

Short communication

House-dust-mite allergen (Der p 1) levels in university colleges

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Allergy 1998; 53: 976-980. © Munksgaard 1998.

Background In coastal Australia, mean house-dust-mite allergen concentration is 20-40 times higher in homes than in public buildings. Allergen concentrations in university colleges, which share some characteristics of both homes and public buildings, are not known. The study aimed to compare bed mite-allergen concentration in colleges with local homes.

Methods Mattress dust was collected from three colleges ($n=60$ in each) and local homes ($n=68$) during summer. Der p 1 was measured by ELISA. Information was collected on the floor plan of the colleges, cleaning practices, age of building, and orientation of room.

Results Most college mattresses (94%) had Der p 1 concentrations less than the mean of homes in the same climate. The geometric means of Der p 1 in the mattresses of the colleges were as follows: A, 8.9 μg Der p 1/g fine dust (95% CI 6.9, 11.5); B, 1.9 (1.5, 2.3); and C, 1.5 (1.2, 2.0), compared to homes, 22.5 (17.6, 28.7). The percentages of college mattresses with less than 2 μg /g were 7%, 48%, and 58%, respectively, compared to 4% for homes. Higher Der p 1 concentrations were weakly associated with age of building in college A, and orientation in college B. Der p 1 concentrations were independent of floor level and age of mattress.

Conclusions These findings indicate that low allergen concentrations are achievable without extreme hygiene and cleaning measures in a climate which supports mite proliferation in homes.

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Key words: allergens; exposure; house-dust mites; housing; public buildings; universities.

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Accepted for publication 18 May 1998

Factors which create differences in mite populations within a community or home have been difficult to isolate, identify, or model. It is widely recognized that mean house-dust-mite allergen levels (Der p 1), which are used as a proxy for mite numbers, in a community are determined by external climatic factors, supporting either high mean levels in coastal climates, such as Sydney, Australia (1, 2), or low levels in drier climates, such as Berlin, Germany (3), or inland Australia (1). Seasonal fluctuations in climate also account for associated fluctuations in allergen levels (4, 5) and the stability of reservoir mite-allergen concentrations.

Within any community, allergen levels are widely distributed both between homes and, to a lesser extent, between different sites in the same home (2). Variability between homes is likely to be the result of differences in indoor humidity, driven by

factors such as age of home, floor level, ventilation, orientation, or living habits of the occupants. Nutrition and natural fluctuations in mite populations may also contribute to the variability.

Studies have shown that public places such as hospitals, offices, cinemas, and schools have significantly lower allergen concentrations than corresponding sites in homes. It has been postulated that the low levels are due to their lower level of occupancy, use of air conditioning, and frequency of cleaning (6-8). University colleges share some features of public buildings, such as size, height, absence of kitchens, and en suite bathrooms, and also some features of homes, such as level of occupancy per room, presence of beds, and frequency of cleaning. Furthermore, within colleges, there is a high level of uniformity between rooms. It was anticipated that in university colleges,

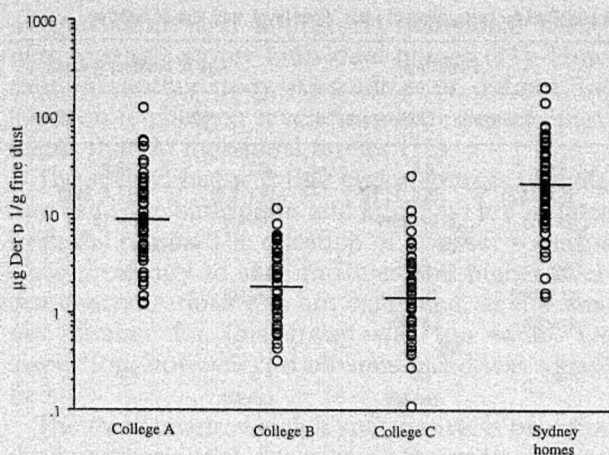


Fig. 1. Distribution of mattress Der p 1 concentrations and geometric means in three university colleges ($n=60$ in each) and Sydney homes ($n=68$).

additional factors, such as floor level or orientation (as a proxy for solar heat gain), might significantly affect indoor humidity, thereby influencing house-dust-mite allergen concentration. For these reasons, we surveyed Der p 1 concentrations in the mattresses of three university colleges and compared them with local homes.

Material and methods

Description of the colleges

Three colleges associated with the University of Sydney participated in this study. The occupancy rate for all three colleges was approximately 90% throughout the year. The colleges did not have any form of air conditioning. In colleges A and B, vacuuming of the rooms was left to the students, with fresh linen provided weekly by staff. However, in college C, residential staff were responsible for both providing fresh linen and cleaning of the rooms weekly.

College A is constructed mainly from brick, and comprises three separate residential wings built, respectively, in 1893, 1930, and 1960. They are surrounded by landscaped gardens and courtyards. All occupants are female with one occupant per room. The sizes of the rooms, number of floors (one to four levels), presence of balcony, and type of flooring (concrete or wooden) vary by wing. There are a total of 280 rooms, and all are carpeted and have at least one window. The average age of the mattresses was greater than 10 years, with none less than 5 years old.

Dust samples from college B were collected from one section of a three- and four-storey sandstone Gothic Revival-style building on an H-shaped plan. College B is a four-storey rectangular building built

in the 1960s. It is situated on a large grass oval. The room capacity of college B is 175. All of the occupants are male with one occupant per room. The size and shape of the rooms are consistent for each floor. Each room has a sink, one vent, and one set of windows, and is carpeted. The age of the mattresses ranged from 4 to 10 years.

College C is an eight-storey, rectangular concrete/brick veneer building built in the 1960s. The building is situated on a main road and partly shaded on three sides by other tall brick buildings. The total room capacity is 200. The college has both male and female residents, but with only one occupant per room. All rooms are consistent in size and shape, are carpeted, and have one set of windows. The age of the mattresses ranged from 4 to 5 years.

Homes

Homes in the Sydney suburb of Manly were sampled as part of a previous study (1). The homes were located approximately 10 km from the university colleges and were mainly free-standing, single-storey brick homes.

Methods

Dust sampling and mite-allergen analysis. Dust sampling in both colleges and homes took place during the summer. Rooms in the colleges were not selected randomly, but were chosen to represent the range of rooms within the colleges. Samples were collected from the mattresses in the colleges ($n=60$ in each college) and in Sydney homes ($n=68$) for 1 min with a portable hand vacuum cleaner (Makita). During collection in the colleges, information was obtained about the floor plan, frequency of cleaning, age of building, and orientation of rooms. No information on cleaning procedures in homes was collected.

Dust samples were prepared for Der p 1 analysis (1). Der p 1 concentrations were measured in fine dust by ELISA by the procedure previously described (9), with a double monoclonal antibody assay kit supplied by the University of Virginia. Plates were read with the BioRad plate reader model 450 (BioRad, Richmond, CA, USA) and calculations performed with Microplate Manager software (BioRad).

Analysis of data. As the distribution of allergen concentration was skewed, calculations were performed on log-transformed data. Mite-allergen Der p 1 results are expressed as geometric means ($\mu\text{g Der p 1/g fine dust}$), with 95% confidence intervals (95% CI). In an attempt to define which college

Table 1. Geometric mean (95% CI) Der p 1 allergen concentration for three colleges stratified for orientation of room, floor level, and age of building

College	Orientation of room				Floor level		Age of building (years)	
	North	South	East	West	Ground	Above ground	<30	>30
A	10.5 (3.2, 4.5) (n=28)	7.4 (3.2, 5.6) (n=11)	11.2 (5.9, 12.5) (n=8)	6.6 (2.8, 4.9) (n=13)	9.5 (5.4, 16.8) (n=12)	8.8 (6.6, 11.7) (n=48)	6.7 (5.1, 8.8) (n=41)	16.8 (11.4, 24.8) (n=19)
B	1.7 (1.3, 2.3) (n=30)	2.1 (1.6, 2.8) (n=30)	NS na	na	2.0 (1.3, 2.9) (n=20)	1.9 (1.4, 2.4) (n=40)	1.9 (n=60)	na
C	na	na	NS 1.2 (0.9, 1.5) (n=40)	2.8 (1.6, 5.1) (n=20)	na	1.5 (n=60)	1.5 (n=60)	na

P<0.01

Note that in southern hemisphere, north-facing aspect is sunniest. na: not applicable.

design feature may be of importance, mean allergen concentrations were compared by ANOVA. In addition, for determination of the overall importance of the design features, a model was constructed by logistic regression, with Der p 1 content greater than or under 2 µg/g as the outcome variable. The categorical explanatory variables included were college (A, B, C), orientation (N, S, E, W), and floor level (ground or above ground). For all results, *P* values less than 0.05 (*P*<0.05) were regarded as significant. Calculations were performed with the statistical packages SAS (SAS Institute, Cary, NC, USA) Statview and SPSS (version 7.5).

Results

The geometric mean Der p 1 concentration for mattresses in the three university colleges were as follows: college A, 8.9 µg Der p 1/g fine dust (95% CI 6.9, 11.5); college B, 1.9 (1.5, 2.3); and college C, 1.5 (1.2, 2.0). The mattress mean allergen concentration for college A was higher than the other two colleges (*P*<0.05), but lower than the mean for Sydney beds (*P*<0.05). The distribution of allergen concentration in the three colleges compared to Sydney homes is shown in Fig. 1.

The numbers of rooms studied within each college with mattress mean allergen concentration below 2 µg Der p 1/g fine dust were as follows: college A, four (7%); college B, 29 (48%); and college C, 35 (58%), compared to three (4%) for Sydney homes. The numbers of rooms with levels exceeding 10 µg Der p 1/g fine dust were as follows: college A, 22 (37%); college B, one (2%); and college C, three (5%), compared to 55 (82%) for Sydney homes.

No significant differences in mean allergen concentrations were observed between rooms located on the ground floor and those above the ground

floor in either of the three colleges. Higher mean Der p 1 concentrations were associated with orientation of rooms in college C: east, 1.2 (0.9, 1.5) (*n*=40), and west, 2.8 (1.6, 5.1) (*n*=20) (*P*<0.01); and with increasing age of building in college A: greater than 30 years, 16.8 (11.4, 24.8) (*n*=19), and less than 30 years, 6.7 (5.1, 8.8) (*n*=41) (*P*<0.001) (Table 1). No significant differences were found when mean Der p 1 levels were compared with age of the mattress. The only feature significantly associated with a Der p 1 concentration greater than 2 µg/g after controlling for other factors was college A. An easterly aspect showed a trend (*P*=0.13) to levels less than 2 µg/g.

Discussion

In this study, we have demonstrated that most college rooms (94%) which are naturally ventilated, carpeted, and occupied for long periods, and which all contain mattresses more than 4 years old, have Der p 1 allergen concentrations below the mean concentration in homes in the same climate. This finding was unexpected, as the outdoor relative humidity and temperature in Sydney for most of the year are highly conducive to mite proliferation and survival. However, this finding is in agreement with the study of Massey et al. in Hawaii, which found significantly fewer mites in university dormitories than in homes (10).

Three factors may be important in influencing Der p 1 allergen concentration within these colleges. The first is the nature of the buildings themselves. These buildings are large and of very solid construction and are more like public buildings than homes, and, therefore, may have allergen levels comparable to apartments rather than homes. This is supported by Wickman et al., who showed that mite-allergen levels were lowest

in apartments and multistorey individual homes than in single-storey individual homes (11). However, in another study, Andrade et al. did not find lower mite-allergen levels in mattresses in apartments than in individual homes (12).

The second factor is that major sources of moisture (en suite bathrooms and kitchens) are isolated from the rooms. The question of whether rooms in close proximity to such facilities had higher allergen concentrations was not examined, as the sample number for this group was too small. On inspection, however, no obvious trend was identified.

The third factor, which is speculative, is based on the hypothesis that, for part of the year, physical conditions in the buildings are such that mites are killed. This may occur in summer, when the buildings heat up and gradually dry out, creating long periods when indoor conditions are too dry and hot for mite survival. This is analogous, but in contrast, to the situation in Denmark, where homes are desiccated by mechanical ventilation with cold, but dry external air during winter (13).

Although mean allergen concentrations were significantly lower in the colleges than in Sydney homes, the mean allergen concentration for college A was significantly higher than the other two colleges. In addition, the distribution of allergen concentration within college A followed a similar pattern to that of homes, varying up to 50–100-fold. This finding was contrary to our expectations, as we anticipated that allergen concentrations would be similar for each college, because colleges are more uniform in construction than homes. A possible explanation for this could be differences in the indoor microclimate between the colleges due to their construction. College A is more like a home in its construction, and is comprised of smaller, separate buildings with balconies, many windows, and few floor levels. This provides a greater opportunity for natural ventilation, dissipating any thermal accumulation over the summer months. In a study investigating the relationship between housing characteristics and mite-allergen concentration in The Netherlands, van Strien et al. found higher Der p 1 concentration in mattresses in homes with natural ventilation than in homes with continuous mechanical ventilation (14). Sydney's mean annual outdoor relative humidity at 9.00 a.m. is high in summer (68.8% RH), and the increased natural ventilation may result in an indoor air humidity which is more reflective of the outside climate, than if natural ventilation was limited. In contrast, colleges B and C are large, multistorey, rectangular buildings with a large thermal mass and smaller windows. They can retain heat and remain drier for longer periods, thereby

providing an indoor microclimate unsuitable for mite survival.

The variables likely to be important determinants of mite proliferation in homes (such as age of mattress and presence of carpet) are not of importance in these colleges. However, variables such as age of building in college A and orientation in college C were significantly associated with higher Der p 1 concentrations. Older buildings have been shown to contain higher mite-allergen concentration (14, 15). Allergen concentration was independent of floor level. However, other studies have shown mite numbers and allergen levels to be greater in dust from beds located on the ground floor than in mattress dust from upper floors (16).

The implications of the findings from this study are that low allergen levels (less than 2 µg/g) are achievable without extreme hygiene and cleaning measures in a climate which supports mite proliferation and high allergen levels. We propose that a building with a high thermal mass is capable of reducing indoor relative humidity, despite high external relative humidity, to a level below which mite growth is sustainable.

Acknowledgments

This study was funded by the National Health and Medical Research Council. We thank the principals of all three colleges for consenting to participate, the housekeepers for their time and assistance, the students for their co-operation, and Dr Richard Sporik for assistance with the statistics and discussion sections of the paper.

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