

## Short communication

# House-dust mites and mattresses

**Background:** Despite considerable efforts to develop anti dust mite strategies, surprisingly few studies have evaluated the allergen content in different types of mattresses in everyday use. This study investigated the presence of mite feces (an indicator of mite allergens) in foam and spring mattresses.

**Methods:** The homes of 152 schoolchildren in Northern Norway were investigated. Dust samples were collected in a standardized way from 24 foam mattresses without covers, 68 foam mattresses with covers, and 24 spring mattresses, and the presence of mite feces detected by a guanine colorimetric paper test (Acarex).

**Results:** We found mite feces in 15 (40.5%) of the dust samples from the foam mattresses without covers and 18 (26.3%) of the foam mattresses with covers. Only three (12.5%) of the spring mattresses contained detectable amounts of feces. Signs of dampness, age of mattress, cleaning of mattress, frequency of vacuuming the bedroom, mechanical ventilation, bedroom temperature and bedroom relative humidity were associated with the presence of mite feces. After adjustment for relevant confounders, the risk of finding mite feces was four times higher in foam compared to spring mattresses (odds ratio 4.0, 95% confidence interval (CI) 1.1–15.1), and eight times higher for the foam mattresses without cover (OR 8.1, 95% CI 1.8–36.9).

**Conclusion:** A simple replacement of foam mattresses with spring mattresses may reduce the exposure to house-dust-mite allergens.

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House-dust mites (HDM) are the most common cause of sensitization and bronchial asthma in most parts of the world (1), and the primary source of antigen in house dust. The principal antigen is a heat-labile glycoprotein (*Der p 1*), 95% of which occurs in mite feces. The feces are 10–40 µm in diameter and easily respirable (2). Airborne levels of *Der p 1* are low compared to the high concentrations found in mattresses and bedding. Thus, mite-sensitive patients with allergic asthma, allergic rhinitis, and atopic eczema/dermatitis syndrome (3) should be given advice on how to avoid mite feces in their mattresses (4). Prevention of exposure to house-dust-mite allergens remains a challenging task, often proving labor intensive, expensive and impractical, and still with uncertainty related to methods of removal.

Vacuuming of mattresses has proved to be ineffective (5), or to give short-term effects (6, 7). Plastic mattress covers are uncomfortable (8), and liquid nitrogen applications are impractical other than experimentally (9). Accaricides may not penetrate into the depths of mattresses, and long-term toxicity is uncertain (10). Newer mattress covers have been developed that are more comfortable and efficient, but these are still not in common use (11). In clinical practice, a combination of

encasing the mattress and control of mites (e.g. by acaricides), and removal of allergens from carpets and non-enclosed bedding is often recommended (12)

Several studies have looked for preventive measures. Reduction in mite count is associated with increased ventilation in the house due to reduced indoor humidity (13). An increase of bedroom temperature may also be beneficial (14). The effects depend partly on geographic factors and whether the main type of mite is *D. pteronyssinus* or *D. farinae* (15). A number of housing characteristics are established as risk factors for high levels of mite infestation.

Despite much research and long-term efforts to develop anti dust mite strategies, surprisingly few studies have evaluated the allergen content in different types of mattresses in everyday use, to be able to give simple guidance in choice of mattress.

This paper reports a study of mattress-dust related to mattress type, and a number of household and occupant characteristics. Two trained investigators visited the homes of all selected children during the months of October and November. The study area, northern Norway, has a temperate climate, with daily average outdoor temperatures in the summer of 10–20°C, and –15–10°C in the winter. One published

study on mites from this region found mites in only a fraction of the households, and only the species *Dermatophagoides pteronyssinus* (16).

## Material and Methods

### Subjects

The homes included in this study were inhabited by 50 asthmatic schoolchildren and 102 controls aged 7–11 years, matched by geography. The children participated in a study of the relationship between indoor environment and asthma, and were selected from a regional asthma cohort.

### Dust sampling and analysis

In each house a sample was taken from the child's mattress by vacuuming (Nilfisk GS, Fisker & Nielsen, Copenhagen, Denmark) the entire mattress surface for 4 min at a power of 1000 W, after bedding and sheets were removed. Mattress covers were not removed. In a few beds with underblankets, vacuuming was done for 2 min on the underblanket and 2 min on the mattress. The dust was collected on cellulose filters using sampling nozzles manufactured by ALK Laboratories (Hørsholm, Denmark). After sampling, the filters with dust were stored in closed Petri dishes at  $-20^{\circ}\text{C}$ . Analysis is based on the guanine colorimetric paper test, Acarex (Werner & Mertz, GmbH, Mainz, West Germany). The guanine content from mite feces is a convenient proxy for faecal mite allergens and allergenic potency (16). After treatment of the dust according to Acarex standard procedures, diazamin compounds are formed, coloring the test paper yellow with different intensities. The concentration of guanine in the samples is determined with reference to a standard curve with guanine (Merck, Paris, France). The detection limit is 600  $\mu\text{g}$  guanine, approximately equivalent to 10 mites/sample.

### Checklist of building and occupant characteristics

We used a checklist to evaluate the environmental indicators of house-dust-mite infestation. A trained investigator completed the checklist in each dwelling. A questionnaire, completed by the principal occupant, was used to obtain information of perceived problems with the indoor climate and further facts regarding the dwelling and the occupants.

### Indoor measurements

Relative humidity and temperature were measured in the children's bedrooms, by thermohygrometers. The measurement period was approximately 20 min, with the instrument placed about 1.5 m above floor/ground level. The thermohygrometers were calibrated at the beginning of the measuring period, and at regular intervals.

### Data analysis

To fit a logistic regression model, the presence or absence of mite feces is expressed as a dichotomous variable. Most categorical housing characteristics were also dichotomised, and their association to the Acarex test checked with *chi*-squared tests. For ordered categorical data we used the Mann–Whitney test, equivalent to *chi*-squared test for trend. The continuous variables were not normally distributed, so we decided to use Kruskal–Wallis nonparametric tests. All variables with at least borderline significant relation to mite detection were included in the logistic regression model. We used backward stepwise regression to fit the model. Statistical analysis was done using STATA software (version 6.0) (STATA Corporation, TX).

## Results

Thirteen mattresses did not fit the classification and were excluded from the analysis. Eleven other households were excluded from the regression analysis due to one or more of the relevant values missing.

Table 1 presents the housing and occupant characteristics significantly related to the presence of mite feces.

Variables like cat/dog in the house, carpet on bedroom floor, and number of occupants, were not related to positive Acarex test. The homes studied are quite homogenous with 85.4% one-family houses, 11.3% several-family houses and 3.3% apartments. There were no significant differences in mite findings between the building types.

Table 2 shows the final logistic regression model predicting the risk of finding mite feces, after stepwise removal of insignificant variables from Table 1. Dummy variables for each type of mattress are included. Results from using a dichotomous variable

Table 1. Housing and occupant characteristics related to the presence of mite feces

| Variables related to positive dust-mite test                    | $\chi^2$ (Yates corrected) | P-value         |
|-----------------------------------------------------------------|----------------------------|-----------------|
| <i>r</i> × <i>c</i> tables                                      |                            |                 |
| Ever visible humidity on the windows                            | 10.18                      | <0.01           |
| Visible mould growth in the house                               | 5.19                       | <0.05           |
| Cleaning of mattress > 52 weeks ago                             | 4.22                       | <0.05           |
| Type of mattress                                                | 5.84                       | <i>p</i> = 0.05 |
| Age of mattress                                                 | 4.5                        | <i>p</i> = 0.11 |
| Fisher's exact test for small expected values, two sided        |                            |                 |
| Mechanical ventilation ( <i>n</i> = 12)                         |                            | <0.05)          |
| Mann–Whitney (equiv. to <i>chi</i> -square test for trend)      | Mann–Whitney               |                 |
| Type of mattress (spring, foam with cover, foam without cover). | 5.78                       | <0.05           |
| Age of mattress (<5 years, 5–10, >10)                           | 4.41                       | <0.05           |
| Continuous variables (non-normally distributed)                 | Kruskal–Wallis             |                 |
| Relative humidity in bedroom                                    | 4.45                       | <0.05           |
| Temperature in bedroom                                          | 5.6                        | <0.05           |
| Number of times vacuumed in bedroom/month                       | 5.6                        | <0.05           |

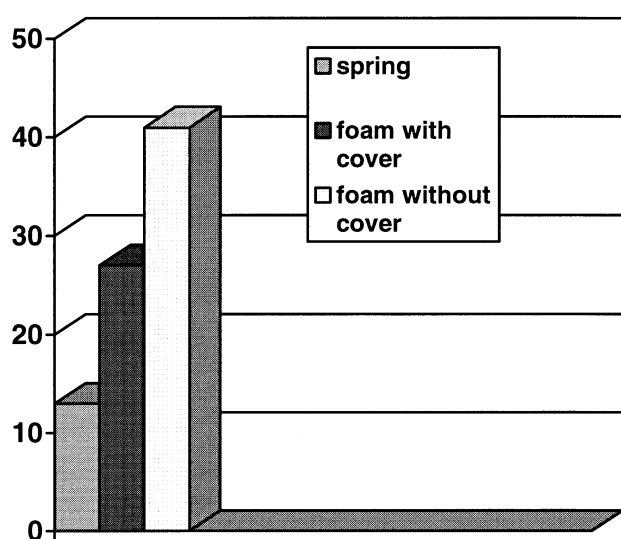


Figure 1. Percentage of mattresses with mite faeces

on mattress type (foam/not-foam), adjusted for the same additional variables, are also included in the table. Type of mattress gives an odds ratio (OR) of 3.3 (borderline significance) for foam with cover, and OR of 8.1 (highly significant) for foam without cover. For all foam mattresses there is a fourfold higher risk of positive Acarex test ( $P < 0.05$ ), compared to spring mattresses. Fig. 1 shows the percentage of the different mattresses types containing mite feces.

The mean temperature was 18.3°C, range 12–23 with SD = 2.5. Relative humidity (RH) was 44.4%, range 27–64 with SD = 7.7. We found mite feces in 43 (28%) of the households, not significantly different between asthmatics and nonasthmatics.

## Discussion

Our study indicates a fourfold higher risk of finding house-dust mite feces in foam than in spring mattresses. The risk is clearly highest in foam mattresses without a cover. The typical foam mattress cover was a thin cotton textile, not intended to be impermeable. The

allergen-preventive effects of standard mattress covers have also been reported in other studies, but mainly for a thicker underblanket type (17).

The large difference in guanine content between foam and spring mattresses is, as far as we know, new in the literature, and has clinical and preventive implications. One Australian study from 1981 (18), counting mites per square meter, gave the opposite conclusion; twice as many mites per square meter on kapok, and three times as many mites on spring mattresses, compared to foam mattresses. The study concluded that foam mattresses are preferable for mite-sensitive atopic subjects. This study from 1981 does not adjust for confounders. In the years after 1981, few other studies have addressed the issue of mattress choice for mite-sensitive patients. Mosbech et al. (17) installed new mattresses, and investigated the amount of *Der p 1* allergen after 8–25 months of use. They found no significant differences between the groups, which may indicate that the differences occur after a longer period of use. The sample size was relatively small, with less than 20 mattresses in each group.

The preferred type of mattress varies widely between countries. It is the authors' impression that foam mattresses are becoming more popular in poor countries, replacing traditional bedding, while the more expensive spring mattresses are taking over in western countries. In our study area, foam mattresses were clearly still the most common among children (61%). We speculate that children tend to get their parents' old foam mattresses.

The mattress base should always be considered in conjunction with mattress replacement, as this could be a major reservoir of domestic mite allergens. Changing a mattress without thorough cleaning of the base could lead to rapid recontamination of the new mattress (19).

Different methods of indicating mite allergen content/exposure are used in different studies, making direct comparison difficult. The presence of live mites at sampling could be different from the amount of accumulated main allergens (*Der p 1*, *Der p 4*), or guanine content (Acarex method). Some studies have showed that total mite count correlates poorly with both allergen and guanine measures, while fecal allergen and guanine content correlates well (20). The guanine-based Acarex method has also showed strong correlation with allergenic potency (16, 20).

Table 2. Logistic regression model predicting risk of positive dust mite test ( $n = 128$ )

|                                                               | Odds ratio | P-value | 95% confidence interval |       |
|---------------------------------------------------------------|------------|---------|-------------------------|-------|
|                                                               |            |         | Lower                   | Upper |
| Ever-visible humidity on windows                              | 0.25       | <0.01   | 0.10                    | 0.68  |
| Cleaning of mattress > once/year                              | 0.11       | =0.01   | 0.02                    | 0.62  |
| Temperature in bedroom                                        | 0.94*      | 0.49    | 0.77                    | 1.13  |
| Spring mattress reference value                               | 1.0        |         |                         |       |
| Foam mattress with cover                                      | 3.3        | <0.10   | 0.81                    | 13.6  |
| Foam mattress without cover                                   | 8.1        | <0.01   | 1.77                    | 36.94 |
| With dichotomous mattress variable (same adjusting variables) |            |         |                         |       |
| All foam compared to spring mattresses.                       | 4.02       | <0.05   | 1.06                    | 15.17 |

\*OR for 1°C; for 5°C, OR = 0.72; for 10°C, OR = 0.52.

## Temperature and humidity

House-dust mites satisfy their demands for water by extraction of water vapour from the air (15). The relative humidity (RH) must be above a certain minimum value for this to happen, usually around 55–60%. The mites will usually survive if RH reaches this level for only one to three hours per day. The optimal conditions for mite growth at room tempera-

ture is 70–80% RH (21–23). The minimum RH value needed for survival tends to increase with increasing temperature, while RH tends to decrease with increasing temperature. In this study an average temperature increase of 10°C, reduced the risk of finding mite feces to approximately one half (OR = 0.52). In conjunction with these findings, a study from the Netherlands showed that mite counts are higher in October and November (14), due to lower temperature and higher indoor RH. When mites are sampled over an extended period of time, adjustments must be made for seasonal variations. Our sampling was completed within six weeks and no adjustment was considered necessary.

Our study found an increased risk of mites in homes with visible humidity on the windows, high relative humidity and visible mould growth. These findings are in conjunction with several other studies (24). It should be noted that the effects of temperature and humidity have been found to affect *D. pteronyssinus* (*Dp*) more than *D. farinae* (*Df*) (15). The geographic variations of these species are only partially known. Our sample is assumed to consist of mainly *Dp*, based on one earlier study in northern-Norway (25). From a clinical point of view, the use of mechanical ventilation in the bedroom to reduce RH (13), and an increased constant temperature is recommended. The ventilation-demands will vary with climate. Korsgaard, in Denmark (13), has reported that ventilation in homes at a rate of 0.5 ach for six months significantly reduced the HDM concentrations in mattresses. In our study only 12 houses used mechanical ventilation. Interestingly, mite feces were not found in any of these homes ( $P = 0.02$ , see Table 1).

#### Other household characteristics

The nonstratified *chi*-squared tests showed influence by the age of the mattress, as reported in other studies (24). Cleaning of the mattress and frequency of vacuuming the bedroom was, not surprisingly, also related to the risk of finding mite feces. In the literature, higher levels of mite allergen or mite numbers in houses have also been associated with different building structures (26) with increasing age of furniture and bedding (27), increasing number of occupants (28), age of house and carpet in the bedroom (24).

#### Prevalence of mites

Our study shows that mites are relatively common even in the sub-arctic regions of Northern Norway. We found mite feces in 28% of the households, not significantly different between asthmatics and nonasthmatics.

#### Conclusion

This study indicates that replacing foam mattresses with spring mattresses could have benefits for mite sensitive patients, and could form part of preventive strategies.

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