

## Original article

# Predictors of high house dust mite allergen concentrations in residential homes in Sydney

**Background:** In parts of coastal Australia, house dust mite allergen concentrations in homes are often very high with at least 80% of homes in Sydney exceeding concentrations of 10 µg of allergen per gram of fine dust. In this study, we report the relation between characteristics of the home environment and house dust mite allergen concentrations at three sites in Sydney homes.

**Methods:** A total of 616 families were recruited as part of the Childhood Asthma Prevention Study (CAPS). Information about the home environment and structural aspects of the home was collected using a questionnaire. Samples of dust were collected from the parents' bed, the bedroom floor and the living room floor and assayed for Der p 1.

**Results:** A total of 68% of participants' beds, 65% of bedroom floors and 56% of living room floors had Der p 1 concentrations above 10 µg/g, with the highest concentrations of allergen in the bed. The most significant predictor of high Der p 1 concentrations in the bed and floors was the age of the home. We also found that beds with mattresses over two years old and with woollen or synthetic blankets or synthetic quilts had higher Der p 1 concentrations. Carpeted floors had higher Der p 1 concentrations than hard floors.

**Conclusion:** The finding that high Der p 1 allergen concentrations in homes with carpets and older mattresses indicates that control strategies directed at these sources are likely to be effective in reducing exposure. Alternatives such as the use of house dust mite impermeable mattress encasings on older mattresses may also be effective in reducing exposure.

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Key words: Der p 1; house characteristics; house dust mite allergen; risk factors.

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In parts of coastal Australia, house dust mite allergen concentrations are very high, with at least 80% of homes in Sydney having one or more sites with a reservoir concentration of allergen above 10 µg of allergen per gram of fine dust (1). There are numerous sources of this allergen within homes with the highest concentrations found in carpets and beds (2). Studies in Sweden, Germany, UK, USA, New Zealand and Australia (2–7) have all identified factors that are associated with high concentrations of indoor allergens. Inadequate ventilation, high indoor humidity, presence of carpets and the type and age of residential buildings all affect indoor allergen concentrations (8–12). In beds, age and type of mattress and type of bedding are additional determinants of allergen concentrations (12, 13). However the impact of such factors on indoor microclimate may

differ between different climate zones and housing construction practices. The importance of these factors may need to be determined for each community.

Exposure and allergy to house dust mite allergens are important risk factors for allergic asthma in most parts of the world (14). In Australia, the prevalence of allergy to house dust mite allergens in children is 26–32% (13). Avoiding exposure to these allergens can reduce airway hyperresponsiveness and asthma symptoms (15). Therefore, it is important to know which environmental and residential characteristics are conducive to high concentrations of house dust mites in order to design effective avoidance measures and to design houses which provide lower intrinsic levels of allergen exposure.

In Sydney, a multicentre randomised trial is being conducted to investigate different methods of reducing the prevalence of childhood asthma (16). At enrolment of families in this study, information about housing characteristics and aspects of the home environment were recorded. Samples of dust were collected from three sites in the home in order to obtain a measure of

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the preintervention concentration of allergen. In this paper, we report the relation between characteristics of the home, bedroom and bedding and house dust mite allergen concentrations in dust collected from the bedroom floors, living room floors and beds.

## Material and methods

### Study design

The data described in this paper were collected as part of the Childhood Asthma Prevention Study (CAPS) which is a large multicentre randomised controlled trial designed to test the effect of house dust mite reduction and dietary supplementation with omega-3 fatty acids on the incidence of childhood asthma. The study was approved by ethics committees of the University of Sydney, the Children's Hospital at Westmead, and the Western, South-western and Central Sydney Area Health Services.

### Subjects

A total of 616 pregnant women whose unborn children were at high risk of having asthma on the basis of a family history of the disease were identified using a screening questionnaire which was administered at antenatal clinics in six Sydney hospitals. Inclusion criteria were: a first-degree relative with current symptoms of asthma, living no more than 30 km from the center of recruitment, ability to understand English, a telephone, and no cat at home. Women who fulfilled these criteria and did not deliver before 36 weeks were enrolled and informed consent was obtained at a home visit before commencement of the study.

### Home environment data collection

Information about the home environment was collected by inspection and by interview with the mother during a home visit that was conducted in approximately the 36th week of pregnancy. Information was collected about structural aspects of the house (type, age, foundation and construction, number of rooms), general home environment (number of people, power sources used for heating, cooling and cooking), and environmental factors associated with allergens (presence of visible mould and presence of dogs and cats). Information on the type of flooring, type of bedding, type and age of mattress was also collected.

### Dust collection

Dust samples were collected from the parents' bed, parents' bedroom floor and the living room floor using a 850-W Sanyo vacuum cleaner [Model SC21R, Sanyo Australia Pty Ltd, Sydney, Australia] modified to collect coarse and fine dust in separate nylon bags which were mounted at the head of the cleaner. Clean bags were used for each dust sample and the sampling head was wiped clean with a damp cloth between every sampling site. The beds were sampled first. When the bed was vacuumed the sampling time was divided as follows: upper bedding (quilts and blankets) collection for 1 min, mattress (below the sheets) for 30 s, and pillows for 30 s. Carpeted floors were sampled for 1 min by vacuuming an area of 1 m<sup>2</sup>. Hard floors were sampled for 2 min by vacuuming an area of 2 m<sup>2</sup>. Following collection, dust samples were stored at -20°C to prevent mite allergen degradation and fungal growth.

### House dust mite allergen assays

The weight of fine dust collected was recorded and a 50-mg sample was extracted for 45 min in 1 ml of 0.2% bovine serum albumin (BSA) in phosphate-buffered saline (PBS)-Tween 20 (0.5%). Extracts

were stored at -20°C before analysis. Concentration of Der p 1 was measured using a double monoclonal ELISA assay (17). Allergen assays were standardized using the internal standard supplied with the ELISA kit (Indoor Biotechnologies Ltd, Cardiff, UK). House dust mite allergen concentrations were expressed as micrograms of Der p 1 per gram of fine dust.

### Statistical analysis

The data were analyzed using SPSS<sup>®</sup> BASE 8.0 for Windows (SPSS Inc. Chicago, IL). Because the distribution of Der p 1 allergen concentrations was skewed, they were log<sub>10</sub> transformed to normalize the distribution and allow the use of parametric tests. Der p 1 allergen concentrations were expressed as geometric means with error bars showing the 95% confidence intervals (CI). The effect of various environmental characteristics on allergen concentrations was examined in terms of their effect on the levels of exposure and their effect on the risk of having high allergen concentrations [i.e. > 10 µg/g]. The results of the former analysis, which utilized simple and multivariate linear regression, were expressed as number of 'fold' differences between sites with and without the particular characteristic. The results of the latter analysis, which utilized simple and multivariate logistic regression, were expressed as odds ratios for high allergen levels given the presence or absence of that particular characteristic. The effect of the variables that were measured on a continuous scale was assessed using Pearson's correlation (18).

## Results

Of the 616 participants recruited, all had complete data about housing characteristics (Table 1). More than 80% of homes were freestanding houses. Almost 65% of homes were more than 10 years old and most were made from brick material. Mould (excluding mould in the bathroom) was present in 23.6% of homes and dogs were present in 41.2% of homes.

Dust samples were taken from the parents' bed in 609 (98.9%) homes, the bedroom floor in 589 (95.6%) homes and the living room floor in 590 (95.8%) homes. A total of 577 homes (93.7%) had all three sites sampled, 588 (95.5%) had at least two sites sampled and 612 (99.4%) had at least one site sampled. Table 2 shows the concentrations and distribution of Der p 1 at each site. Der p 1 allergen concentrations tended to be highest in the parents' bed and lowest in the living room floor. A total of 96.4% of homes had at least one site with Der p 1 allergen concentrations over 2 µg/g and 89.7% had at least one site with Der p 1 allergen concentrations above 10 µg/g.

There was a moderate correlation between bedroom floor and living room floor concentrations of Der p 1 (Pearson's  $r=0.54$ ,  $P<0.0001$ ). There was poor correlation between bed and bedroom floor Der p 1 concentrations (Pearson's  $r=0.32$ ,  $P<0.0001$ ) and bed and living room floor concentrations (Pearson's  $r=0.22$ ,  $P<0.0001$ ).

### Predictors of high floor Der p 1 allergen concentrations

Table 3 shows that the most significant factors associated with higher concentrations of Der p 1 on

Table 1. Housing characteristics of 616 participants in study

| Variable                  | N   | Percentage |
|---------------------------|-----|------------|
| Type of home              |     |            |
| free-standing house       | 502 | 81.5       |
| unit/townhouse            | 112 | 18.2       |
| mobile home               | 2   | 0.3        |
| Age of home               |     |            |
| <2 years                  | 56  | 9.1        |
| 2–10 years                | 163 | 26.5       |
| 11–50                     | 305 | 49.6       |
| >50 years                 | 91  | 14.8       |
| Structural material       |     |            |
| double brick/brick veneer | 457 | 74.2       |
| weatherboard/fibro/wood   | 156 | 25.3       |
| concrete                  | 3   | 0.5        |
| Foundation                |     |            |
| wood                      | 311 | 50.6       |
| concrete                  | 298 | 48.5       |
| Mould present in home     | 145 | 23.6       |
| Dogs in home              | 254 | 41.2       |

bedroom floors were carpets and homes over 10 years old. The type of home, structural material, use of heating in the room or the presence of rugs or mats on the floor had no effect on bedroom floor concentrations of Der p 1. Although homes with wooden foundations had higher concentrations of Der p 1 allergens than homes with concrete foundations, this effect was not significant after adjusting for other factors listed in the table. Analysis of living room floor concentrations of Der p 1 allergen showed similar results (data not shown).

An additional analysis was performed to determine the concentration of Der p 1 that could be achieved if each of the listed factors was at the reference level. The regression analysis indicates that brick units/townhouses, with a concrete foundation, of less than 10 years old, with no visible mould, no carpeting or rugs, and with heating used in the previous week, would have a mean concentration of Der p 1 in bedroom floors of 1.16 µg/g (95% CI 0.56–2.40). If all other factors were unchanged and if carpets were absent the mean Der p 1 concentration was reduced from 12.51 µg/g to 4.11 µg/g (95% CI 2.88–5.86).

#### Predictors of high bed Der p 1 allergen concentrations

Table 4 shows the age of the home was a significant factor associated with higher Der p 1 concentrations in beds. Beds with mattresses over two years old and with synthetic or woollen blankets or synthetic quilts also had higher Der p 1 concentrations. Factors that were significant in the unadjusted analysis, such as type of building, type of floor covering, structural material, foundation and presence of visible mould in the bedroom were not significant after adjusting for the other factors in the table. The type of mattress, presence

Table 2. Concentrations and distributions of Der p 1 (µg/g dust) from different sites in the home

|                               | Bed<br><i>n</i> = 609 | Bedroom floor<br><i>n</i> = 589 | Living room floor<br><i>n</i> = 590 |
|-------------------------------|-----------------------|---------------------------------|-------------------------------------|
| Geometric mean Der p 1        | 14.30 µg/g            | 12.51 µg/g                      | 9.37 µg/g                           |
| (95% CI)                      | 12.77–16.04           | 10.88–14.38                     | 8.07–10.88                          |
| Range                         | 0.09–234.42           | 0.004–794.33                    | 0.012–575.43                        |
| Low percentage (<2 µg/g)      | 13.1%                 | 17.2%                           | 23.7%                               |
| Medium percentage (2–10 µg/g) | 18.6%                 | 17.2%                           | 20.2%                               |
| High percentage (>10 µg/g)    | 68.3%                 | 65.7%                           | 56.1%                               |

of rugs or mats on the floor and whether or not heating was used had no significant effect on the concentrations of Der p 1 in the bed.

The regression analysis shows that houses with the following characteristics: brick units/townhouses, with concrete foundations, that are less than 10 years old and have carpets but no rugs, with no heating used, with beds that have an innerspring mattress less than two years old, with no woollen, cotton or synthetic blankets or sheepskins, with no synthetic or feather quilts and a synthetic pillow but no feather pillow, would have a Der p 1 of 3.19 µg/g (95% CI 1.21–8.39). When only the significant factors (i.e. synthetic blankets and quilts and woollen blankets) were absent from the bed and when the mattress was less than two years old the mean Der p 1 allergen concentration in the bed was reduced from 14.30 µg/g to 8.55 µg/g (95% CI 6.54–11.16).

#### Other factors

There was poor correlation between number of people residing in the home and concentrations of Der p 1 on the bedroom floor (Pearson's  $r = 0.13$ ,  $p = 0.002$ ) and no significant correlation between the number of people residing in the home and Der p 1 concentration on the living room floor or in the bed. We found no relationship between the presence of dogs indoors and Der p 1 allergen concentrations on the floors or in beds.

#### Discussion

We found that the age of the home was a significant predictor of high house dust mite allergen concentrations in beds and floors of homes in Sydney. Other predictors of high bed Der p 1 concentrations were mattresses over two years old and the presence of synthetic and woollen blankets and synthetic quilts on the bed. Homes with carpets were more likely to have higher concentrations of house dust mite allergen in floor dust. The age of the home was interrelated with many other factors including type of structural material used for the walls, foundation of the home and type of home. The presence of visible mould did not have an

Table 3. Factors influencing Der p 1 concentrations on the bedroom floor

| Factor/level                  | N   | Mean Der p 1 concentration ug/g (95% CI) | p-value <sup>#</sup> | Adjusted* fold difference (95% CI) | Odds ratio for > 10 µg/g (95% CI) | Adjusted* OR for > 10 µg/g (95% CI) |
|-------------------------------|-----|------------------------------------------|----------------------|------------------------------------|-----------------------------------|-------------------------------------|
| Type of building              |     |                                          |                      |                                    |                                   |                                     |
| Unit/townhouse                | 100 | 9.92 (6.86–14.33)                        | 0.144                |                                    | 1.00                              | 1.00                                |
| Freestanding house            | 487 | 13.08 (11.25–15.22)                      |                      | 1.29 (0.85–1.97)                   | 1.10 (0.70–1.72)                  | 1.17 (0.68–2.03)                    |
| Structural material           |     |                                          |                      |                                    |                                   |                                     |
| Weatherboard                  | 130 | 12.39 (9.40–16.33)                       | 0.958                | 1.34 (0.89–2.02)                   | 1.04 (0.69–1.57)                  | 1.20 (0.66–2.18)                    |
| Brick                         | 435 | 12.28 (10.39–14.50)                      |                      |                                    | 1.00                              | 1.00                                |
| Foundation                    |     |                                          |                      |                                    |                                   |                                     |
| Wood                          | 302 | 15.80 (13.33–18.74)                      | 0.001                | 1.68 (1.04–2.69)                   | 1.33 (0.95–1.88)                  | 1.47 (0.75–2.89)                    |
| Concrete                      | 282 | 9.80 (7.84–12.24)                        |                      |                                    | 1.00                              | 1.00                                |
| Age of home                   |     |                                          |                      |                                    |                                   |                                     |
| ≤ 10 years                    | 209 | 9.41 (7.30–12.13)                        | 0.001                |                                    | 1.00                              | 1.00                                |
| > 10 years                    | 322 | 15.31 (12.83–18.27)                      |                      | 1.66 (1.08–2.57)                   | 1.50 (1.04–2.16)                  | 2.05 (1.13–3.73)                    |
| Visible mould                 |     |                                          |                      |                                    |                                   |                                     |
| Yes                           | 51  | 17.15 (11.56–25.37)                      | 0.171                | 1.07 (0.61–1.87)                   | 1.15 (0.62–2.13)                  | 1.52 (0.70–3.28)                    |
| No                            | 538 | 12.14 (10.47–14.08)                      |                      |                                    | 1.00                              | 1.00                                |
| Floor covering                |     |                                          |                      |                                    |                                   |                                     |
| Carpet                        | 502 | 15.10 (13.02–17.51)                      | <0.0001              | 4.90 (3.16–7.58)                   | 5.75 (3.49–9.50)                  | 8.79 (4.76–16.25)                   |
| Hard surface                  | 85  | 4.11 (2.97–5.68)                         |                      |                                    | 1.00                              | 1.00                                |
| Rugs on the floor             |     |                                          |                      |                                    |                                   |                                     |
| Yes                           | 63  | 10.07 (6.66–15.22)                       | 0.292                | 1.04 (0.65–1.66)                   | 1.21 (0.71–2.08)                  | 1.24 (0.65–2.39)                    |
| No                            | 526 | 12.83 (11.06–14.89)                      |                      |                                    | 1.00                              | 1.00                                |
| Heating used in previous week |     |                                          |                      |                                    |                                   |                                     |
| Yes                           | 57  | 11.32 (7.28–17.62)                       | 0.644                |                                    | 1.00                              | 1.00                                |
| No                            | 528 | 12.66 (10.91–14.68)                      |                      | 1.11 (0.68–1.83)                   | 1.04 (0.59–1.86)                  | 1.47 (0.72–3.04)                    |

<sup>#</sup> P-value for difference in mean Der p 1 concentration.

<sup>\*</sup>Adjusted for other factors in the table.

independent effect on Der p 1 allergen concentrations. These factors have important implications for attaining a low allergen environment.

The high Der p 1 concentrations in some homes have clinical implications. The highest concentration of Der p 1 was in the bed, which has been observed in other studies (7, 9, 12). This is significant because of extended exposure during periods spent sleeping. More than 86% of participants' beds, 82% of bedroom floors and 76% of living room floors had concentrations above 2 µg/g. A total of 68% of participants' beds, 65% of bedroom floors and 56% of living room floors had Der p 1 concentrations above 10 µg/g.

In comparison to other cross-sectional studies in Australia and New Zealand, our mean concentrations of house dust mite allergen in beds and floors are approximately 1.4-fold lower than in Melbourne (7), 2–4-fold lower than in Wellington, NZ (9), and approximately 6-fold higher than in Tasmania (8). However, in the Tasmanian study, dust was collected from the bedroom floors and beds of newborn infants, whereas the dust in the other studies was collected from the beds of older children and adults. In the UK and Europe, concentrations of Der p 1 are consistently lower than in Australia and New Zealand with reported geometric mean ranges for beds 0.3–2.5 µg/g and floors 0.4–5 µg/g (10, 11, 19–21). Although methodological issues may account for some of the differences, they are unlikely to account for such a large difference in the results.

A similar cross-sectional study conducted in Melbourne found that houses with wooden foundations had high Der p 1 concentrations (7). In other studies, concrete foundations contributed to high indoor humidity and were associated with higher Der p 1 concentrations in mattresses (10). In the univariate analysis we found that houses with concrete foundations had significantly lower concentrations of Der p 1 in beds and floors than homes with wooden foundations, but this effect was not significant after adjusting for other factors such as the age of the home because only 22% of older homes had concrete foundations.

In freestanding houses higher Der p 1 concentrations have been found in beds than in homes with common walls (5, 22). However, freestanding homes in our study tended to be older with 64.6% being more than 10 years old and only 42.1% of townhouses and units being more than 10 years old. Therefore, the high concentrations of Der p 1 in beds were presumably due to the age of the home and not the type of home. Another factor related to the age of the home was the type of structural material used. We found that houses made with weatherboard or fibro had significantly higher geometric mean concentrations of Der p 1 in beds than homes made from brick material, but this was because homes made from these materials were older than brick homes. A total of 98.6% of homes under 10 years old were made of brick material, whereas only 64.2% of

Table 4. Factors influencing Der p 1 concentrations in the bed

| Factor              | Level        | n   | Mean Der p 1 concentration (µg/g) | P-value <sup>#</sup> | Adjusted* fold difference (95% CI) | Odds ratio for >10µg/g (95% CI) | Adjusted* OR for >10µg/g (95% CI) |
|---------------------|--------------|-----|-----------------------------------|----------------------|------------------------------------|---------------------------------|-----------------------------------|
| Structural material | Weatherboard | 134 | 20.69 (16.98–25.21)               | <0.0001              | 1.05 (0.72–1.53)                   | 2.22 (1.40–3.53)                | 1.14 (0.57–2.25)                  |
|                     | Brick        | 451 | 12.62 (10.99–14.48)               |                      |                                    | 1.00                            | 1.00                              |
| Foundation          | Wood         | 309 | 19.57 (17.12–23.38)               | <0.0001              | 1.09 (0.72–1.64)                   | 2.18 (1.54–3.09)                | 1.04 (0.52–2.11)                  |
|                     | Concrete     | 294 | 10.15 (8.47–12.18)                |                      |                                    | 1.00                            | 1.00                              |
| Age of home         | ≤ 10 years   | 215 | 9.33 (7.52–11.57)                 | <0.0001              | 1.77 (1.22–2.58)                   | 1.00                            | 1.00                              |
|                     | > 10 years   | 336 | 18.75 (16.38–21.47)               |                      |                                    | 2.30 (1.59–3.32)                | 2.25 (1.20–4.21)                  |
| Visible mould       | Yes          | 53  | 23.21 (16.40–32.85)               | 0.01                 | 1.13 (0.67–1.90)                   | 2.41 (1.15–5.03)                | 1.81 (0.62–5.32)                  |
|                     | No           | 556 | 13.66 (12.12–15.41)               |                      |                                    | 1.00                            | 1.00                              |
| Floor Covering      | Carpet       | 519 | 13.91 (12.30–15.74)               | 0.078                | 1.10 (0.75–1.62)                   | 1.00                            | 1.00                              |
|                     | Hard surface | 88  | 18.54 (14.14–24.31)               |                      |                                    | 1.79 (1.04–3.07)                | 1.37 (0.66–2.82)                  |
| Rugs on the floor   | Yes          | 67  | 19.81 (14.94–26.38)               | 0.047                | 1.34 (0.89–2.04)                   | 1.69 (0.92–3.08)                | 1.63 (0.75–3.55)                  |
|                     | No           | 542 | 13.74 (12.15–15.53)               |                      |                                    | 1.00                            | 1.00                              |
| Heating used        | Yes          | 59  | 20.39 (14.14–29.39)               | 0.054                | 1.29 (0.83–2.01)                   | 1.88 (0.98–3.64)                | 2.38 (0.96–5.91)                  |
|                     | No           | 548 | 14.05 (12.48–15.81)               |                      |                                    | 1.00                            | 1.00                              |
| Type of mattress    | Foam         | 21  | 21.39 (13.77–33.25)               | 0.195                | 1.11 (0.49–2.52)                   | 1.98 (0.66–5.97)                | 1.12 (0.30–4.31)                  |
|                     | Inner spring | 527 | 14.22 (12.58–16.07)               |                      |                                    | 1.00                            | 1.00                              |
| Mattress age        | ≤ 2 years    | 157 | 10.31 (8.03–13.24)                | 0.003                | 1.54 (1.16–2.06)                   | 1.00                            | 1.00                              |
|                     | > 2 years    | 410 | 15.47 (13.47–17.67)               |                      |                                    | 1.79 (1.22–2.61)                | 2.12 (1.31–3.39)                  |
| Woollen blankets    | Yes          | 86  | 27.18 (21.06–35.08)               | <0.0001              | 2.12 (1.46–3.09)                   | 4.07 (2.05–8.05)                | 6.72 (2.51–17.98)                 |
|                     | No           | 525 | 12.88 (11.38–14.57)               |                      |                                    | 1.00                            | 1.00                              |
| Cotton blankets     | Yes          | 66  | 15.39 (11.32–20.94)               | 0.659                | 1.22 (0.80–1.86)                   | 1.09 (0.64–1.88)                | 1.20 (0.58–2.50)                  |
|                     | No           | 545 | 14.18 (12.54–16.02)               |                      |                                    | 1.00                            | 1.00                              |
| Synthetic blankets  | Yes          | 94  | 22.18 (17.51–28.11)               | 0.001                | 1.58 (1.10–2.26)                   | 2.16 (1.25–3.73)                | 2.17 (1.14–4.29)                  |
|                     | No           | 517 | 13.21 (11.64–14.99)               |                      |                                    | 1.00                            | 1.00                              |
| Sheepskin           | Yes          | 41  | 22.95 (14.37–36.66)               | 0.031                | 1.56 (0.91–2.66)                   | 1.47 (0.70–3.06)                | 1.00 (0.39–2.53)                  |
|                     | No           | 570 | 13.84 (12.31–15.56)               |                      |                                    | 1.00                            | 1.00                              |
| Synthetic quilt     | Yes          | 353 | 14.89 (12.83–17.28)               | 0.421                | 1.27 (0.91–1.77)                   | 1.22 (0.87–1.73)                | 1.91 (1.05–3.45)                  |
|                     | No           | 258 | 13.54 (11.34–16.18)               |                      |                                    | 1.00                            | 1.00                              |
| Feather quilt       | Yes          | 176 | 13.49 (10.81–16.86)               | 0.525                | 1.11 (0.77–1.60)                   | 1.17 (0.81–1.70)                | 1.49 (0.78–2.86)                  |
|                     | No           | 435 | 14.65 (12.82–16.73)               |                      |                                    | 1.00                            | 1.00                              |
| Synthetic pillow    | Yes          | 582 | 14.21 (12.63–15.97)               | 0.577                | 1.21 (0.63–2.33)                   | 1.00                            | 1.00                              |
|                     | No           | 29  | 16.54 (10.26–26.67)               |                      |                                    | 1.48 (0.62–3.51)                | 1.53 (0.46–5.13)                  |
| Feather pillow      | Yes          | 103 | 16.15 (12.56–20.76)               | 0.350                | 1.02 (0.71–1.48)                   | 1.22 (0.77–1.94)                | 1.21 (0.63–2.32)                  |
|                     | No           | 508 | 13.96 (12.30–15.86)               |                      |                                    | 1.00                            | 1.00                              |

# P-value for difference in mean Der p 1 concentration.

\*Adjusted for other factors in the table.

homes over 10 years old were made of brick. The type of structural material did not have any effect on the floor concentrations of allergen.

We found that mattresses older than two years were likely to have higher Der p 1 concentrations than newer mattresses. This association has been found in other studies (7, 10, 11). We also found that the use of woollen or synthetic blankets and synthetic quilts is likely to increase Der p 1 levels in beds. Other bedding materials such as feather quilts did not affect Der p 1 concentrations. Other studies have found that beds with woollen mattress coverings have higher Der p 1 levels than beds with other types of covers (3, 9, 23, 24). Wool may create a microenvironment that favors the growth of house dust mites.

However, allergen concentrations reported for different types of bedding must be treated with caution because many beds had over three pieces of bedding, made up of different materials, and we were not able to separate these factors. Only six beds had bedding

materials made up of only feather materials (feather quilts and pillows) and all of these beds had allergen concentrations higher than 10 µg/g. The geometric mean concentration of these six beds was 26.71 µg/g (95% CI 16.22–43.98). A total of 277 beds had bedding made up of only synthetic materials and the mean Der p 1 concentration was 13.51 µg/g (95% CI 11.37–16.05).

In summary, our findings confirm that older homes with carpeted floors tend to have higher floor concentrations of Der p 1. The age of the home also effected allergen concentrations in beds, with other factors such as mattress age, presence of woollen and synthetic blankets, and synthetic quilts also contributing to high Der p 1 concentrations. The finding that high Der p 1 allergen concentrations in homes with carpets and older mattresses indicates that control strategies directed at these sources are likely to be effective in reducing exposure. Alternatives such as the use of allergen impermeable mattress encasings on older mattresses may also be effective in reducing exposure.

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