

House dust mite allergen levels in carpeted sleeping accommodation are higher in private houses than public places

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Objective: To compare mite allergen levels in carpeted sleeping accommodation in private dwellings and public places.

Methods: The concentration of *Dermatophagoides pteronyssinus* Group 1 allergen in house dust was measured in mattresses and bedroom floors in 12 homes, 5 hotels, 11 child care centres and a university hall of residence. Indoor temperature and relative humidity were also measured. A questionnaire clarified details regarding the age of the building, age of the carpet, method and frequency of cleaning, frequency of room use and use of air-conditioning.

Results: Median allergen levels in mattresses and carpets in private homes (21.1 and 20.6 µg/g dust, respectively) were significantly higher than in public places (2.5 and 3.1 µg/g, respectively; $P < 0.0001$). Mean relative humidity was significantly higher in private houses (68.5%; 95% CI 67.2–69.3%) than in public places (56.4%; 95% CI 52.7–60.1%; $P < 0.0001$).

Conclusions: Carpeted sleeping accommodation in public places has lower house dust mite allergen levels than private houses. Lower levels of relative humidity may be an important component of the explanation.

Key words: *Dermatophagoides pteronyssinus* Group 1; house dust mite; public buildings.

Exposure and sensitization to *Dermatophagoides pteronyssinus* Group 1 allergen (Der p1), the major allergen from the house dust mite, is a major risk factor for asthma and allergic diseases. Exposure to Der p1 occurs in private houses and, potentially, in public places. Possible factors influencing house dust mite allergen concentrations in private housing have been well studied.^{1–4} The indoor factors influencing concentrations of Der p1 in public places are less well established. A number of studies have found low Der p1 levels in public places compared with levels in domestic dwellings.^{5–10} For example, there are very few mites in British trains,⁶ and dust mite levels in aeroplanes, airport lounges, cinemas and banks are all low.^{5,9} Four studies showed low dust mite levels in hospitals,^{5,7,9,11} although another reported that the carpets in a hospital ward contained house dust mite allergen levels of 30–50 µg/g,¹² well above the levels regarded as a threshold for development of symptoms of asthma.^{1,13} In a New Zealand study, Der p1 levels were much lower in public places than in domestic dwellings, with floor levels primarily affected by floor covering.⁵ In particular, floor Der p1 levels in public places were higher with carpeted floors and lower with recent cleaning. Our interest in the present study was a further exploration of carpeted sleeping accommodation in public places. In particular, we wished to confirm that dust mite allergen levels in carpeted sleeping accommodation were lower in public places than in private

housing, and to explore possible explanations for these differences, such as humidity and method of cleaning carpets.

METHODS

This cross-sectional survey was conducted in the coastal city Newcastle, New South Wales, Australia, in summer and early autumn (January to March).

The private houses and public places were selected from the suburbs under the jurisdiction of Newcastle City Council (NCC). Ten of the 52 suburbs were chosen randomly, covering most of the Newcastle area. Every first and tenth address for each of the suburbs was randomly selected from the 10 suburbs using the local telephone directory. All of the selected households were sent an invitation and a consent form. The owners or occupants of 12 houses (response rate 60%) agreed to participate. Six hotels, 12 child care centres and a single university hall of residence were randomly selected not by suburb, but from a list obtained from the NCC. Five hotels (response rate 83%), 11 child care centres (response rate 92%) and one University hall of residence were included in the present study. The overall response rate in public places (89%) was significantly higher than the private houses (60%; $P = 0.02$, Fisher's exact test). Inclusion criteria were that the private house or public building

was more than 1 year old, was carpeted and had sleeping accommodation.

The concentration of mite allergen in house dust was set as a measure for the exposure to house dust allergen. Dust samples were collected from bedroom carpets, mattress surfaces, pillows, sheep skins and soft furnishings. A portable and modified Makita (4071D) hand held vacuum cleaner (Makita; Silverwater, NSW, Australia,) was used to collect dust samples on reusable 25 µm pore sized nylon mesh bags. For the present study, no bags were reused. Samples were collected from a 1 m² area at each site for a period of 1 min. On two occasions, both in public places, dust was collected for a second minute to obtain an adequate sample. The indoor relative humidity and temperature was measured by a battery-operated thermal-hygrometer (Ratona R-407, Sato, Tokyo, Japan), which measured relative humidity and temperature hourly for 24 h. A semi-structured questionnaire was used to measure the use of air-conditioning and heaters, the frequency of room use, and the frequency and method of cleaning.

The dust samples were sieved through a 450 µm diameter mesh to remove large particles and fibres. Then 50 mg of dust was mixed with 1 ml of 0.1% Tween 20 and 0.2% bovine serum albumin in phosphate buffered saline (pH 7.4). Dust samples were resuspended using a vortex mixer, then the tubes were rotated for 30 min on an orbital rotator. Extracts were centrifuged for 10 min at 2500 r.p.m. at 4°C. The supernatant was transferred to another tube and Der p1 levels were assayed by enzyme-linked immunosorbent assay using a double monoclonal assay antibody kit from Platts-Mills/Chapman (University of Virginia, Virginia, PA, USA) according to standard techniques.¹⁴ Values were expressed as µg of mite allergen per g of fine dust. Dust samples with allergen extracts below the lower limit of detection of the assay were assigned a value of 0.01, corresponding to the approximate lower limit of assay.

The central tendency of the data was expressed as means ± SD (if normally distributed) or medians with interquartile ranges (if non-normal). Student's *t*-test was used for normally distributed data, with Wilcoxon rank sum for non-normal data. Sample size calculations were based on a pilot study, which showed that 12 samples in each group would have 80% power to show significant differences in allergen levels at the 0.05 level.

RESULTS

Dust samples were collected from both the bed mattresses and the bedroom carpet of the 12 private houses. A total of 22 samples from bed mattresses and 19 from bedroom carpets were obtained from the public places. In hotels, we regarded the rooms in the same hotel as different and collected an extra five bedroom mattress samples and three bedroom carpet samples from the same hotel.

Table 1 shows the significantly higher median mite allergen levels in mattresses and carpets in bedrooms of private houses compared to public places. When analysis was confined to single samples taken from mattresses and carpets in public places, the differences were also significant ($P = 0.0001$).

It has been suggested that 2 µg/g of Der p1 should be considered the threshold level for sensitization and 10 µg/g as a level to trigger asthma in individuals who are already sensitized.^{1,13} Only three out of the 41 dust samples collected from public places had Der p1 levels above 10 µg/g. Sixteen out of the 41 samples from public places had levels less than 2 µg/g compared to only three out of 24 samples from private houses ($P = 0.04$, Fishers exact test).

Mean relative humidity was significantly higher ($P < 0.0001$) in private houses (68.5%; 95% CI 67.2–69.3%) than public places (56.4%; 95% CI 52.7–60.1%). A comparison between mite allergen level and relative humidity (Fig. 1) showed that when relative humidity was below 60%, house dust mite allergen levels were significantly more likely to be below 10 µg/g (Fisher's exact test, $P < 0.001$). Even when the relative humidity was greater than 60%, samples from public places were less likely than private houses to have mite allergen levels above 10 µg/g (Fisher's exact test, $P < 0.01$). Average temperatures in public places (25.8°C) and private houses (25.6°C) were similar. Places with air-conditioning did not differ significantly in mean temperature suggesting that the intermittent use of an air-conditioner did not play an important role in modifying ambient air temperature. There were non-significant trends for higher allergen levels in older buildings with older carpets and with more frequent room use, but this did not explain any of the differences between private and public places.

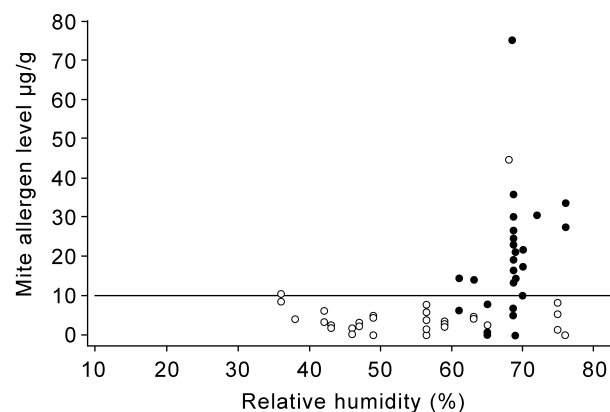


Fig. 1 Mite allergen level and relative humidity. Combined data for private houses (●) and public places (○). The reference line is drawn at 10 µg *Dermatophagoides pteronyssinus* Group 1 per g of dust.

Table 1 Comparison of median dust mite allergen levels (µg/g dust) between 12 private houses and 17 public places

	<i>n</i>	Private houses		<i>n</i>	Public places		<i>P</i>
		Median	Interquartile range		Median	Interquartile range	
Mattresses	12	21.1	15.4–27.8	22	2.51	0.06–5.34	0.0001
Carpets	12	20.6	8.9–22.9	19	3.12	0.31–5.03	0.0001

DISCUSSION

The present study has demonstrated that carpeted sleeping accommodation in bedrooms in public places have lower house dust mite allergen levels than carpeted bedrooms in private houses. Many previous studies that have demonstrated lower house dust mite allergen levels in public places than private houses have considered settings that are very different from the bedrooms of private houses. Although observations of low house dust mite allergen levels in airport lounges, aeroplanes, passenger trains, libraries, cinemas and banks have increased our understanding of environments that inhibit mite proliferation,^{5,6,9} they have limited relevance in helping us to understand possible building designs in private dwellings that could lead to decreased dust mite levels. A major determinant of the differences found in a previous study was the presence of carpet in private homes and its absence in public places.⁵ In the present study we restricted our assessment to buildings that had carpet on the floors of sleeping accommodation, particularly carpeted public places where people slept and where they would dress and undress, shedding skin in the process. This provided a closer comparison to private houses than the microenvironment of an aeroplane or train, and supports the observations of low Der p1 levels in university colleges.¹⁵

Many studies have identified that higher relative humidity is the most important factor aiding mite proliferation.^{16–21} The present study found significantly lower relative humidity in public places than in private houses (56.4% vs 68.5%; $P < 0.0001$). In this cross-sectional survey, the relative humidity was measured at the time of dust collection, so it might not have been representative of the microenvironment in the previous months when the mites would have been multiplying. It is also apparent that, although mite allergen levels were less than 10 µg/g in all cases when the relative humidity was less than 60%, some houses and public places with high humidity also had mite allergen levels of less than 10 µg/g. Nevertheless, these observations are consistent with current strategies to decrease humidity in domestic dwellings.² There is an apparent paradox that warm moist air protects against exercise-triggered asthma but provides a microenvironment for the house dust mite to proliferate.

The sampling technique used in the present study aimed to ensure that the houses represented a random sample of suburbs in Newcastle. The suburbs that were sampled appeared to be representative of distance from the ocean and socio-economic status for Newcastle. It was impossible to sample by suburb for public places because there were too few of them. Thus, we sampled the single university and a random sample of hotels, which tended to be located on the coast, rather than in the suburbs. However, we believe it is unlikely that the differences in dust mite allergen levels can be explained by location.

Thus, carpeted sleeping accommodation in public places was found to have lower house dust mite allergen levels than private houses, just as has been demonstrated in public places without carpets.⁵ The present study points to the importance of relative humidity as the main explanatory variable.

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