Domestic control of house dust mite allergen in children's beds

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Background: House dust mite allergen levels in humid coastal regions of Australia are high, particularly in beds. Because high allergen levels in beds are associated with more severe asthma, reduction of levels may be important for asthma control.
Objective: We tested the effectiveness of an acaricidal treatment of bedding in combination with occlusive mattress and pillow encasings in reducing allergen levels in children's beds in a community setting.
Methods: A total of 14 beds of children were selected for the active intervention. In each home the bed of a sibling of nearest age was selected as the control. Dust was vacuumed from beds by using a standard protocol, and Der p 1 levels were measured by using ELISA. Adjacent settling dust was collected by using opened Petri dishes. The intervention consisted of encasing mattresses and pillows in occlusive covers and washing all bedding with Acaril, an acaricidal additive. The acaricidal wash was repeated twice in 7 households at 2-month intervals. Control beds were not treated.
Results: The mean Der p 1 concentration at baseline was 27.9 μg/g in the active beds and 18.1 μg/g in the control beds. At 4 days after intervention, Der p 1 decreased to 3.2 μg/g and 15.7 μg/g in active and control beds, respectively. The average difference (active minus control) over the first 8-week cycle was 78.5% ($P < .0001$), and the difference over 3 washing cycles was 125.1% ($P < .05$). The mean rate of settling Der p 1 adjacent to the actively treated beds decreased from 24.4 ng·m^{-2}·d^{-1} at baseline to 10.0 ng·m^{-2}·d^{-1} after intervention ($P < .01$).
Conclusion: A substantial reduction in Der p 1 levels in beds and in airborne dust in a humid region with naturally high house dust mite allergen levels can be achieved and sustained in a community setting with use of occlusive covers and a rigorous washing routine. (J Allergy Clin Immunol 2000;105: 1130-3.)

Key words: *Allergen avoidance, allergens, mites, encasing, occlusive covers, acaricides, laundry additives*

House dust mite (HDM) allergen levels are very high in homes in humid and coastal parts of Australia where epidemiologic studies have shown that exposure to HDM allergens is an important risk factor for asthma.[1-3] Interventions that have reduced levels of HDM allergen in domestic reservoirs have shown that clinical benefits can be achieved.[4,5]

Abbreviations used
CI: Confidence interval
HDM: House dust mite

Beds are an important reservoir where allergen control is both desirable and achievable. Dust from the bed often has higher allergen concentrations than other domestic sites, and beds are the only site where allergen levels are associated with severity of asthma.[6,7]

Semipermeable encasing of mattresses, pillows, and bed coverings form a barrier that substantially reduces the amount of HDM allergen collected from mattress surfaces and pillows.[5,8-15] Although this method is more effective than interventions based on the use of acaricides[5,10,16] and allergen denaturants,[17] subjects anecdotally report that they find such encasings less acceptable for blankets and duvets because they can be slippery and uncomfortable and do not easily allow changes of bed covering with seasons. An alternative to encasing all the bedding is to encase the mattresses and pillows and regularly launder all the other bedding. This protocol has been used in both experimental settings[18-22] and clinical trials.[4,13,23-25] The specific washing strategy has varied from washing in boiling water,[24] using normal laundry detergent,[19,21,22,25] and using water soluble acaricides.[20-22] Despite advocacy of laundry[26,27] for bedding, there have been no studies to optimize such treatments for either efficiency of allergen removal or to determine the length of time of the effect. In addition, most studies have not been conducted in a community setting.

This study used occlusive covers plus repeated cycles of regular washing and dust collections to determine the degree and length of effectiveness of a standardized washing protocol in a community setting.

METHODS

Study design

A matched-pair study design was implemented. The bed selected for the intervention (the active bed) was that of a child identified in a previous study as being sensitized to Der p 1, with a history of recent wheeze, or both. The bed of a sibling of nearest age was selected as the control bed.

The study was approved by the Human Ethics Committee of the University of Sydney. Parental consent for participation was given before the commencement of the study.

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Treatment and sampling regimen

To obtain baseline allergen measurements, dust samples were collected from participants' homes 2 weeks and immediately before the intervention began. At the commencement of the intervention, mattresses and pillows of active beds were encased with DAC Dust Mite Allergen Control Premium Covers (Allersearch Pty Ltd, Vermont, Victoria, Australia). All bedding in the active bed was subjected to home laundry with Acaril, an acaricidal laundry additive containing 30% benzyl benzoate as the active ingredient (Allergopharma Joachim Ganzer KG, Reinbek, Germany). In a subset of 7 households, the acaricidal wash was repeated twice at 2-month intervals over a total 6-month study period.

Most washing machines in Australia are top-loading, with a wash cycle that runs for 5 to 15 minutes followed by two rinse cycles and use either cold or warm water. All householders were given a guide indicating the correct volume of Acaril to add to their washing machine, so that the final 0.03% concentration of benzyl benzoate, which has been recommended for complete mite control,[21] could be attained during the wash cycle.

Once fitted, mattress or pillow encasings were not removed at any of the sampling visits or at any other time during the study. New cotton mattress protectors (with polyester fibre fill) were fitted over the mattress encasing. To minimize reintroduction of allergen from other sources, parents or guardians were asked not to allow any additional bedding or soft toys to be placed on the active bed unless they were also washed with Acaril. No special washing regimen was implemented for the control bed, and its mattress was not encased.

Dust-sampling protocol

In addition to baseline measurements, dust samples were collected from both the active and control beds at 4 days, 4 weeks, and 8 weeks after the intervention and after each subsequent acaricidal wash. At each sampling visit, dust was collected from beds by vacuuming with a modified 850-W mains-powered vacuum cleaner (Sanyo Australia Pty Ltd, Sydney, Australia). The whole bed was vacuumed, and sampling time was divided as follows: upper bedding (sheets and all layers above) for 1 minute, pillow (both sides) for 30 seconds, and lower bedding (below sheets) for 30 seconds. Dust was not collected from below the encasings. A total of 1 m^2 of the floor of each room (four 0.5 m × 0.5 m areas of each room's floor) was also vacuumed for 1 minute.

The vacuum cleaner was modified so that coarse and fine-pore replaceable dust bags could be used to separate fine dust from coarse particles during the collection of each sample, and clean bags could be used for each individual sample. The vacuum was washed between sampling sites in each house, and the active bed was always sampled first to minimize contamination between the active and control samples.

Settled airborne dust was collected in Petri dishes[17] for 2 weeks before and for 4 weeks after the intervention, starting at day 4. In 8 houses active and control beds were in different rooms, and in these rooms, the dishes were placed on the item of furniture nearest to each bed, whereas in the 6 houses where one bedroom contained the active and control beds, a single dish was placed near the active bed only.

Allergen analysis

The weight of fine dust collected was recorded, and allergen was extracted in 0.2% BSA in PBS with 0.5% Tween-20. This buffer was also used to elute dust from Petri dishes. Extracts were stored at –20°C before analysis. Der p 1 allergen was measured by using a 2-site monoclonal ELISA.[28] The allergen concentration in vacuum samples was expressed as micrograms of Der p 1 per gram of fine dust, and settled airborne allergen was expressed as nanograms of Der p 1 per square meter per day.

Statistical analysis

The allergen concentrations and dust weights were log transformed to normally distribute them. Differences in allergen concentrations between active and control beds were tested by using a paired *t* test. The average allergen concentration over 8 weeks was estimated by calculation of the area under the time-by-concentration curve for each bed. To investigate the overall effectiveness of the intervention, allergen concentration measurements from active and control bed dust were converted to percentage of the preintervention baseline levels, and the mean pairwise (active minus control) differences in allergen levels before and after treatment were evaluated. Repeated-measures ANOVA was used to compare allergen levels in Petri dishes in active and control bedrooms. Multivariate regression was used to determine whether allergen levels in actively treated beds were related to levels in the floors or Petri dishes.

RESULTS

The allergen level from each bed presented in this study is a *total bed* level (ie, contains a mix of mite allergen from the mattress, pillow, and upper and lower bedding). The mean concentration of Der p 1 at baseline was 27.9 μg/g (95% confidence interval [CI], 16.1-48.3 μg/g) in the active beds and 18.1 μg/g (95% CI, 8.0-41.0 μg/g) in the control beds (Table I).

Four days after the intervention, the Der p 1 concentration in active beds decreased to 11.6% of baseline, whereas in control beds there was no significant change from baseline (86.5% of baseline; $P < .01$ for difference from change in active beds). By 4 weeks after the intervention, the mean Der p 1 level in active beds increased slightly from the concentration 4 days after the intervention, but levels remained less than 20% of baseline and less than 30% of levels in the control beds (Table I). The average Der p 1 concentration in actively treated beds over the 8 weeks after the implementation of the intervention was 27.9% of baseline (95% CI, 14.7%-41.1%). The mean active-control difference over this 8-week period in units of percentage change from baseline was 78.5% (95% CI, 56.3%-100.8%; $P < .0001$; Fig 1).

In the subset of 7 households in which the active bedding was washed 3 times over 6 months, the Der p 1 concentration in the active beds remained less than 30% of baseline and significantly below the concentrations observed in the control beds at almost all sampling times after the initial intervention (Table I). With the second and third washes of bedding, there was only a small (and nonsignificant) further reduction in Der p 1 concentration in the active beds compared with concentrations in these beds immediately before each of these washes. The average concentration of Der p 1 over 3 washing cycles (6 months) in this subset of 7 households was 25.7% of baseline (95% CI, 7.0%-44.4%) in these actively treated beds. The mean difference between active and control beds in units of percentage change from baseline over this 6-month period was 125.1% (95% CI, 42.0%-208.2%; $P < .05$).

In the 8 houses where active and control beds were in different rooms, before the intervention, Der p 1 in settling dust was collected at a geometric mean rate of 24.4 and 21.0 $ng \cdot m^{-2} \cdot d^{-1}$ in the active and control rooms,

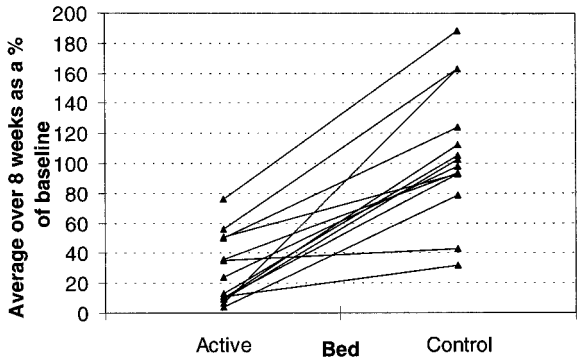

FIG 1. Average Der p 1 level as a percentage of baseline in active and control beds over 8 weeks after intervention. *Lines* link the paired beds in each household.

TABLE I. Geometric mean Der p 1 concentrations in active and control beds before and after intervention over a single and 3 cycles of washing

		Active beds, mean (95% CI)	Control beds, mean (95% CI)	*P* value
Single cycle of washing (n = 14)	Baseline	27.9 (16.1-48.3)	18.1 (8.0-41.0)	NS
	+4 d	3.2 (1.9-5.6)	15.7 (7.2-34.4)	<.01
	+4 wk	4.0 (2.2-7.3)	15.3 (6.8-34.4)	<.01
	+8 wk	5.2 (2.8-9.7)	19.3 (9.4-39.6)	<.01
Three cycles of washing (n = 7)	Baseline	31.0 (10.4-92.6)	24.4 (6.9-86.3)	NS
Cycle 1	+4 d	2.8 (1.2-6.7)	18.8 (5.7-62.1)	<.05
	+4 wk	3.7 (1.4-10.0)	20.1 (7.6-53.1)	<.05
	+8 wk	6.3 (1.9-20.2)	22.6 (9.6-53.1)	<.05
Cycle 2	+4 d	4.5 (1.1-19.0)	22.5 (5.7-88.9)	<.01
	+4 wk	7.9 (2.8-22.2)	24.0 (6.4-89.4)	NS
	+8 wk	6.7 (3.2-13.9)	31.8 (11.3-89.9)	<.001
Cycle 3	+4 d	4.0 (1.2-12.9)	19.8 (11.5-34.3)	<.05
	+4 wk	1.0 (0.1-21.2)	23.0 (6.9-76.4)	<.01
	+8 wk	3.4 (1.2-9.6)	24.8 (6.9-89.7)	<.01

NS, Not significant.

respectively. The reduction in the rooms where the bed was actively treated was significantly greater than that found in the control bedrooms; the geometric mean settling rate after intervention was 10.0 and 18.1 $ng \cdot m^{-2} \cdot d^{-1}$ in active and control rooms, respectively ($P < .01$).

The rate of increase in Der p 1 concentration in actively treated beds over the period from 4 days to 4 weeks after intervention was not related to the rate of settling of airborne allergen over this period or to the concentration of Der p 1 in dust collected from the floor at the beginning and end of this period ($F_{3,12}$, 1.47; $P = .29$).

DISCUSSION

The allergen avoidance regimen that we tested for the reduction of HDM allergen in beds was effective. By fitting occlusive mattress and pillow encasings and thoroughly laundering all bedding with an acaricidal additive, HDM allergen concentration in children's beds was immediately reduced almost by 10-fold, and reduced levels were maintained over an extended period. A decrease in the amount of allergen settling from the air close to the active beds was also observed after the treatment.

Although the allergen reduction observed was not as substantial as that found in some other studies, this may be explained on the basis of the different protocols used. Research groups who have encased mattresses with occlusive covers and taken samples from the mattress before and after they were put in place[5,8,10,11,29] have reported larger reductions in concentration or in total amounts of allergen. However, this may simply be because with the encasing in situ, access to the mattress is blocked, and very little dust and allergen can be accessed by vacuum sampling.

We aimed to reduce mite allergen throughout the bed, including the upper bedding, and not just on the mattress surface. Other researchers have also treated upper bedding in a variety of ways. Some groups used covers for the upper bedding,[10,11,13,14] and others have implemented weekly washing regimens.[15,25] However, only two of these groups have reported a reduction in HDM allergen in upper bedding,[11,25] and the others have so far reported results for mattress surface samples only. Although such reductions are impressive, there may be difficulties in obtaining good compliance with regimens that are either uncomfortable or inconvenient.

Previously, we have achieved a more than 20-fold reduction in HDM allergen when washing bedding in a warm detergent solution under controlled laboratory conditions by using a washing machine with a 9-minute washing cycle.[19] However, the current results show that when the procedures were performed in a community setting with minimal supervision, the immediate reduction in Der p 1 concentration was less than 10-fold, and no further reduction was achieved with subsequent washes. There are several possible explanations for this lesser reduction. It is possible that some participants used washing machines with wash cycles of less than 9 minutes or did not wash all the bedding as instructed.

The observation that the active beds with the least reductions in allergen over time were usually in the houses with the greatest increases in allergen levels in the control beds and vice versa (Fig 1) suggests that an active biologic phenomenon involving allergen production and distribution is occurring in these households over the period after the intervention. Measurements of settling aeroallergen and allergen in settled dust from the floor did not identify this mechanism. It is unlikely to have a seasonal basis because participants were not recruited at the same time.

This study has shown that even in a humid region that is favorable for HDM proliferation, it is possible to achieve substantial reductions in reservoirs of mite allergen in bedding by using a combination of allergen barriers and a regular washing routine performed by householders. Improvements in some technical aspects of the intervention could possibly further enhance the degree of allergen reduction. Now that an effective method of allergen control has been established, it will be important to test methods to further improve effectiveness and its efficacy in reducing the severity of symptoms in subjects allergic to HDM.

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