

Mite and pet allergen exposure in hotels in Uberlândia, Midwestern Brazil

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Abstract Mite allergens are involved in airway sensitization and allergic diseases. We evaluated the exposure to house dust-mite (Der p 1 and Der f 1) and pet (Fel d 1 and Can f 1) allergens in hotels in Uberlândia, Midwestern Brazil. A total of 140 dust samples were collected from bedding ($n = 98$) and carpet ($n = 42$) of bedrooms in 20 hotels enrolled for this study. Geometric mean (GM) levels of Der f 1 (11.30 $\mu\text{g/g}$ of dust; 95% CI: 8.34–15.30 $\mu\text{g/g}$) were significantly higher than Der p 1 (0.15 $\mu\text{g/g}$ of dust; 95% CI: 0.13–0.18 $\mu\text{g/g}$) in bedding dust samples ($P < 0.001$), regardless of the hotel classes. Der f 1 levels were significantly higher in bedding (11.30 $\mu\text{g/g}$ of dust; 95% CI: 8.34–15.30 $\mu\text{g/g}$) than carpet (6.32 $\mu\text{g/g}$ of dust; 95% CI: 4.31–9.26 $\mu\text{g/g}$) dust samples ($P < 0.05$). High levels of Der f 1 ($> 10 \mu\text{g/g}$ of dust) were found in 58%, 76%, and 69% of dust samples from Simple, Economical, and Tourist/Superior hotels, respectively, while GM levels of Fel d 1 (0.11 $\mu\text{g/g}$ of dust; 95% CI: 0.09–0.14 $\mu\text{g/g}$) and Can f 1 (0.30 $\mu\text{g/g}$ of dust; 95% CI: 0.20–0.44 $\mu\text{g/g}$) were relatively low. These results indicate that Der f 1 is the predominant allergen in hotels in Uberlândia, especially in bedding dust samples, regardless of the hotel classes and could represent an important risk factor for exacerbation of allergic symptoms in previously mite-sensitized guests.

Practical Implications

Mites and pets are important sources of indoor allergens. Most people spend the greatest part of their time indoors. Hotels can constitute an important allergen reservoir of the indoor environment and could represent an important risk for exacerbation of allergic symptoms in previously sensitized guests. Thus, hotels should also be included for planning indoor allergen avoidance as part of a global management strategy, especially in patients with respiratory allergy.

Introduction

In recent decades, there has been a change in both lifestyles and environmental quality, particularly in economically developed and rapidly developing western countries (Jones, 1998). Most people spend the greatest part of their time indoors, thus favoring a constant contact with potential indoor allergen reservoirs such as fitted carpets, upholstered furniture, curtains, pets, and artificial air ventilation systems as

air conditionings (Carrer et al., 2001). Thus, these alterations in the modern indoor environments may be contributing to a worldwide increase in the prevalence of morbidity and mortality of allergic diseases, especially atopic asthma and rhinitis, in genetically susceptible individuals (Platts-Mills et al., 1996), although this is a theory that to date has not been conclusively demonstrated.

Dermatophagoides pteronyssinus and *Dermatophagoides farinae* are the main sources of allergens in indoor

environments (Kaliner and White, 1994), although the predominance of these species can vary in different geographical areas (Arruda et al., 1991; Sopelete et al., 2000). Several studies have reported a strong relationship between asthma and house dust-mite (HDM) allergens, showing a dose-dependent correlation between HDM concentration and sensitization rate in susceptible individuals (Platts-Mills, 1995). Thus, a threshold of 2 $\mu\text{g/g}$ of dust of group 1 HDM allergens has been considered a risk factor for sensitization in genetically predisposed individuals (Platts-Mills et al., 1992). However, lower or no threshold has also been suggested (Custovic and Chapman, 1998; Platts-Mills et al., 1992).

It is known that HDMs and their allergens are preferentially distributed on bedding (mattresses, pillows) and to a lesser extent on upholstered furniture (van Strien et al., 1994). The knowledge of this relative allergen distribution is most relevant when treating HDM allergic patients, with the priority given to those sites which contribute significantly to the total load of HDMs and their allergens in different environments (Sidenius et al., 2002), including private houses or public places, such as hotels, schools, day-care centers, hospitals, churches, cinemas, and offices.

In addition to mite allergens, pet allergens have been implicated in the development of allergic diseases in several countries, especially the Fel d 1 allergen originated from cat (*Felis domesticus*) and the Can f 1 allergen derived from dog (*Canis familiaris*) danders. Cat and dog allergens may be found in houses and public places where no pets are kept, but are deposited by passive transport on clothes (De Lucca et al., 2000). The aim of this study was to evaluate the mite and pet allergen exposure in hotels in the city of Uberlândia, Brazil, as the knowledge of allergen levels in these public places is important for planning indoor allergen avoidance as part of a global management strategy in allergic patients.

Method

Hotels

Twenty hotels were selected among a total of 46 hotels in the city of Uberlândia (altitude 863 m), Midwestern Brazil for a study on allergen exposure. The hotel selection was based on hotel classes according to the Brazilian Association of the Hotel Industry criteria and the hotels were classified in four classes as follows: (1) Simple ($n = 4$), with simple accommodation and basic services or even overnight stay only; (2) Economic or ** stars ($n = 9$), with modest accommodation, food and beverage services and room available for meetings; (3) Tourist or *** stars ($n = 6$), with installation and equipments of good quality, complete food and beverage services with some restriction related to prede-

termined time; and (4) Superior or **** stars ($n = 1$), with installation and equipments of very good quality, food and beverage services during 24 h, bar service, installation and equipments for meetings, qualified and trained employees and areas for entertainment and work. Only one hotel was included in the Superior class because there was just one hotel in this category at that time. Informed consent was obtained from hotel owners or managers for the dust collection in the hotel bedrooms, and the confidentiality of the hotels was maintained. No hotel manager showed any refusal to participate in this study and pets were not allowed in any of these hotels.

Dust sampling and allergen extraction

Dust sampling was carried out between June and October 2002 in five randomly selected bedrooms after a room cleaning of each hotel included in the study. A total of 140 dust samples were obtained from bedding ($n = 98$), including mattress and pillow samples as one composite dust sample from each room, and from fitted carpets ($n = 42$), if there was carpet on the bedroom floor. Thus, the smaller number of carpet samples was due to the fact that some hotels did not have carpeted floors, which were predominantly found in tourist and superior hotels. Dust samples were collected by using a vacuum cleaner (Electrolux, 1200 W, Manaus, Brazil) with an acrylic adapter containing paper filter for dust retention by vacuuming 1 m^2 from mattress and all pillow surface (bedding samples) and 1 m^2 from carpeted floors (carpet samples) during 2 min. Dust samples were stored at 4°C until further allergen extraction.

Fine dust was obtained by sieving through a 300 μm mesh screen (Standard Sieve Series A.S.T.M., Newark Wire Cloth Co, Newark, NJ, USA). Samples of 100 mg were extracted overnight at 4°C in 2 ml of borate-buffered saline (pH 8.0) and after centrifugation at 10,000 g for 10 min, supernatants were stored at -20°C prior to immunoassays.

ELISA for measuring mite and pet allergen levels

ELISAs for mite (Der f 1 and Der p 1), cat (Fel d 1), and dog (Can f 1) allergens were carried out as described by Sopelete et al. (2000) using the respective capture monoclonal antibodies (mAb) anti-Der f 1 (clone 6A8), anti-Der p1 (5H8), anti-Fel d 1 (6F9), or anti-Can f 1 (6E9) and corresponding detection antibodies consisting of biotinylated anti-group 1 *Dermatophagoides* allergens (4C1), anti-Fel d 1 (3E4C4) mAbs or polyclonal rabbit serum anti-Can f 1. After incubation with streptavidin-peroxidase (Sigma Chemical Co., St Louis, MO, USA) for mite and cat allergens or goat anti-rabbit IgG-peroxidase for dog allergen detection, the assays were developed by adding the

enzyme substrate (0.01 M 2,2'-azino-bis-3-ethyl-benz-thiazoline sulfonic acid containing 0.03% H_2O_2) and the reaction was read at 405 nm. Reference standards were included in each plate to obtain standard curves ranging from 250 to 0.5 ng/ml for Der f 1 (University of Virginia – UVA 93/03) and Der p 1 (UVA 93/02), from 80 to 0.078 ng/ml for Fel d 1 (UVA 94/02), and from 500 to 0.5 ng/ml for Can f 1 (Indoor Biotechnologies Inc., Charlottesville, VA, USA). Absorbance results were expressed in $\mu\text{g/g}$ of dust as previously described (Luczynska et al., 1989).

Statistical analyses

As the allergen concentrations followed a non-Gaussian distribution even after log transformation, calculations were performed using nonparametric tests. Geometric means (GM) with 95% confidence interval (CI) were obtained for the allergen levels, and the differences between the means were analyzed by the Mann–Whitney U test to compare mean levels in bedding and carpet samples or Kruskal–Wallis using Dunn's multiple comparison test as *post-hoc* test to analyze differences among allergens or hotel classes. Values of $P < 0.05$ were considered statistically significant.

Results

Mite and pet allergens were measured in dust samples collected from bedding ($n = 98$) and carpets ($n = 42$) of the 20 hotels selected for the study (Figure 1). Of these, only 46 and 18 dust samples, respectively,

contained enough dust for measuring the Can f 1 allergen. The GM of Der f 1 levels ($11.30 \mu\text{g/g}$ of dust; 95% CI: $8.34\text{--}15.30 \mu\text{g/g}$) was significantly higher than those found for Der p 1 ($0.15 \mu\text{g/g}$ of dust; 95% CI: $0.13\text{--}0.18 \mu\text{g/g}$) in bedding dust samples ($P < 0.001$). Dust samples from carpets also showed mean levels of Der f 1 ($6.32 \mu\text{g/g}$ of dust; 95% CI: $4.31\text{--}9.26 \mu\text{g/g}$) significantly higher than Der p 1 ($0.12 \mu\text{g/g}$ of dust; 95% CI: $0.09\text{--}0.14 \mu\text{g/g}$) ($P < 0.001$). Most of the bedding samples contained low mean levels of Fel d 1 ($0.11 \mu\text{g/g}$ of dust; 95% CI: $0.09\text{--}0.14 \mu\text{g/g}$) and Can f 1 ($0.30 \mu\text{g/g}$ of dust; 95% CI: $0.20\text{--}0.44 \mu\text{g/g}$). In addition, Der f 1 levels detected in bedding samples were significantly higher than that in carpet samples ($P < 0.01$), but this difference was not observed for Der p 1, Fel d 1, and Can f 1 levels ($P > 0.05$).

Levels of mite and pet allergens detected in bedding dust samples were analyzed according to the different hotel classes (Simple, Economical, and Tourist/Superior) and are illustrated in Figure 2. Again, mean Der f 1 levels were significantly higher than Der p 1 levels in all the hotel classes analyzed ($P < 0.001$), but no significant difference was found among the different hotels for the same allergen ($P > 0.05$).

The highest Der f 1 level from the two sites analyzed (bedding and carpet) in each hotel bedroom was taken as an index of exposure to that allergen. As demonstrated in Figure 3, Der f 1 levels above the threshold value for allergen sensitization ($> 2 \mu\text{g/g}$ of dust) were detected in 100% of dust samples from Simple hotels, 86% from Economical and 86% from Tourist/Superior hotels, with significant differences ($P < 0.001$) in relation to dust samples with Der f 1 levels below the

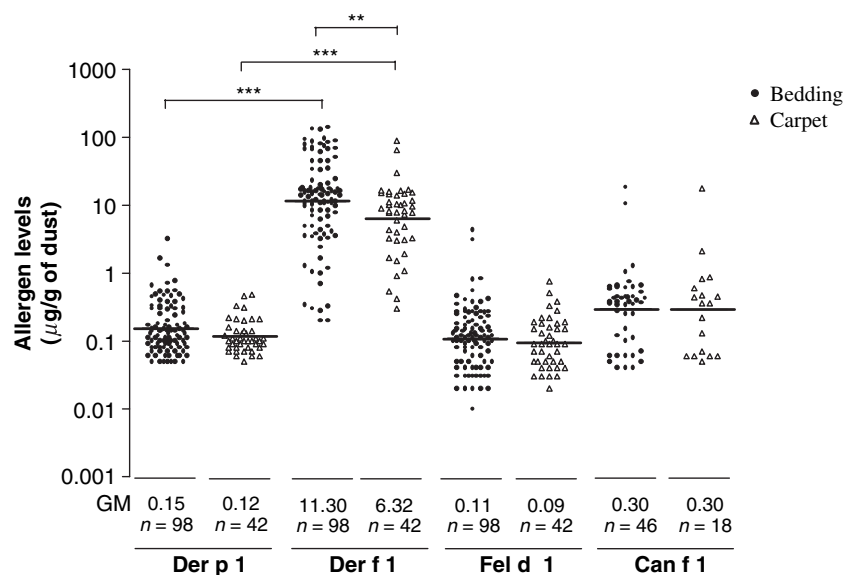


Fig. 1 Allergen levels of *Dermatophagoides pteronyssinus* (Der p 1), *Dermatophagoides farinae* (Der f 1), *Felis domesticus* (Fel d 1) and *Canis familiaris* (Can f 1), expressed in $\mu\text{g/g}$ of dust determined by ELISA in dust samples from bedding and carpet of 20 hotels in the city of Uberlândia, Brazil. The horizontal bars represent the geometric mean (GM). Statistical differences were determined by Kruskal–Wallis using Dunn's multiple comparison test. ** $P < 0.01$; *** $P < 0.001$

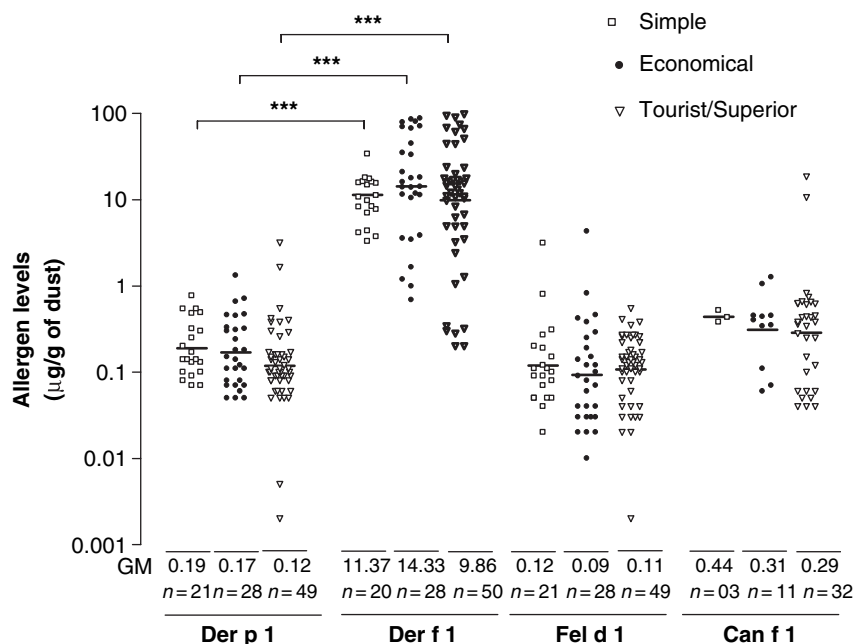


Fig. 2 Allergen levels of *Dermatophagoides pteronyssinus* (Der p 1), *Dermatophagoides farinae* (Der f 1), *Felis domesticus* (Fel d 1) and *Canis familiaris* (Can f 1), expressed in $\mu\text{g/g}$ of dust determined by ELISA in dust samples from bedding of 20 hotels in the city of Uberlândia, Brazil, according to the different hotel classes (Simple, Economical, Tourist/Superior). The horizontal bars represent the geometric mean (GM). Statistical differences were determined by Kruskal–Wallis using Dunn's multiple comparison test. *** $P < 0.001$

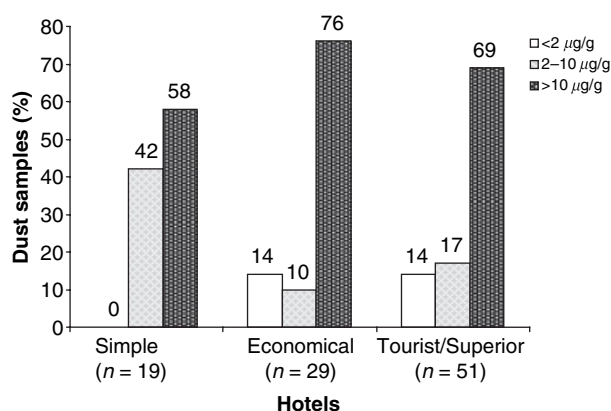


Fig. 3 Percentage of dust samples analyzed as index of exposure for Der f 1 (*Dermatophagoides farinae*) allergen at different ranges (<2, 2–10, >10 $\mu\text{g/g}$ of dust) in Simple ($n = 19$), Economical ($n = 29$), and Tourist/Superior ($n = 51$) hotels in the city of Uberlândia, Brazil

threshold value, but without significant difference among the hotel classes. High levels of Der f 1 (>10 $\mu\text{g/g}$ of dust) were also found in 58%, 76%, and 69% of dust samples from Simple, Economical, and Tourist/Superior hotels, respectively.

Discussion

Over the last century, behavioral pattern of the population has changed considerably, with people spending most of the time indoors, not only at home

but also at workplaces, and consequently little time outdoors (Platts-Mills, 2003). In addition, modern environments are well-insulated and warmer, with indoor upholstered furnishings and fitted carpets. These conditions may be contributing to the production and concentration of indoor allergens, and consequently have been associated with the increase in the prevalence of several allergic diseases, including asthma (Jones, 1998; Platts-Mills, 2003).

Previous studies have established threshold limits of allergen exposure in house dust for allergen sensitization (Platts-Mills et al., 1992). Although these threshold limits were based on a birth cohort of children and allergen exposure in the home, public places as hospitals, schools, cinemas, day-care centers (Green et al., 1992), workplaces (De Lucca et al., 2000), and public transport vehicles (Pereira et al., 2004) have also been considered other potential allergen reservoirs.

In the present study concerning the allergen exposure in hotels, a high index of mite allergen exposure, particularly the Der f 1 allergen, was found in the great majority of dust samples collected from the bedding and carpet in all hotels analyzed. Additionally, bedding dust samples had the highest levels of Der f 1 allergen (GM = 11.30 $\mu\text{g/g}$ of dust), indicating that bedding constitutes the main reservoirs of this allergen in hotel bedrooms. These findings are in agreement with our previous studies on acarologic analyses and allergen exposure carried out in the cities of Uberaba (altitude 801 m) (Terra et al., 2004) and Uberlândia (altitude

863 m) (Sopelete et al., 2000), Brazil, where a higher prevalence of the mite *D. farinae* and its Der f 1 allergen than *D. pteronyssinus* was found in private houses. In the latter study, 70% of the house dust samples showed high levels of Der f 1 allergen ($\geq 10 \mu\text{g/g}$ of dust) compared with 47% of the samples that had similarly high levels of Der p 1 allergen (Sopelete et al., 2000). On the other hand, studies on acarologic analysis in other Brazilian cities have reported the predominance of the mite *D. pteronyssinus* in relation to *D. farinae* in house dust, with respective prevalence rates of 70% and 8% of houses in Salvador (altitude 8 m) (Serravalle and Medeiros, 1999) and 93% and 7.5% of houses in Campinas (altitude 854 m) (Oliveira et al., 1999). Thus, although the mite *D. pteronyssinus* has been demonstrated to play an important role in the allergen exposure and sensitization in susceptible subjects in other Brazilian regions with different or similar altitudes, the species *D. farinae* has been found as the major mite involved in the allergen exposure in Midwestern Brazilian regions, where this study took place. A probable explanation for this difference in the predominance of these mite species can be related to the different climatic conditions. In this context, *D. pteronyssinus* is more frequent in higher humidity (75–80%) regions, particularly in coastal areas as Salvador, while *D. farinae* is more related to the lower humidity (25–75%) regions as inland areas with high mean temperature (25–30°C). Therefore, the relationship between regional climatic conditions and indoor microenvironment rather than altitude can be the determinant factors in the mite population and allergen levels (Oribe and Miyazaki, 2000; Silva et al., 2005).

A number of studies have demonstrated lower mite allergen levels in dust samples from public places such as libraries, airports, passenger trains, hotels, and banks than those found in separate studies of domestic dwellings (Colloff, 1987; Custovic et al., 1994; Green et al., 1992; Wickens et al., 1997a,b). A major factor for high mite allergen levels was related to the type and age of floor covering in private homes, with significantly higher Der p 1 allergen levels in households with older carpets than households with no carpets or newer carpets (Wickens et al., 1997b). Also, in most of public places where the floors were carpeted, a significant association was found between high mite allergen levels and carpeted vs. uncovered floors (Wickens et al., 1997a). Interestingly, the importance of carpets as a major determinant for increasing mite allergen levels in both private homes (van Strien et al., 1994) and public places (Wickens et al., 1997a) was not observed in our study as bedding constituted the major reservoirs of Der f 1 allergen in hotel bedrooms.

In addition to mite allergens, cat allergens have been investigated in public places, where the cat is not present and the allergen is transported by individuals who have these animals at home (De Lucca et al.,

2000). Even though a large variation of pet allergen levels has been found in dust from homes and public places, in our study, Fel d 1 and Can f 1 were predominantly detected at levels $< 1 \mu\text{g/g}$ of dust in both bedding and carpet dust samples in all of the analyzed hotel bedrooms. Although the threshold value ($> 1 \mu\text{g/g}$) for Fel d 1 and Can f 1 has not been proven as a risk factor for sensitization, it has been selected based on the fact that different public places have Fel d 1 and Can f 1 levels in the range of 1–8 $\mu\text{g/g}$ of dust (Tranter, 2005). Thus, our findings suggest that Fel d 1 and Can f 1 allergens could be less clinically relevant for guests with the potential to become allergic or previously sensitized guests of these hotels analyzed.

Levels of mite and pet allergens were analyzed according to the different hotel classes. This relationship was investigated because previous reports have shown that indoor allergen exposure is markedly influenced by the design and management of houses as well as the inhabitants' socioeconomic conditions (Kitch et al., 2000). However, in our study, high levels of Der f 1 were found regardless of the hotel classes analyzed, showing that the luxury and comfort levels of the hotels did not seem to influence the allergen content.

When analyzing Der f 1 at sensitizing levels ($> 2 \mu\text{g/g}$ of dust), the vast majority of bedding and/or carpet dust samples had Der f 1 levels above this threshold value, including high values as much as 10 $\mu\text{g/g}$ of dust or more, regardless of the hotel classes studied. For many people, a hotel stay is brief so that the allergen exposure levels found in hotel bedrooms could not be a risk factor for the allergen sensitization in genetically predisposed guests. However, many long-term hotel guests might already be pre-sensitized and then high allergen levels in hotel bedrooms associated with additional occupational concerns, such as housemaids raising dust everyday by continually vacuuming carpets and changing bedding could represent a risk factor for exacerbation of allergic symptoms in these guests.

Conclusions

- Our results demonstrated that Der f 1 is the predominant allergen in hotels of the city of Uberlândia, an inland Midwestern Brazilian city with temperate climate, and Der f 1 levels were the highest in bedding samples, regardless of the hotel classes.
- Most of the dust samples contained very high levels of Der f 1 allergen that could represent an important risk factor for exacerbation of allergic symptoms in previously mite-sensitized guests.
- The data of this study are useful for the knowledge of the allergen levels in hotels and for planning indoor allergen avoidance as part of a global management strategy in allergic patients.

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