and low ventilation rates) (Platts-Mills et al., 1997).

There is evidence of a dose–response relationship between indoor allergen exposure and symptom elicitation in sensitized subjects with asthma and rhinitis. Such relationship is not very strict because assessment of exposure in environmental surveys may not be very accurate and because response to exposure to allergens is extremely variable between individuals. However, risk exposure thresholds have been defined and employed for characterization of environmental exposure both for house dust mites and cats. A level of 10 $\mu\text{g/g}$ of dust for HDM group I allergens has been proposed as risk threshold for elicitation of asthma (Platts-Mills, 1994). As concerns cat allergen, it had been proposed that Fel d 1 levels of 8 $\mu\text{g/g}$ of dust should be considered a threshold level for asthma for elicitation of symptoms, while levels less than 1 $\mu\text{g/g}$ should not be clinically relevant (Platts-Mills, 1990).

A dose–response relationship between indoor allergens exposure and sensitization is accepted for house dust mites. A threshold level for risk of sensitization has been proposed at 2 $\mu\text{g/g}$ of dust (Sporik and Platts-Mills, 2001), though recent papers suggest that exposure to lower allergen levels is required to avoid sensitization (Warner et al., 1996; NIH/WHO, 2002).

For other indoor allergens, e.g. cat and dog, such relationship is controversial. For instance, as concerns cat allergen exposure, recent reports seem to indicate that in children the presence of a pet in the home in the first years of life might reduce the risk of sensitization and asthma (Platts-Mills et al., 2001).

Exposure to indoor allergens takes place mainly in domestic dwellings, but several data have shown that significant exposure to domestic allergens can occur outside homes in other indoor environments, such as hospitals, schools, hotels, cinemas and public transports.

The concentrations of indoor allergens in public places have already been investigated in the UK (Custovic et al., 1994, 1996, 1998), Sweden (Almqvist et al., 1999), France (Dornelas de Andrade et al., 1995), Finland (Partti-Pellinen et al., 2000), USA (Sporik et al., 1999), New Zealand (Patchett et al., 1997; Wickens et al., 1997), Singapore (Zhang et al., 1997), Australia (Green et al., 1992). Allergen levels have been found generally low but occasionally very high in upholstered furniture.

At present no data are available in Italy.

Respiratory symptoms are a common complaint among office workers both when they work at their desk and when they have to consult documents in archives.

In this study we aimed to measure the levels of HDM, cat and cockroach allergens in indoor workplaces (floor and upholstered-seats samples from offices and archives of banks, and from headquarters of a highway-company and of a media-company) in Italy, and to evaluate the possible relationships between allergens levels and environmental characteristics (geographical location, floor above ground, type of ventilation, indoor relative humidity and temperature).

2. Material and methods

2.1. Sampling sites

One hundred and sixty dust sampling were performed in work-places between 1998 and 1999 (59 in Northern Italy, 68 in Central Italy and 33 in Southern Italy). 22 sites were <10 km from sea, in the remaining cases the climate was continental. 119 samples were from offices (99 from floors and 20 from upholstered seats): 77 from banks, 32 from headquarters of a media-company and 10 from headquarters of a highway-company; 41 samples (all from floors) were from bank archives.

Information was collected on building characteristics (floor above ground, air conditioning, presence of windows) by means of a questionnaire.

Indoor temperature and relative humidity were measured by a wet bulb thermometer and a dry bulb thermometer (psicrometric method).

2.2. Dust collection and analysis

Collection was performed as described by Dreborg et al. (1995). Briefly, trained technicians collected the samples in a standardized manner by means of a dust collection device containing a cellulose filter (ALK Laboratories, Horsholm, Denmark) connected to a HEPA filter vacuum cleaner (1200 W). The ALK filter retains 74% of particles 0.3–0.5 μm in size, 81% of particles 0.5–1 μm , 95% of particles 1–10 μm , and 100% of larger particles (Johansen et al., 1990). Four square meter of the office floors and the upholstered chairs were vacuumed for a time of 2 min for each m^2 . Dust sampling was performed at least 48 h after routine cleaning.

Dust samples were sieved to remove large particles by means of a 300 μm sieve and weighted. The dust was extracted together with the filter paper by agitation in dust extraction buffer (0.125 M ammoniumhydrogencarbonate buffer + 0.1% sodium azide) (ALK Laboratories, Horsholm, Denmark), in a 1:100 dust weight/volume ratio for 2 h at room temperature (15–30 $^{\circ}\text{C}$). The suspension was centrifuged for 15 min at $1000\times g$ and supernatants stored at -20°C until analysis.

Allergen content of the supernatant was measured by DUSTSCREEN (CMG, Fribourg, Switzerland) (de Weck et al., 1998). Briefly, dust extract was incubated in a special incubation tray with nitrocellulose strips loaded at various points with monoclonal antibodies specific each for some indoor allergen for 1 h at room temperature on a horizontal shaker. After washing, strips were incubated for 2 h at room temperature on a horizontal shaker with revealing monoclonal antibodies directed against the same allergens labeled with horseradish peroxidase. After another washing, strips were incubated with a chromogen/substrate solution for 15 min at room temperature on a horizontal shaker and washed. Sticks were let dry

for 30 min and results evaluated with a densitometer.

The detection limits of the assay were 0.05 $\mu\text{g/g}$ for Der p 1 and Der f 1, 0.01 $\mu\text{g/g}$ for Fel d 1 and 0.5 U/g 1 for Bla g 2.

2.3. Expression of results

Results were expressed and analysed as $\mu\text{g/g}$ fine dust for Der p 1, Der f 1, Fel d 1, and as U/g fine dust for Bla g 2. The levels of the same allergens were also expressed and analysed, as concentrations per surface ($\mu\text{g}/\text{m}^2$ and μ/m^2) (obtained by multiplying the above concentrations with the weight of collected dust).

Levels of HDM allergens were compared with the two proposed risk threshold for Group I allergens: 2 $\mu\text{g/g}$ and 10 $\mu\text{g/g}$ (threshold for sensitization and elicitation of symptoms of asthma, respectively). Levels of cat allergens were compared with the two risk threshold of 1 and 8 $\mu\text{g/g}$ of dust. Results are also expressed as number of samples exceeding these thresholds.

2.4. Statistical analysis

The different parameters did not approach a normal distribution, even after log transformation. Results were expressed as median, 1st–3rd quartiles.

Non-parametric Mann–Whitney U test was used to evaluate associations between Der p 1 and Der f 1 levels and geographical location, floor above ground, type of ventilation (natural vs. forced). Correlations between Der p 1 and Der f 1 levels and temperature and relative humidity were assessed by means of Spearman correlation coefficient (ρ). Statistical analysis was performed with SPSS for Windows.

3. Results

3.1. Characteristics of work-places

One hundred and one samples were from work-places at the groundfloor, 23 on the first floor, 11 on the second and 25 on floors above the second. Fifty-eight (36%) samples were from work-places

Table 1
Concentrations of Der p 1, Der f 1, Fel d 1, Bla g 2

Allergen	Concentration (median, 1st–3rd quartiles; max)	No. of samples with detectable allergens Floors (<i>n</i> = 99) (<i>N</i> /%)	No. of samples with detectable allergens Archives (<i>n</i> = 41) (<i>N</i> /%)	No. of samples with detectable allergens Chairs (<i>n</i> = 20) (<i>N</i> /%)
Der p 1	0.08, 0.05–0.25; 19.5 µg/g	42/42	25/60	19/95
Der f 1	0.09, 0.05–0.41; 77.5 µg/g	50/50	21/51	16/80
Fel d 1	0.025, 0.01–0.2; 5.5 µg/g	74/74	1/2	11/55
Bla g 2	nd, nd–nd; 25 µg/g	2/2	1/2	0/0

nd = Non detectable.

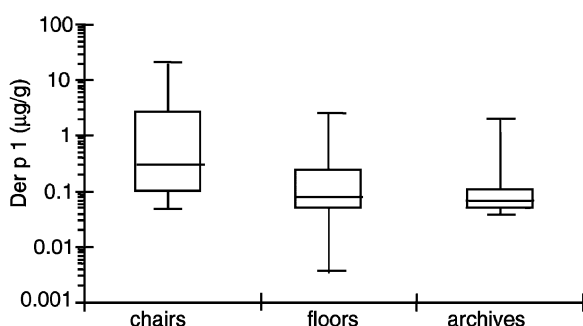


Fig. 1. Der p 1 concentrations in dust samples (chairs vs. floors: $P < 0.001$; chairs vs. archives $P < 0.001$).

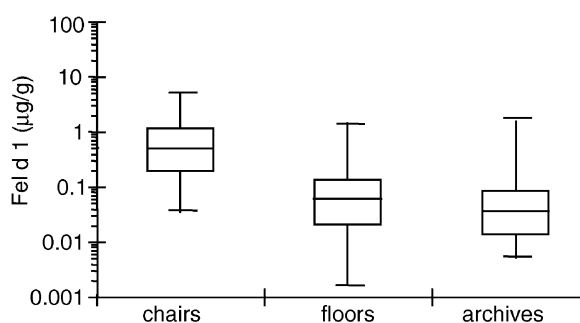


Fig. 3. Fel d 1 concentrations in dust samples (chairs vs. floors: $P < 0.001$; chairs vs. archives $P < 0.001$; floors vs. archives $P < 0.001$).

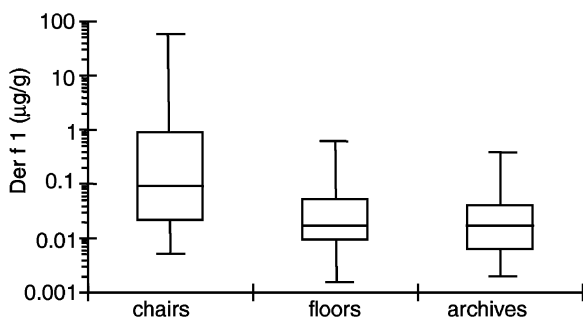


Fig. 2. Der f 1 concentrations in dust samples (chairs vs. floors: $P < 0.001$; chairs vs. archives $P < 0.001$).

with ventilation through windows, 63 (39%) from work-places with air conditioning, the remaining were from work-places without air exchange. Temperature ranged 19.1–26.3 °C (mean: 23.2 °C), relative humidity 21–68% (mean: 39%).

3.2. Distribution and levels of indoor allergens

Concentrations of Der p 1, Der f 1, Fel d 1, Bla g 2 are shown in Table 1. The highest allergen levels were detected in samples from upholstered seats (Figs. 1–3).

Allergen concentrations expressed per weight were higher than the proposed sensitization thresholds in 8/160 (5%) samples for Der p 1 (6 from upholstered seats, 1 from archives floor, 1 from office floor), in 6/160 (3.7%) for Der f 1 (4 from upholstered seats and 2 from archives floor), in 6/160 (3.7%) for Fel d 1 (4 from upholstered seats and 2 from office floors) and in 3/160 (1.8%) for Bla g 2 (2 from office floor and 1 from archives floor). House dust mites allergen concentrations exceeded the proposed threshold for elicitation of symptoms in only one sample for Der p 1 (19.5 µg/g of dust) and in one sample

for Der f 1 (77.5 $\mu\text{g/g}$ of dust). Both samples were from upholstered chairs.

No association was found between the concentration of mite allergens and the environmental characteristics (geographic location, floor above ground, type of ventilation).

A significant correlation was found between Der f 1 levels on floors and indoor temperature ($r=0.39$; $P<0.01$) when levels were expressed per surface. No correlation was found when levels were expressed per weight.

No correlation was found between indoor humidity and allergen levels.

4. Discussion

Levels of HDM, cat and cockroach allergens in dust samples collected in indoor work-places (offices and archives) in Italy were significantly lower than those previously found in domestic dwellings in Italy (Moscato et al., 2000).

Levels of HDM and cat allergens were detectable in a high percentage of work-places, while cockroach allergens were found only in a very low number of samples.

Allergen levels exceeded the proposed thresholds for sensitization in a small number of work-places, and concentrations were significantly higher on upholstered chairs than on floors.

Exposure to indoor allergens takes place mainly in domestic environment.

However, public places and particularly offices often share with domestic dwellings many characteristics favouring house dust mite growth, such as human presence, type of furniture, location (offices are often contiguous to flats), levels of temperature and humidity. Thereby, it was not surprising to detect these allergens in a large proportion of offices. However, the levels of Der p 1 and Der f 1 were higher than the threshold level regarded as a risk for sensitization (2 $\mu\text{g/g}$) in a small proportion of samples (5% and 3.7%, respectively), and exceeded the proposed significant level for acute attack of asthma in mite sensitive asthmatic patients (10 $\mu\text{g/g}$) only in two samples. Nevertheless, in the latter the levels were very high, showing that occasionally a significant exposure to HDM allergens may also occur at the

work-place. In contrast to our previous data in homes (Moscato et al., 2000), it is interesting to note that in this study no difference was found between Der p 1 and Der f 1 levels.

In the current study HDM allergens levels were lower than those detected in various public places in the UK (Custovic et al., 1994, 1996), USA (Sporik et al., 1999), New Zealand (Wickens et al., 1997), Singapore (Zhang et al., 1997), Australia (Green et al., 1992), while they were comparable to those found in France (Dornelas de Andrade et al., 1995) and higher than in Finland (Partti-Pellinen et al., 2000).

This finding could be partly related to the different sampling sites, e.g. mostly floors in our study, whereas in previous studies dust was mostly collected from upholstered seats. In fact, when we considered upholstered seats separately, allergen levels were higher than on floors, and more similar to those of previous reports.

Upholstered seats have been reported as a reservoir of indoor allergens in most studies (Custovic et al., 1994; Dornelas de Andrade et al., 1995; Wickens et al., 1997; Zhang et al., 1997; Munir et al., 1993). Our results are in agreement with these findings. However, archives floors had the lower allergen levels. This may be due to the fact that in archives human presence and temperature (both factors favouring HDM growth) are reduced.

Considering other possible factors related to building characteristics that might have influenced the HDM allergen concentrations in our study, only a correlation between Der f 1 levels and temperature was found. This reflects the well-known influence of high temperatures on mite growth. It is noteworthy that the correlation was found only with the concentration per surface and not per weight. As we have previously reported, this suggests that expressing allergen levels per surface might better represent the level of exposure since the weight of dust may be affected by several factors, including dust and particles carried on the floor by people (Moscato et al., 2000).

Cat allergens also represent a risk factor for eliciting symptoms of asthma in allergic individuals in public places as it has recently been reported in day-care centers (Dornelas de Andrade et al., 1995; Zhang et al., 1997), schools (Almqvist et

al., 1999; Sporik et al., 1999; Patchett et al., 1997; Zhang et al., 1997; Almqvist et al., 2001), hospitals (Custovic et al., 1998; Zhang et al., 1997), public transport (Partti-Pellinen et al., 2000).

It has been demonstrated that allergens can be transported into environments where cats have never been present through the clothes of cat owners (Patchett et al., 1997; D'Amato et al., 1997; De Lucca et al., 2000).

The concentrations of cat allergens found in our study were generally lower than those detected in various public places in the UK (Custovic et al., 1994, 1998), France (Dornelas de Andrade et al., 1995), Finland (Partti-Pellinen et al., 2000), USA (Sporik et al., 1999), New Zealand (Patchett et al., 1997), Singapore (Zhang et al., 1997). Levels exceeded the lower proposed threshold (1 $\mu\text{g/g}$) for elicitation of symptoms in 3.7% of samples, and, in agreement with most previous studies, were significantly higher on upholstered seats than on floors (Custovic et al., 1994; Dornelas de Andrade et al., 1995; Partti-Pellinen et al., 2000; Zhang et al., 1997).

Again these findings could be related to the prevalence of samples from floors in our study.

Cockroach allergens were detectable only in a few samples. This finding confirms that cockroach cannot be considered an important risk factor for allergy in Italy and is in agreement with the finding of a low prevalence of sensitization to this allergen in a multicentric Italian study, where cross reactivity with HDM allergens accounted for the majority of positive prick test to cockroach (Riario-Sforza et al., 1997).

The role of indoor allergen exposure in respiratory allergy is well recognized.

The benefit of allergen avoidance in sensitized subjects with respiratory allergy has been clearly demonstrated and is associated with symptomatic improvement and reduction in airway hyperreactivity and medication. Allergen avoidance is particularly recommended as a primary intervention in the management of allergic asthmatics (NIH/WHO, 2002).

In this study mite allergen levels were negligible, confirming that, generally, the bulk of exposure occurs in the domestic dwelling. However, the concentrations occasionally found in some

work-places in our study may be high enough to worsen or maintain inflammation in the mucous membranes of the airways and to elicit or aggravate symptoms of asthma. Therefore, the control of HDM allergen levels at the workplace and of rigorous cleaning procedures aimed to diminish these levels are recommended.

As concerns cat, the importance of exposure to low levels in public places may be more relevant. If we consider the case of a cat sensitized subject who has been able to reduce exposure at home, exposure levels in the workplaces may overcome those at home. In fact, significantly higher Fel d 1 levels have already been found in public places than in comparable seats in the homes without a cat (Custovic et al., 1998). Since it is impossible to prevent cat allergens being brought into public places, efforts should be put to minimize the risk. Since chairs are an important reservoir of allergens, increased vacuum cleaning of upholstered chairs in offices is recommended.

In conclusion, in our study we found generally low levels of indoor allergen in offices/public places. However, on upholstered chairs levels were significantly higher and constitute a significant reservoir both of house dust mite and cat allergens. In particular cases exposure to these allergens may represent a risk factor for sensitization, elicitation of symptoms and/or induction/maintenance of inflammation. Therefore, it would be important to limit the number of soft furnishing in offices to avoid creation of reservoirs for indoor allergens.

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