

Original article

Effectiveness of an intervention to reduce house dust mite allergen levels in children's beds

Background: In temperate climates, exposure to house dust mite (HDM) allergens is the strongest environmental risk factor for childhood asthma. Environmental modifications to limit exposure have the potential to reduce the prevalence of asthma. The aim of this study was to reduce allergen exposure for children at high risk of developing asthma.

Methods: A total of 616 pregnant women were randomized to HDM intervention and control groups. The control group had no special recommendations whereas the intervention group was given allergen impermeable mattress covers and an acaricidal washing detergent for bedding. Children were visited regularly until 18 months of age to have dust collected from their bed.

Results: Der p 1 concentrations in the control group increased from 5.20 µg/g at 1 month to 22.18 µg/g at 18 months but remained low in the intervention group, ranging from 3.27 µg/g at 1 month to 6.12 µg/g at 18 months.

Conclusions: In a high HDM allergen environment, a combined approach using physical barriers and an acaricidal wash, is effective in reducing HDM allergen concentrations in bedding. However, even with these control measures in place, HDM allergen levels remained high by international standards.

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Key words: acaricide; allergens; allergen avoidance; asthma prevention; Der p 1; impermeable mattress covers.

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Accepted for publication 25 February 2003

Australia has one of the highest prevalences of childhood asthma in the world (1). Among the factors that are implicated in causing this high prevalence of asthma is a high prevalence of sensitization to house dust mite (HDM) allergens, which has been associated with a several fold increased risk of asthma (2). Allergen exposure in infancy is also an important factor in the subsequent development of specific sensitization and asthma (3). Even modest reductions in HDM allergen concentrations may lead to a reduction in the severity of asthma (4). The maintenance of a low HDM allergen environment in the first years of life has the potential to decrease the subsequent development of asthma.

Beds have been suggested as the most important source of HDM allergen exposure for children, who spend more than half their time in close contact with bedding (5, 6). Despite this, few investigators have established the effectiveness of HDM allergen avoidance methods in the beds of young children. The majority of allergen avoidance trials have been in older children and adults (7). Methods have included encasing mattresses in impermeable covers and applying acaricides to bedding (8). Concentrations of HDM allergens in Sydney are very high with a recent study showing over 60% of homes

having more than 10 µg of Der p 1 allergen per gram of fine dust in at least one site (9). It has become clear that a strategic approach is required to control levels of HDM allergen in Sydney homes.

In Sydney, a multi-centre randomized trial is being conducted to investigate different methods of reducing the prevalence of childhood asthma (10). These methods include implementing both physical and chemical methods for the reduction of HDM allergens in children's beds. We chose to adopt the use both of impermeable mattress covers and washing bedding in an acaricide. In this paper, we report the effectiveness of this intervention in reducing HDM allergens in children's beds in the first 18 months.

Methods

Study design

The data described in this paper were collected as part of the Childhood Asthma Prevention Study (CAPS) which is a large multi-centre randomized controlled trial designed to test the effect of HDM reduction and a dietary intervention 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 and South Western 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 centre 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.

Randomization

Women were randomized to one of two groups, the HDM reduction intervention group and the control group. Block randomization was performed prior to the first home visit at 36 weeks gestation, and implemented using sequentially numbered sealed envelopes. A detailed account of the recruitment and randomization process has been published (11).

House dust mite reduction intervention

The HDM reduction protocol was developed to be simple and easy to implement on a large scale. The standard recommendations, which were given to both study groups, included simple cleaning and ventilation practices and involved opening the windows and doors of the child's room for several hours each day, vacuuming and dusting all surfaces weekly. Other recommendations included avoidance of humidifiers and vaporizers that increase indoor humidity.

For the intervention group, the intervention began before the birth of the child and involved the use of both physical and chemical methods for the reduction of HDM allergen concentrations. These interventions were focused on the child's sleeping area and the child's main play area as the major sites for allergen exposure during infancy. The HDM reduction recommendations were developed in a form that would either reduce or have no influence on the risk of Sudden Infant Death Syndrome. There was no placebo HDM reduction intervention and no materials were given to the control group to reduce HDM exposure. Because impermeable covers are widely available, a decision to provide placebo covers may have been viewed as withholding standard care. However, the placebo group received the standard recommendations, as described above.

Child's sleeping area

The mattresses of the child's cot or bed were covered with an allergen-impermeable cover (Auspharm Pty Ltd, Rushcutters Bay, NSW, Australia), provided by the study team at the first visit. A washable sheet protector was used above the mattress cover if required, but parents were asked not to use any other under-bedding such as sheepskin underlays throughout the study, and not to use a pillow for the first 12 months. Parents were instructed to allow only washable toys on the child's bed. They were asked to wash any previously purchased bedding with an acaricidal laundry additive before adding it to the child's bed.

Laundry additives/washing instructions

Parents were instructed to wash the child's bedding (blankets and quilts), toys, playmats and pram, stroller or car capsule inserts in Acaril® (Allergopharma Joachim Ganzer KG, Hamburg, Germany) before the birth of the child and then every 3 months. Acaril®, an acaricidal laundry additive designed to kill HDMs and remove allergens in bedding and clothing was provided free for all families in the active intervention group. The active ingredient in Acaril® is 320 g/l benzyl benzoate (National Registration Authority permit no: 1171). The strength of the final washing solution was approximately 0.03% benzyl benzoate (i.e. 1 ml Acaril® per 1 l water). Washing and dilution instructions were clearly marked on an insert with the bottle and in the information sheets provided. Parents were provided with a laundry diary and were asked to record the frequency and materials that were washed in acaricide.

Parent's bed

Co-sleeping with parents was discouraged but if the child slept for more than 2 h/day in the parents' bed, the mattress was covered with an allergen impermeable cover and impermeable covers were used on the pillows for the parent's bed. Parents were also asked to wash their bedding in Acaril® before the birth of the child and then every 3 months.

Child's play area

Parents in the intervention groups were also given a playmat consisting of a 1 m × 1 m section of polyester blanket material with an impermeable backing. This was used for the child to play on, to reduce contact with carpets wherever possible. The playmat was designed to be washable and parents were asked to wash the playmat in a normal wash as often as necessary and to wash it with acaricide once every 3 months.

Adherence to the recommended interventions

In the intervention group, study nurses recorded whether the prescribed mattress cover was in place at 6-, 9-, 12- and 18-month home visits. Information on adherence to the acaricidal washing regimen was collected using the laundry diary and confirmed by checking volumes of acaricide wash used.

Dust collection

Dust samples were collected at home visits conducted when the children were 1, 3, 6, 9, 12 and 18 months old. Dust was not collected prior to birth of the child because in many cases the cots/basinettes had not yet been purchased. An 850 W Sanyo vacuum cleaner (Model SC21R, Sanyo Australia Pty Ltd, Sydney, NSW, Australia) was modified to collect coarse and fine dust in separate nylon bags which were mounted in series 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. 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. Following collection, dust samples were stored at -20°C to prevent mite allergen degradation and fungal growth. Indoor relative humidity and temperature in the subject's bedroom and outdoor temperature and relative humidity in a shaded area of the garden were recorded

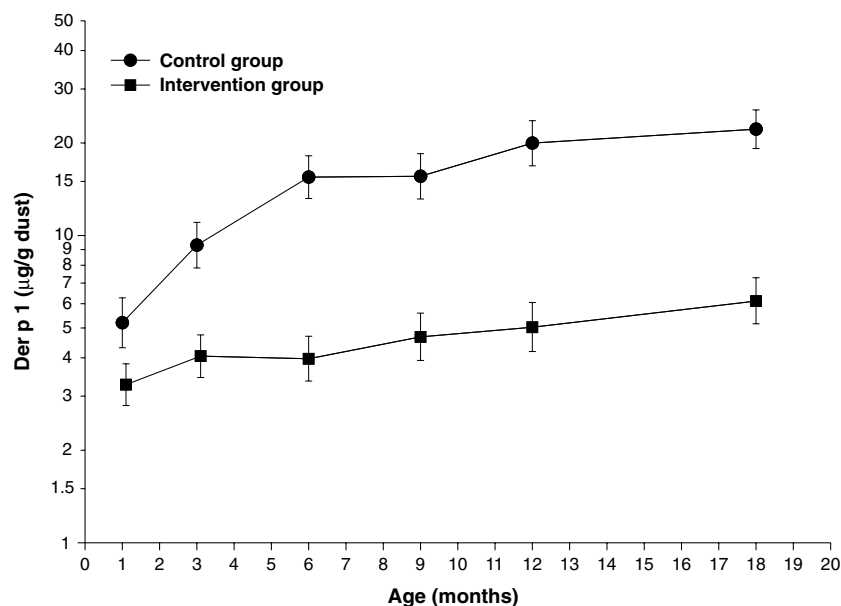


Figure 1. House dust mite allergen concentrations in children's beds.

at the time of each visit using a digital thermohygrometer (Cole-Palmer Instruments Pty Ltd, IL). Information on the type of bedding, type and age of mattress was also collected.

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 PBS-Tween 20 (0.05%). Extracts were stored at -20°C before analysis. Concentration of Der p 1 was measured using a double monoclonal ELISA assay (12). 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 and also expressed as total allergen collected in micrograms. As there was a standardized area of collection in each case, this total amount is influenced by both changes in dust weights and changes in concentration of allergen in dust.

Statistical analysis

The data were analysed using SPSS® Base 8.0 for Windows (SPSS Inc. Chicago IL). Because the distribution of Der p 1 allergen concentrations was skewed, they were $\log_{10}$ transformed to normalize the distribution and allow the use of parametric tests. The results are expressed as allergen concentration (i.e. micrograms per gram of fine dust) and total allergen collected (micrograms). Der p 1 allergen concentrations were expressed as geometric means with error bars showing the 95% confidence intervals.

Results

Of the 616 families recruited into the study, 476 had data collected at all five time points. Figure 1 shows Der p 1 concentrations in the control and intervention groups. In

the intervention group, Der p 1 concentrations increased less than 2-fold from $3.27\text{ }\mu\text{g/g}$ at 1 month to $6.12\text{ }\mu\text{g/g}$ at 18 months. In the control group, Der p 1 concentrations increased to more than four times the baseline value of $5.20\text{ }\mu\text{g/g}$, to $22.18\text{ }\mu\text{g/g}$ at 18 months. The rate of increase in Der p 1 concentration was significantly lower in the intervention group than in the control group ($F = 11.466$, $P < 0.001$, treatment by time interaction, repeated measures ANOVA).

Total allergen levels were also significantly different between the groups at all time points. By 18 months, the control group mean total allergen level was $2.13\text{ }\mu\text{g}$ when compared to the intervention group mean of $0.5\text{ }\mu\text{g}$. (Fig. 2).

Adherence to the intervention, that is use of mattress covers and regular acaricidal washing ('as directed') improved as the study progressed. Table 1 shows Der p 1 concentrations in the three adherence groups.

Discussion

Successful interventions to reduce the numbers of HDMs and the concentration of their allergens may potentially have a significant impact on the burden of asthma. To be useful as a public health measure, environmental control measures need to be effective and easy to implement in the population. The large reservoir of allergen that is present in houses in Sydney together with the favourable conditions for house dust mite proliferation, present a challenge for conducting allergen avoidance strategies. In this randomized trial we have demonstrated that in a high mite environment, a strategy which combines physical

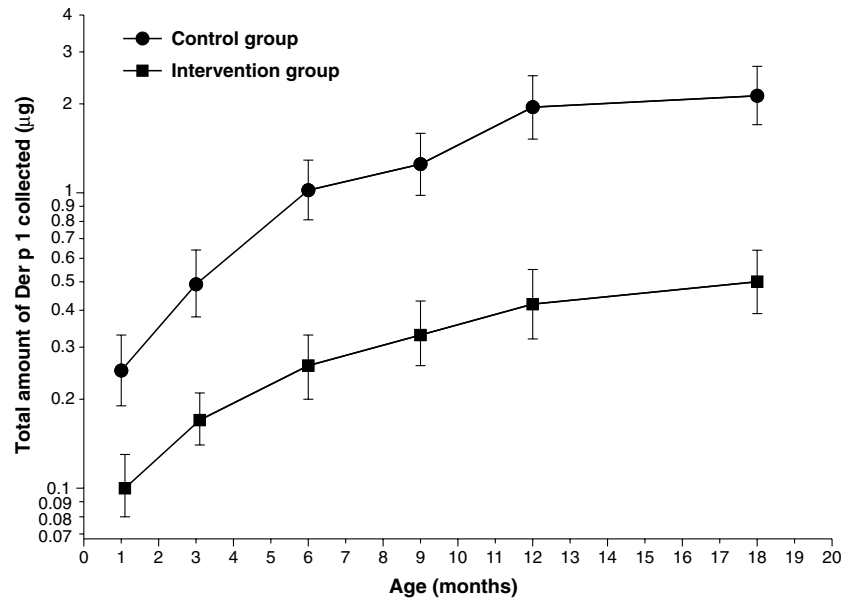


Figure 2. Total amount of Der p 1 collected in children's beds.

Table 1. Adherence to the interventions in the active intervention group and geometric mean house dust mite allergen levels

Visit	As directed		Mattress covers only		Acaril only	
	%	Der p 1 concentration µg/g dust (95% CI)	%	Der p 1 concentration µg/g dust (95% CI)	%	Der p 1 concentration µg/g dust (95% CI)
6 months	65.2	3.47 (2.83–4.25)	81.7	3.42 (2.83–4.13)	79.2	4.03 (3.35–4.86)
9 months	77.2	4.61 (3.82–5.58)	89.9	4.43 (3.68–5.32)	85.1	4.93 (4.10–5.92)
12 months	74.7	4.36 (3.54–5.37)	84.8	4.36 (3.59–5.30)	84.0	4.78 (3.91–5.85)
18 months	78.0	5.27 (4.36–6.39)	80.7	5.27 (4.38–6.36)	94.2	6.01 (5.03–7.17)

and chemical methods is effective in reducing HDM allergen concentrations in children's beds.

During the 18-month period of this study, 63 families withdrew for reasons including loss of contact, a move interstate or medical reasons. In addition there were 60 occasions on which families who remained in the study could not be visited for a schedule dust collection for a variety of reasons. These missing data represent a potential source of selection bias; however, the number of families who had missing data was similar in the control and intervention groups. It is also possible that the home visits themselves may have served as a stimulus for a change in behaviour of the participants, resulting in increased cleaning, washing and vacuuming and therefore a reduction in allergen levels. However, this would have affected both intervention and control groups equally.

For this study, it was not possible to blind the researchers who were responsible for explaining the study and collecting data to the group allocation because different advice was given to each group. However, the researcher who performed the dust analysis was unaware of the group allocation of any of the participants. It is possible that some of the participants may have guessed

that their children were in the control group. It was not possible to give the control group placebo covers or a placebo acaricide because this may have been considered to be withholding standard care. Some of the participants in the intervention group may also have been aware of their group allocation but this would not have an effect on the results of the dust analysis.

It is possible that lack of adherence to the interventions may have contributed to the small increase in Der p 1 concentrations that occurred in the intervention group during the study period. Adherence was reasonable with the majority of families undertaking the interventions as directed (i.e. both washing in the acaricidal wash and using the mattress covers). Analysis of allergen levels according to adherence status suggested that adherence to use of the mattress covers was more important in reducing the concentrations of allergen than adherence to the acaricidal washing regimen.

Other research groups have reported success in reducing HDM allergen levels in young children's beds. A recent study in Manchester employed rigorous HDM reduction techniques including the replacing of carpeted floors with vinyl and the use of mite proof covers, high

filtration vacuum cleaners, new cribs and mattresses and the application of benzyl benzoate to carpets and soft furnishings (13). This intensive intervention resulted in lowering the total amount of house dust mite allergen by 29-fold in the intervention group compared with the control group throughout the first year of life. However, the allergen levels in this study were very low even without active intervention. After 1 year, the mean house dust mite allergen concentration in crib mattresses in the control group was less than 1 µg/g. Similarly, in Vancouver and Winnipeg, Canada, where house dust mite allergen levels are also relatively low compared to those in Australia, use of mattress covers and weekly hot washing of bedding reduced house dust mite allergen concentrations in mattresses by one-third, from 1.3 to 0.9 µg/g during the first 12 months of life (14).

In a sub-study, we measured the agreement between our methods and dust analysis methods from the Manchester study (13) (data not shown). A total of 30 dust samples from each centre were sent to the other centre for analysis. The data showed a difference in concentrations of house dust mite allergen between centres and were 1.6-fold higher using our methods. This does not account for the large differences in concentrations, confirming that geographic region is an important determinant of HDM allergen concentrations.

Sydney is a high HDM allergen environment (9, 15). In a previous randomized controlled trial of allergen avoidance in older children and adults conducted in Sydney, the combination of a mattress cover with a surface chemical spray was not effective in achieving a substantial sustained reduction in HDM allergen levels (16). In the present study, we implemented a more aggressive method for reducing allergen levels. We recommended washing bedding with an acaricidal solution, instead of simply applying a surface chemical such as an 'anti-mite' shampoo, which has been shown to be ineffective in another study (17). In addition, impermeable mattress covers were supplied to our intervention group. In Melbourne, where HDM allergen levels are also relatively high, beds with impermeable mattress covers had a 3-fold

lower concentration of HDM allergen (3.1 µg/g) than beds with cotton mattress covers (9.7 µg/g) after 3 months (18).

In the present study, HDM allergen concentrations in the actively treated mattresses, although lower than in the control mattresses, remained high by international standards. In the UK and Europe, concentrations of Der p 1 are consistently lower than in Australia and New Zealand (19–23). Although minor differences in dust collection and analysis methods may account for some of the differences, they are unlikely to account for the large observed differences.

In summary, the combination of physical and chemical methods for the reduction in HDM exposure in children's beds was effective in reducing house dust mite concentrations by four-fold over the first 18 months of life with some evidence that the use of HDM-impermeable mattress covers is more effective than acaricidal washing. The clinical relevance of these reductions in HDM allergen concentrations will be determined when objective measurements of atopy and early symptoms of asthma are completed.

Acknowledgments

Senior investigators on the CAPS Study are Jennifer K. Peat, Guy B. Marks, Craig M. Mellis and Stephen R. Leeder. Associate investigators are Euan R. Tovey and Karen Webb. The Study Coordinator is Seema Mihirshahi. The authors wish to thank the CAPS research team involved in the study. Data have been collected by the research nurses Samantha Forbes, Nicola Vukasin, Craig Wainwright and William Krause. Allergen assays were performed by Carl H. Vanlaar and Sally Criss.

Funding: National Health and Medical Research Council of Australia, New South Wales Health Department, The Children's Hospital at Westmead and the Cooperative Research Centre for Asthma.

Contributions of goods and services: Allergopharma Joachim Ganzer KG Germany, John Sands Australia, Hasbro, Refrigerated Roadways, AstraZeneca.

Goods at reduced cost: Auspharm, Allersearch, Meadow Lea Foods, Clover Corporation.

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