

Short communication

Predictors of house-dust-mite allergen concentrations in dry regions in Australia

Background: House-dust-mite allergen content differs between houses and is thought to be a function of the housing characteristics and furnishing choices that affect indoor microclimate and mite proliferation. The importance of these features may differ with regional climates.

Methods: Concentrations of mite allergen were analysed as a function of housing features. Information on housing features was collected by questionnaire in 50 houses in two towns in a dry inland region of Australia. Mite allergen (Der p 1) was measured by ELISA in dust samples collected on five occasions over 2 years from beds and floors.

Results: Der p 1 was detected in all houses. Many housing features did not influence mite allergen concentrations. However, the presence of evaporative cooling increased mite allergen by 3.34-fold in beds ($P=0.007$) and 3.94-fold in floors ($P=0.003$). Mite allergen was threefold higher in mattresses > 5 years old, and synthetic and feather duvets tended to have higher and lower levels of mite allergen, respectively.

Conclusions: In houses in dry, inland regions of Australia, evaporative cooling and older mattresses are associated with higher concentrations of mite allergen. Alternative forms of air conditioning to evaporative cooling may be useful for control of mite allergen in dry regions.

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The development of airway hyperresponsiveness and more severe asthma is related to the level of exposure to house-dust-mite (HDM) allergen in early childhood (1, 2). In Australia, HDM allergen concentrations may be influenced by housing characteristics (3, 4). However, it is not known whether any housing features are capable of altering HDM allergen concentrations in dust in inland Australian homes, where concentrations are usually substantially lower than in coastal areas (5).

HDM proliferate where conditions are warm and humid (5, 6), and housing characteristics that favourably modify the indoor microclimate could have some bearing on HDM allergen concentration. Increased or decreased HDM allergen concentrations have been associated with a number of housing characteristics both in Australia (3, 4) and overseas (7–12). Evaporative cooling, which is common in some warm, dry climates, is a form of air conditioning that raises indoor relative humidity. This may create a microclimate favourable for HDM proliferation in homes which would otherwise be expected to have low mite numbers and allergen concentrations. Identifying such predictors is important for the development and design of low allergen housing.

We undertook a cross-sectional survey of homes in two towns in dry, inland regions of New South Wales,

Australia, and tested whether HDM allergen concentrations in bed and floor dust were associated with the presence or absence of evaporative cooling and other housing characteristics.

Material and methods

Study location and design

The study was undertaken in two rural towns in southeastern Australia, Moree and Wagga Wagga. Both towns are located approximately 300 km inland. The means of the daily 9 am and 3 pm temperatures were 14.6°C and 10.1°C, respectively, during the winter and 28.3°C and 26.4°C, respectively, during the summer. The corresponding values for relative humidity were 60.9% and 70.9% during the winter and 46.3% and 36.9% during the summer. The climate in both towns is classified as temperate.

The parents of a randomly selected sample of children attending primary school in the two towns were approached for permission to collect household dust. Thirty households in Moree and 29 households in Wagga Wagga were recruited. Dust was collected from the bed and floor in the child's bedroom in each of these houses on five occasions over a 2-year period from mid-1997 to mid-1999. Dust sampling was scheduled during all seasons of the year (Fig. 1), and 85–100% of houses in the study were sampled at each visit to the towns. Parents were requested to complete a questionnaire detailing certain aspects of the home environment. In Moree and Wagga Wagga, 27 and 23 parents, respectively, completed this housing

characteristic questionnaire. The study was approved by the Human Ethics Committee of the University of Sydney, and written consent was obtained from all parents.

Collection of dust samples

Separate samples of fine dust were collected from the child's bed and bedroom floor with a modified battery-operated Makita "Handy Vac" (Model 4071D, Makita Electric Works Ltd, Japan) fitted with a 25- μ m nylon filter bag for each sample. The bed sample comprised a 1-min vacuum sample from the pillow, duvet/blanket, and mattress combined. The floor sample comprised a 1-min vacuum sample of 1-m² of floor area where the child typically dressed. The samples were sieved, and 50 mg of fine dust (<0.4 mm particle diameter) was extracted in 1 ml of phosphate-buffered saline. Der p 1 allergen concentration was measured with a double monoclonal antibody ELISA (13).

Housing characteristics questionnaire

A self-administered questionnaire was designed to measure housing features that could affect Der p 1 allergen concentrations in dust. This included questions based on an assessment of the range of housing designs in Moree and Wagga Wagga. The questionnaire was pilot tested in 12 adults living in Sydney. The final version of the questionnaire was administered to parents during the final visit for dust collection.

Statistical analysis

As the distribution of Der p 1 concentrations was positively skewed, the values were log₁₀ transformed prior to analysis. Geometric means were calculated. The distribution of values was expressed as the 95% range, representing the range within which 95% of the population values would be expected to lie. This was calculated as the antilog of the mean, on a log-scale, plus or minus 1.96 times the standard deviation, also on a log scale (14).

Generalized estimating equations were used to determine the fold differences in allergen concentrations that were associated with the presence or absence of a given housing or bedding feature. These equations were robust to unbalanced data and also adjusted for correlation among repeated measures. Separate analyses were carried out for beds and floors. Interactions by town between HDM allergen concentration and housing or bedding features were also tested. The precision of the estimates of the fold differences was presented as 95% confidence intervals.

Seven families changed residence during the 2-year follow-up. Since the responses to the questionnaire related to the home environment at the final visit, data for HDM allergen concentrations in floors and beds for the period up to the date when the family moved to their present home were excluded from all analyses. Six children had their mattresses changed during the 2-year follow-up. Data for HDM allergen concentrations in beds for the period up to the date when the mattress was replaced were excluded from the analyses relating to bed samples. All analyses were undertaken using STATA (Stata Statistical Software, Release 6.0, Stata Corporation, 1999, TX, USA).

Results

Der p 1 was detected in all houses in both towns. Concentrations of Der p 1 were higher in Moree than in Wagga Wagga during each sampling period (Fig. 1) ($P < 0.0001$ for beds and $P < 0.0002$ for floor areas, overall comparison between towns by mixed effects model analysis of variance). At the initial visit, the

geometric mean Der p 1 concentration (micrograms of Der p 1 per gram of fine dust) in Moree beds was 13.6 μ g/g, and the 95% range was 1.1–168.3 μ g/g. In dust from Moree floors, Wagga Wagga beds, and Wagga Wagga floors, the geometric mean Der p 1 concentrations and 95% ranges were, respectively, 5.8 μ g/g (0.3–129.1), 3.3 μ g/g (0.3–32.1), and 2.7 μ g/g (0.1–141.0). There was no significant interaction by town in relations between Der p 1 concentration and any of the housing features. Therefore, it was statistically appropriate to pool Moree and Wagga Wagga data for analysis of each housing feature.

Evaporative coolers were present in 26% of homes in Wagga Wagga and 58% of homes in Moree. Where evaporative cooling was present, concentrations of Der p 1 were 3.34-fold greater in bed dust (95% confidence interval (CI), 1.39–8.04; $P = 0.007$), and 3.94-fold greater in floor dust (95% CI, 1.58–9.84; $P = 0.003$) than in dust from those sites in houses without evaporative cooling (Figs. 2 and 3). In dust from beds or floors of homes with refrigerative cooling, Der p 1 concentrations were not significantly different from houses with no air conditioning ($P = 0.86$).

Beds with mattresses older than 5 years had threefold higher (95% CI, 1.21–7.46; $P = 0.017$) Der p 1 concentrations than those with newer mattresses (Fig. 2). None of the other housing features examined were associated with significantly higher or lower Der p 1 allergen concentrations in beds or floors (Figs. 2 and 3). However, in beds there were strong, but not statistically significant, trends toward higher Der p 1 concentrations where synthetic duvets were present ($P = 0.089$), and lower Der p 1 concentrations in the presence of feather duvets ($P = 0.215$) (Fig. 2).

Discussion

Of all the housing features tested, evaporative cooling and mattress age were strong predictors of HDM allergen concentrations. Houses with evaporative cooling had greater than threefold higher Der p 1 concentrations in both bed and floor dust than houses where this feature was absent. There was also three times more Der p 1 in beds with mattresses older than 5 years than in beds with newer mattresses. This has important implications for HDM avoidance strategies.

These findings are similar to the observed effects of evaporative cooling on allergen concentrations and mite populations in dry environments in the USA (6, 7). Ellingson et al. (7) found that, in Colorado, group 1 HDM allergen concentrations were far greater in homes that used central evaporative cooling during the summer months than in homes that did not. In the Colorado study, allergen concentrations were negligible before evaporative cooler use. Since we were investigating overall concentrations over 2 years of sampling, allergen

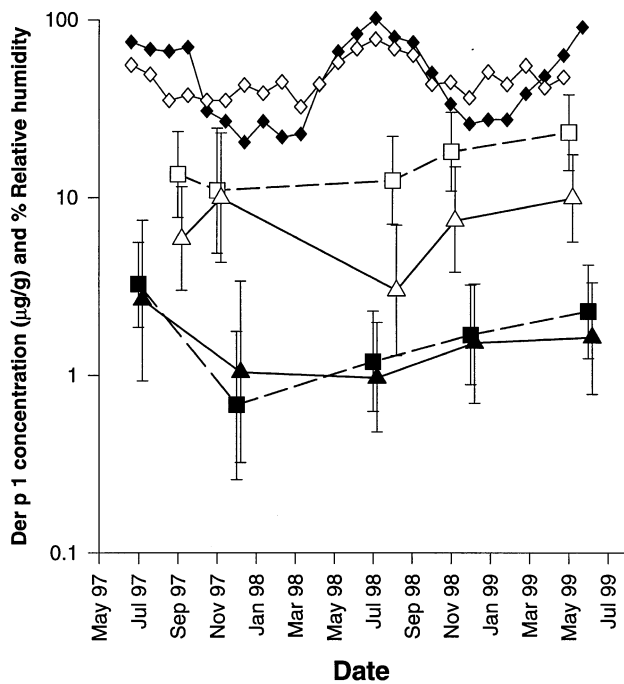


Figure 1. Geometric mean Der p 1 concentrations (μg Der p 1/g fine dust) in reservoir dust and average monthly relative humidity for Moree and Wagga Wagga. Key: white fill: Moree; black fill: Wagga Wagga; squares with broken lines: bed dust; triangles with solid lines: floor dust; diamonds: relative humidity. Error bars denote 95% confidence intervals.

concentrations before and during use of evaporative cooling were not compared in our study. However, there was no season during which allergen concentrations were negligible in either Wagga Wagga or Moree.

No association was observed between the presence of an evaporative cooler and increased HDM allergen concentrations in Broken Hill, Australia (15). Broken Hill is climatically similar to Wagga Wagga and Moree in terms of temperature and relative humidity (16), but HDM allergen concentrations were found to be very low (less than $1 \mu\text{g/g}$) independent of evaporative cooling. It is possible that other, unknown factors operating in the environment of Broken Hill limit a sustainable HDM population and that the presence of evaporative cooling does not overcome this inhibitory effect.

Der p 1 concentrations in homes with refrigerative air conditioning, which was present in very few homes in Wagga Wagga and Moree, were not significantly different from homes with no air conditioning. In some studies, decreased HDM allergen concentrations have been associated with the presence of refrigerative air-conditioning systems (8, 9, 17), although in others this association has not been observed (4, 10, 15). The effect of refrigerative air conditioning is unclear but may be dependent on daily usage and the geographic location in which it is used.

Der p 1 allergen concentrations were higher in Moree than Wagga Wagga throughout the entire study period. Such a difference was unexpected because the climates in both towns are similar. However, the difference reflects the greater proportion of homes in Moree than Wagga Wagga which have evaporative coolers. This supports the hypothesis that the presence of evaporative cooling, in part, determines HDM allergen concentrations.

Beds with mattresses more than 5 years old had significantly higher concentrations of Der p 1 than

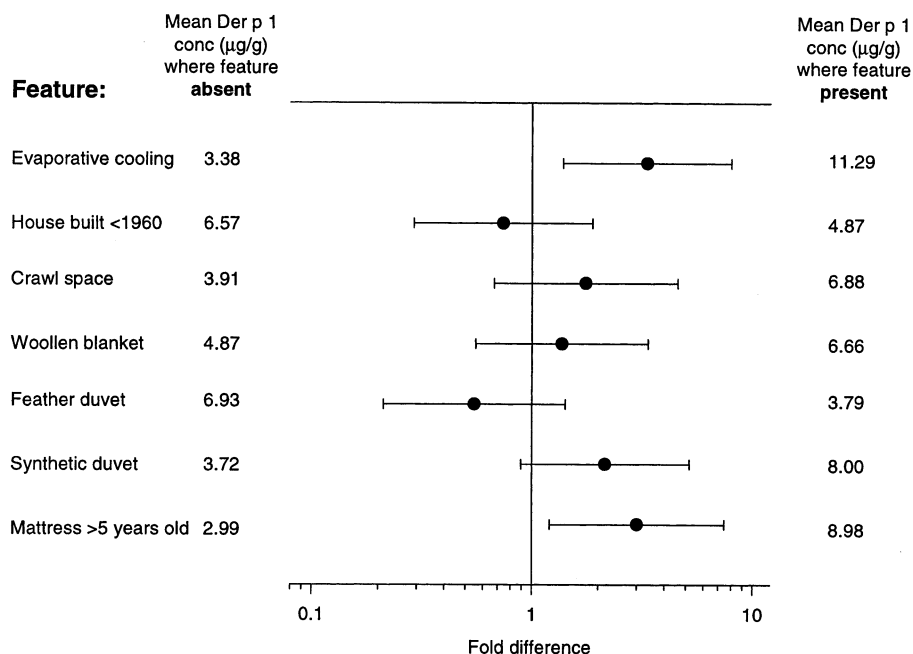


Figure 2. Fold differences in Der p 1 concentration in bed dust associated with presence of specific housing features. Dot represents point estimate, and line represents 95% confidence interval around estimate. Geometric mean Der p 1 concentrations (micrograms of Der p 1 per gram of fine dust) where features are present and absent are also shown.

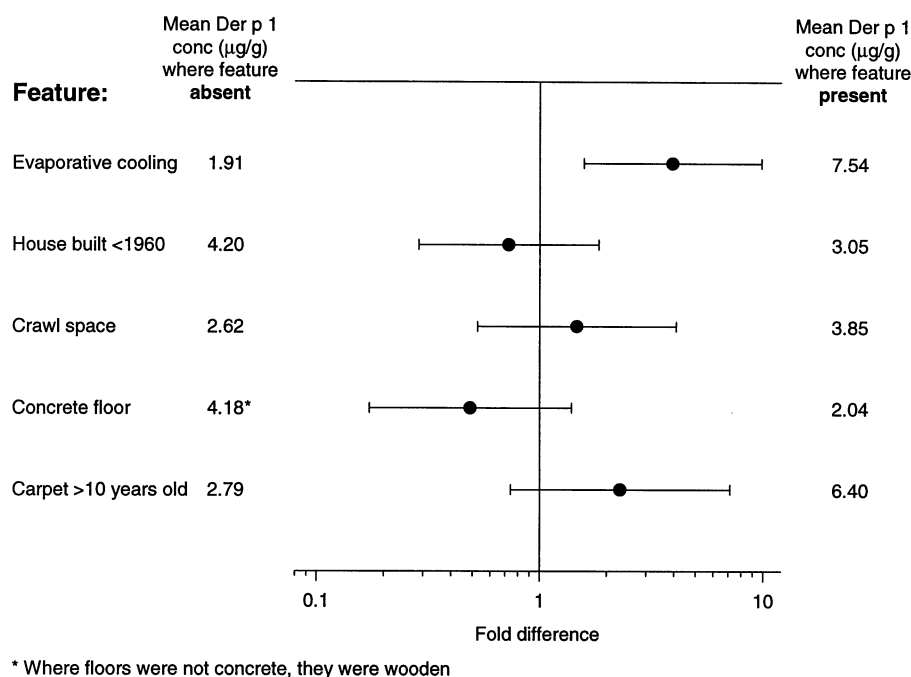


Figure 3. Fold differences in Der p 1 concentration in floor dust associated with presence of specific housing features. Dot represents point estimate, and line represents 95% confidence interval around estimate. Geometric mean Der p 1 concentrations (micrograms of Der p 1 per gram of fine dust) where features are present and absent are also shown.

newer ones, a finding which is not surprising given the rate at which allergen can accumulate in new mattresses (18). Older mattresses have repeatedly been shown to carry greater allergen content (3, 12, 19). We also found strong trends toward higher allergen concentrations in beds with synthetic duvets and lower allergen in beds with feather duvets. While these findings were not statistically significant, they were comparable to recent findings in the UK (20) and New Zealand (21, 22), where greater amounts of HDM allergen and higher rates of allergen accumulation have been observed in synthetic than in feather pillows. Further studies are needed to elucidate the causative mechanisms behind these observations.

Der p 1 concentrations were not associated with any other house design features in Wagga Wagga and Moree. However, in other studies, house age (3, 4, 10, 12), the base structure of the floor or foundation (4, 11), the crawl space (air space) under the floor (3), and carpet age (3, 11, 12) have been shown to be predictors of HDM allergen levels. The wide confidence intervals around the estimates do not exclude the possibility that substantial differences attributable to these factors do exist. In other

words, it is possible that power limitations could explain the lack of association between HDM allergen and these features in our study.

Of the house characteristics investigated in this study, evaporative cooling was an important predictor for increased HDM allergen concentrations in bed and floor dust in houses in dry regions. It is likely that evaporative cooling increases indoor relative humidity to a level that sustains HDM populations through the dry summer months when HDM may otherwise dehydrate and die. We suggest that using alternative forms of air conditioning would be a simple and effective intervention to maintain low HDM allergen concentrations in regions with dry climates.

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