

# A combined approach to reduce mite allergen in the bedroom

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## Summary

**Background** Asthma is a common chronic disease of childhood. House dust mite (HDM) are known to be a major source of allergen affecting atopic asthmatics. No single control method has been demonstrated to consistently reduce asthma.

**Objective** We investigated the effect of a combination of two methods of HDM allergen control on HDM allergen content in the bedding and carpets of asthmatic children.

**Methods** This was a double-blind placebo-controlled trial treating the bedrooms of 56 mite-sensitive asthmatic children. The carpet and the mattress, duvet and pillows (bedding) in the bedroom of children of the active group were treated with the acaricide Acarosan (benzyl benzoate). The bedding was then encased in vapour permeable water-proof fabric (Intervent – cotton coated with polyurethane) for 24 weeks. The carpet and bedding of the control group were treated with placebo and the bedding encased in cotton covers for 24 weeks. Dust samples were collected from all these items in a standard manner at regular intervals and *Der p* I content analysed.

**Results** The group with active treatment had a median reduction of 480 ng (100%) in mite allergen from the mattress vs 215 ng (53%) reduction in placebo-treated group by 6 weeks. The *Der p* I content of the active group's bedding was always less than the placebo group after treatment ( $P < 0.01$ ). The acaricide applied to the carpets or inside the mattress covers was ineffective in reducing allergen content.

**Conclusion** This study confirms the effectiveness of encasing covers in reducing the mite allergen exposure but indicates there is no further advantage in applying acaricide simultaneously.

**Keywords:** allergy, benzyl benzoate, bedding covers, carpets, house dust mite

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## Introduction

The house dust mite, in particular *Dermatophagoides pteronyssinus*, is a major allergen of relevance to asthma worldwide [1] and exposure to it is a risk factor for asthma [2]. A number of control methods have been advocated but no single method has been demonstrated to consistently reduce clinical disability. We investigated a simultaneous combination of two methods each of which is reported to be effective [3,4] in reducing mite allergen exposure in patients the acaricide Acarosan (benzyl benzoate) and allergen exclusion covers.

## Methods

Ethical permission was obtained from the United Bristol Healthcare Trust (UBHT) Ethical Committee. Children aged 7–10 years in the UBHT area were approached through their schools and their parents/guardians requested to fill out a short questionnaire. Between May and June 1992, 7386 questionnaires were circulated and 5436 (74%) were returned by 30 June 1992. Analysis of the questionnaire responses used the formula previously applied [5,6] to establish the diagnosis of asthma. Children were diagnosed as asthmatic if they had wheezing with breathlessness in the last year.

Skin-prick testing [7] was carried out on subjects able to attend the Bristol Children's Hospital. One hundred

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**Table 1.** Summary of allergen reduction measures

| Object                                  | Group   | Intervention                              |                                                    |            |
|-----------------------------------------|---------|-------------------------------------------|----------------------------------------------------|------------|
|                                         |         | Day 1                                     | Day 2                                              | Four weeks |
| Bedding<br>mattress<br>duvet<br>pillows | Active  | Vacuumed + Acarosan spray<br>(left 24 h)  | Vacuumed sealed in<br>Intervent cover for 24 weeks |            |
|                                         | Placebo | Vacuumed + Water spray<br>(left 24 h)     | Vacuumed sealed in<br>cotton cover for 24 weeks    |            |
| Carpet                                  | Active  | Vacuumed + Acarosan powder<br>(left 24 h) | Vacuumed                                           | Vacuumed   |
|                                         | Placebo | Vacuumed + Chalk powder<br>(left 24 h)    | Vacuumed                                           | Vacuumed   |
| Soft furnishing                         | Active  | Vacuumed + Acarosan spray<br>(left 24 h)  | Vacuumed                                           |            |
|                                         | Placebo | Vacuumed + Water spray<br>(left 24 h)     | Vacuumed                                           |            |
| Soft toys                               | Active  | Washed at 60°C                            |                                                    |            |
|                                         | Placebo | Washed at 40°C                            |                                                    |            |

and thirteen children were found to be skin-prick test positive (weal diameter at 15 min  $\geq$  3 mm) to the house dust mite solution (Bencard). Samples of their mattress dust were taken to measure *Der p* I content. The 70 children with the highest mattress *Der p* I content (median 580 ng range 100–28 000) were enrolled into the trial and were randomly allocated into active and placebo groups (35 in each group).

#### Avoidance measures

Avoidance measures (summarized in Table 1) were directed at the children's bedrooms only. If there were two beds in the child's bedroom they were both treated. Every effort was made to keep the families blinded as to whether they were in the active or placebo group. To aid this and to control for any placebo effect in the active group, each procedure in the active group had an equivalent action in the placebo group. The bedroom carpet was treated either with Acarosan powder (major ingredient benzyl benzoate 5%, Crawford Chemicals, Milton Keynes, UK) or inert chalk dust. The mattress(es), duvet(s), pillow(s) and upholstered furniture were treated with Acarosan foam (benzyl benzoate 2.6%) or water spray. Chalk or water spray was used in preference to a placebo resembling Acarosan but with the benzyl benzoate absent as this type of placebo may have a mite reduction effect itself [8].

All items were thoroughly vacuumed using a 1000 W Medivac Microfilter vacuum cleaner (Medivac, Wilmslow, Cheshire, UK), Acarosan or placebo was applied,

left on 24 h (the children slept elsewhere) until the items were dry and then re-vacuumed.

After the second vacuuming, allergen exclusion covers (Intervent; cotton encasings coated on one side with polyurethane, WL Gore, Woking, UK) or cotton placebo covers were then fitted to the mattress(es), duvet(s) and pillow(s) and left *in situ* for 24 weeks.

The active group were requested to wash all bed linen in the room at 60°C as washing at a minimum temperature of 58°C has been shown to exterminate house dust mites [9]. In order to keep the procedures as alike as possible placebo families were asked to wash bed linen at 40°C each week. If soft toys had to stay on the bed they were washed at the appropriate temperature at the beginning of the trial. The carpets only were re-vacuumed again with the Medivac 4 weeks after initial treatment. Throughout the trial families continued their normal cleaning routines.

#### Dust sampling and antigen measurement

Dust samples were taken from the carpet, mattress, duvet and pillow of each index child without removing the normal bed linen before treatment (baseline), and at 2, 6, 14 and 24 weeks post treatment. Further samples were obtained from the mattress surface inside the covers at the end of the study. The dust samples were collected blind by two research assistants using a Hoover Dustette 150 W with a 10  $\mu$ m mesh filter attached. Each dust sample was taken from an area 0.25 m<sup>2</sup> for a period of 2 min in a standard zig-zag manner [10], apart from the pillow samples which were sampled using a 600 cm<sup>2</sup>

template for an equivalent time of 30 s. The total content of allergen in the sample was regarded as the primary measurement [11]. The coefficient of repeatability [12] within the range of dust collection for both intra- and inter-sampler was 0.04 g and the coefficient of variation was 13.7%.

Dust samples were kept at 4°C until extracted for analysis and then stored at -20°C. Mite allergen assays were carried out using two site monoclonal antibody enzyme linked immunosorbent assay (ELISA) for *Der p* I and *Der p* II [13] expressed as content of allergen in nanograms. The reproducibility of the assay (coefficient of variation) for *Der p* I was 21%.

### Statistical analysis

Non-parametric tests were used as the data were very skewed especially after treatment. The non-parametric data were expressed as medians and ranges. Mann-Whitney *U*-tests were used for between group comparisons and Wilcoxon matched pairs signed rank tests for within group comparisons. All *P*-values are two-tailed, with a *P*-value of less than 0.05 considered to indicate statistical significance and confidence intervals set at 95%. The data (*x*) have all been transformed to  $\text{Log}_{10}(1 + x)$  in the figures as this allows both the spread and zero scores to be illustrated. Statistical analysis was performed using SPSS for Macintosh software.

### Results

Sixty-two of the 70 children invited to enter the trial

actually had their bedrooms treated (28 active and 34 placebo). The eight withdrawing did so for a variety of social reasons which were irrelevant to the design and aims of the trial. In six of the treated families, treatment was incomplete due to known difficulty in removing the powder from their type of carpet and one sofa was accidentally omitted. This left 26 active and 30 placebo correctly treated rooms at the start of the trial.

One child (placebo) withdrew after 6 weeks as his parents felt his asthma was getting worse. Two active group and two placebo group covers were removed before the last visit so the subsequent dust measurements were discarded. This meant there were 24 active and 27 placebo allergen results available for the 24th week after treatment.

The sample dust weights collected from the two groups were similar at baseline. Table 2 gives median mattress dust weights collected during the study. Utilization of the concentration of *Der p* I produced similar results to the chosen content measurement. There was a high correlation between *Der p* I and *Der p* II content in all bedding and carpets at each time period measured. Results obtained for duvets showed the same significant differences between treatments as the mattresses, pillows indicated the same pattern. Only our results on the *Der p* I content of mattress and carpet are presented in detail for clarity.

### Bedding

**Baseline** At baseline there was no significant difference in *Der p* I content between groups for any of the items measured. Looking at both groups the mattress had the

**Table 2.** Mattress dust weight results (g)

|                                | Group   | Median | Range        | <i>P</i> |
|--------------------------------|---------|--------|--------------|----------|
| Baseline                       | Active  | 0.107  | 0.008–0.2740 | NS       |
|                                | Placebo | 0.095  | 0.027–0.3180 |          |
| 2 weeks                        | Active  | 0.040  | 0.009–0.1080 | NS       |
|                                | Placebo | 0.041  | 0.013–0.0860 |          |
| 6 weeks                        | Active  | 0.031  | 0.003–0.1720 | 0.046    |
|                                | Placebo | 0.054  | 0.009–0.1020 |          |
| 14 weeks                       | Active  | 0.040  | 0.001–0.1380 | 0.0002   |
|                                | Placebo | 0.070  | 0.021–0.1430 |          |
| 24 weeks                       | Active  | 0.034  | 0.010–0.1700 | 0.001    |
|                                | Placebo | 0.076  | 0.011–0.2370 |          |
| Undercover<br>(after 24 weeks) | Active  | 0.035  | 0.009–0.1190 | < 0.0001 |
|                                | Placebo | 0.132  | 0.022–0.3420 |          |

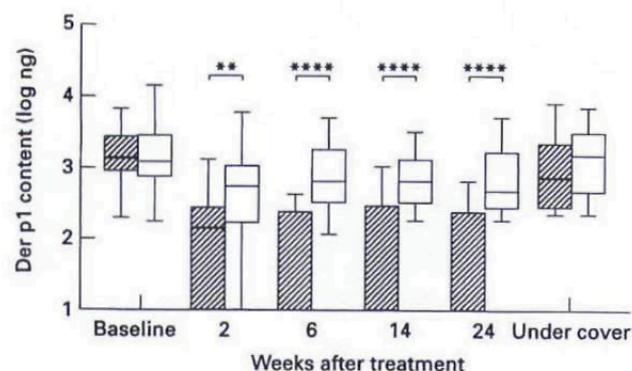


**Fig. 1.** Effect of treatment on *Der p I* content of the mattress. ▨. Active. □. Placebo. Samples were taken through the bed linen and covers after treatment except for the last 'undercover' which was made from the mattress surface after the cover had been removed at 24 weeks. Box shows median (—), 25th percentile (bottom of box) and 75th percentile (top of box). \*\* $P < 0.01$  \*\*\*\*  $P < 0.0001$  (significant difference between active and placebo treatments Mann-Whitney *U*-test).

highest initial median *Der p I* content (440 ng range 34–18400 ng) the duvet median content being 34% of this and the pillow 10%.

**Allergen content above the mite exclusion covers.** Median *Der p I* content of the mattress of the active group was not detectable by 6 weeks after treatment. The *Der p I* content of the mattress was significantly and consistently lower in the active group than placebo at all time intervals after treatment. (2 weeks post treatment  $P = 0.002$  6, 14 and 24 weeks post treatment  $P < 0.0001$  Fig. 1).

Intra-group comparison of active and placebo separately showed both groups, but especially the active, had a significant drop in *Der p I* allergen content after treatment, e.g. active 2 weeks 94.5% drop (estimated median drop 567 ng, CI 349–930  $P < 0.0001$ ) and placebo 2 weeks 63% drop (estimated median drop 320 ng, CI 140–620  $P < 0.001$ .) Only the placebo group at 24 weeks was not significantly lower than baseline ( $P = 0.07$ ). These results indicate that the placebo management of mattress also reduced allergen content.

**Allergen content below bedding covers** No difference was found between treatments in allergen content beneath the covers in mattress, duvet or pillow at the end of the trial nor did either treatment differ from their baseline (Fig. 1). However, the mattress surface allergen content at 24 weeks which was made immediately before removing the covers was less than the allergen content

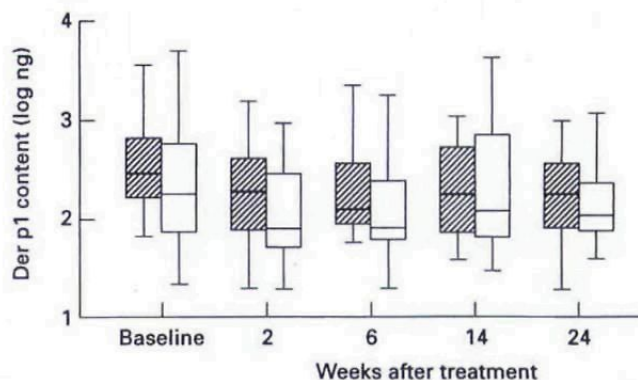


**Fig. 2.** The effect of treatment on *Der p I* content of the bedroom carpet. ▨. Active. □. Placebo. Box shows median (—), 25th percentile and 75th percentile.

of the mattress beneath either type of cover (active  $P < 0.001$ , placebo  $P < 0.01$ ).

### Carpets

Median baseline carpet *Der p I* content was 39% of that of the mattress. There was no difference in *Der p I* content between active and placebo groups before treatment or at any time after treatment (Fig. 2). Neither group differed from baseline with the one exception of the placebo group at 6 weeks which was significantly lower than baseline ( $P = 0.013$ ). The carpets had been thoroughly re-vacuumed at 4 weeks.

### Discussion

Previous work has shown that bedding covers coated with polyurethane reduce the concentration of house dust mites or allergen recovered from mattresses and quilts to 2% of controls [3,14]. Our results confirm this.

No significant evidence of allergen reduction by Acarosan application and vacuuming either below bedding covers or on the carpets was found. Other investigators using controlled trials have similar results for mattresses *Der p I* and *Der f I* [8,14,15] although the first mentioned of these studies did find Acarosan powder applied to carpets was significantly more effective than placebo for *Der p I* and *Der f I* ( $P < 0.05$ ). Another controlled trial [4] has demonstrated a relatively small reduction of total guanine exposure ( $0.05 > P > 0.025$ ) in dust collected from Acarosan treated carpets, mattresses, upholstery and stuffed toys. (Guanine, the major excretory product of mites and other arachnids, was measured by the Acarex test. Acarex scores are reported to have a significant correlation with *Der p I* concentrations [16].) The

percentage of mite allergen reduction in carpets is also dependent upon the length of pile and type of fibre [8].

Placebo treatment of the beds and bedding also had an effect on allergen content. Allergen collected from over the mattress covers of the placebo group was significantly lower than baseline values (although significantly higher than active group allergen collected at the same time interval). In theory this drop could have been caused by one or more of the following: the initial hoovering of the mattress; the cotton encasing or regular washing of the bed linen. Our earlier studies have found vacuuming to be of limited value in mite removal [17]. The reduction in the present study is unlikely to be caused by vacuuming alone as, after 24 weeks, allergen content beneath the covers was not changed from baseline. The cotton covers do appear to have reduced the allergen content as the quantity of *Der p* I collected was significantly lower immediately before removing the covers compared to the quantity collected below the covers. It is likely that regular laundering also contributed to the reduction as it is now known that washing bedding at 40 °C significantly reduces *Der p* I concentration although it does not kill the mites themselves [18].

The results of our study highlight the difficulties of mite allergen removal and indicate that addition of acaricides does not produce an additional effect to that of covers alone. While mite exclusion covers can reduce potential contact between human and mite allergen, reservoirs of mites and allergen may remain in carpets and soft furnishing and these can not be effectively reduced by benzyl benzoate.

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