

The Melbourne House Dust Mite Study: Eliminating house dust mites in the domestic environment

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Background: Hypersensitivity to house dust mite allergens is associated with increased asthma morbidity. Asthma severity appears to be related to the degree of mite allergen exposure. Short-term studies suggest that complete avoidance reduces disease severity.

Objective: The study was designed to assess the effect of different mattress covers and floor coverings on mite allergen concentrations in the homes of mite-sensitive children with asthma in the city of Melbourne, Australia.

Methods: Mite allergen Der p 1 concentration was measured on mattress covers, mattress surfaces, and carpeted and uncarpeted floors in 107 dwellings; and measurement was performed on three occasions over a 5-month period. After the first sampling, all mattress covers and impermeable encasements were permanently removed.

Results: The initial geometric mean concentrations of Der p 1 (micrograms per gram of fine dust) from the surfaces of sheepskin, wool, and cotton mattress coverings were greater than those from the surfaces of impermeable mattress encasements (116, 113, and 19 vs 0.4) ($p < 0.001$); corresponding concentrations on the underlying mattresses were 142, 38, 20, and 0.6, respectively ($p < 0.05$ to 0.001). At the end of the study these mattress surface concentrations were 79, 65, 9.7, and 3.1, respectively. In 24 dwellings an uncarpeted room was adjacent to a carpeted room. At each visit the concentration of Der p 1 in uncarpeted rooms was below the reported threshold for sensitization and significantly less than that in the adjacent carpeted room.

Conclusion: In homes of children with asthma, "asthmogenic" concentrations of Der p 1 were found on nonencased mattresses and carpeted floors, but the use of impermeable mattress encasements and carpet exclusion were associated with concentrations of Der p 1 below the reported threshold for sensitization. (*J Allergy Clin Immunol* 1997;99:323-9.)

Key words: House dust mites, Der p 1, carpets, mattresses, asthma, mite avoidance

The prevalence of asthma has been increasing worldwide over the last 20 years.¹⁻⁴ In Australian children aged 8 to 11 years, the 12-month period of prevalence of wheezing has increased from 12.5% to 25%, and airway hyperresponsiveness has increased from 9% to 18%.⁵ Allergen exposure in infancy has been linked to the development of airway hyperresponsiveness and respiratory illness.⁶ Between 60% and 85% of children living in warm and temperate climates are sensitized to house dust mites, and allergy to house dust mites has been associated with a several-fold increased risk of asthma, depending on the degree of ambient exposure.⁷ Exposure to more than 2 $\mu\text{g/gm}$ of fine dust of the *Dermatophagoides pteronyssinus* allergen, Der p 1, has been proposed as a significant risk factor for the development of sensitization in at-risk individuals; and exposure to more than 10 $\mu\text{g/gm}$ of fine dust has been associated with acute asthma symptoms and hospital admission.⁸ There are numerous sources of mite antigen in the home environment, but the greatest reservoir of the allergen is in carpets and mattresses.⁹ The concentration of mite allergen in Australian homes has increased in the last decade.⁵

A corollary of these findings is that removal of allergen from the environment may be of clinical benefit. Although there have been relatively few public health interventions to test the effect of allergen reduction on reducing asthma morbidity, several studies of children and adults with asthma have demonstrated marked reduction in symptoms, histamine bronchial hyperactivity, and sensitivity to house dust mite challenge after exclusion of house dust mite allergen from the environment by moving subjects to an alpine or hospital setting.¹⁰⁻¹² More recently, immunoreactive Der p 1 has been recovered from bronchoalveolar fluid of patients with house dust mite-sensitive asthma, which has been reported to be significantly reduced 24 hours after moving into a house dust mite-free accommodation.¹³ To some degree, these benefits can be replicated when intensive control of mite allergen exposure in the home has been pursued by using a combination of avoidance methods.^{14, 15}

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Abbreviation used

GM: Geometric mean

Simple methods for reducing house dust mite allergen exposure in the domestic environment are required, and two of the simplest procedures likely to succeed are the use of impermeable mattress encasements and the presence of uncarpeted floors in homes. However, there are limited data on the efficiency of these individual control methods, because most studies¹⁶ have used a combination of different treatment methods, and few have measured allergen concentrations. As a consequence, although uncarpeted floors and impermeably encased mattresses would be expected to be associated with reduction in house dust mite allergen exposure, their efficacy in different environmental situations requires confirmation.

We studied, over a 5-month period, the variation in concentrations of Der p 1 in the differing home environments of a large number of children with asthma and house dust mite sensitivity. This cohort provided an opportunity to examine the effect of different mattress covers on mite allergen concentrations on mattresses and to assess the changes in allergen concentration once covers were removed. We also compared the allergen concentrations in uncarpeted bedrooms with those in carpeted bedrooms of children with asthma and the concentration of Der p 1 in uncarpeted areas with those in carpeted areas from the same dwelling over time.

METHODS**Conduct of study**

This study was conducted between winter (July) and late spring (November 1991).

One hundred seven children with moderately severe asthma (median dose of inhaled steroids, 600 µg/day), 71 boys with a median age of 8 years (range, 4 to 17 years) and 36 girls with a median age of 9.3 years (range, 4 to 16 years) who were all under the care of a single physician, were enrolled in the 5-month study. All had demonstrated skin prick test reactivity (wheals >6 mm) to an extract of *D. pteronyssinus* (30,000 allergen units/ml) (Hollister Stier, Spokane, Wash.).

Mattress covers

Children were using a variety of mattress covers including sheepskin, plastic, woollen, and cotton covers, as well as impermeable encasements. Impermeable encasements were from different manufacturers and of differing quality. Twelve were described as poly-cotton-bonded with polythene; six were thick, plastic "fitted" sheets, which encased all but the undersurface of the mattress; and four were plastic sheets, which encased all but the undersurface. For the purposes of this study, all the plasticized and polythene covers have been grouped together and considered "impermeable" encasements.

Sampling methods

Dust samples were collected within 3-week periods in July (winter), August to September (early spring), and October to

November (late spring). Dust samples were collected from the mattresses and mattress covers and from the living room, children's bedroom, and parents' bedroom floors. Parents were asked not to clean the mattresses or sweep or vacuum these floors for 48 hours before sampling and were encouraged to clean the house a maximum of twice per week. At the first visit, the surfaces of the impermeable encasements, sheepskin, wool, and cotton mattress covers were sampled and then permanently removed; all mattress surfaces were sampled immediately after coverings and encasements had been removed and at subsequent visits.

All samples were collected by using a Nilfisk GS90 (700 W) vacuum cleaner with the manufacturer's upholstery nozzle including a plastic insert. A standard hose attachment was used with two steel extension tubes for floor samples and one steel tube for bed samples. Dust bags (Hoover Dustette, Melbourne, Australia) were attached to the vacuum cleaner through a plastic sleeve designed by the Department of Biomedical Engineering, Royal Children's Hospital (Melbourne) and anchored by strong rubber O rings. To avoid cross-contamination between samples from different sites, vacuum cleaner parts were cleaned with wet cloths and then dried after each sampling. All washable machine parts were washed at the end of each sampling day. The same make of vacuum cleaner was used to collect dust samples from all sites, and collection was performed by one of two trained allergy research nursing staff. All samples were sealed in plastic bags and sent to the laboratory where they were stored at 4° C, under desiccant, until they were extracted.

Floors were sampled over a 2-minute period from within a 1 m² frame; in bedrooms this was adjacent to the bed, and in living rooms it was adjacent to where the child would normally sit. Whole single-bed mattress surfaces were sampled during a 4-minute period.

Measurement of Der p 1

Dust samples were sieved, weighed, and extracted (100 mg/2 ml) with borate-buffered saline solution containing 0.1% (vol/vol) Tween-20 and 250 U/ml of the serine protease inhibitor aprotinin (Bayer Pharmaceuticals, Sydney, Australia) for 2 hours at 4° C with rocking. Where dust was limited, samples were extracted on a pro rata basis. However, total dust samples weighing less than 10 mg were not analyzed. The samples were centrifuged, and supernatants were removed and analyzed for Der p 1 content by using a monoclonal antibody capture ELISA, essentially as described by Luczynska et al.¹⁷ Aliquots of supernatant were dispensed into ELISA plates (MaxiSorp, Nunc, Denmark) together with dilutions of standards. The standard used was an extract of spent mite growth medium previously standardized against the preparation obtained with the monoclonal antibody kit. The substrate used in the assay was 3,3',5,5'-tetramethylbenzidine (Kirkegaard and Perry Labs Inc., Gaithersburg, Md.), and optical densities were read at 630 nm. Data were analyzed by using the ELISA-AID software (RMA Inc.) and expressed as micrograms of Der p 1 per gram of fine dust.

Data management and statistical analysis

The concentrations of mite allergen (micrograms per gram of fine dust) were compared between the rooms of each dwelling. In places (notably floorboards) where there was insufficient dust (<10 mg) to extract, samples were assigned a value of Der p 1 of 0.005 µg/gm of fine dust (which was half the minimum detectable concentration) and included in the analysis. Data were log-transformed because of the heavily skewed distributions. Groups were summarized by using geometric means

(GMs), and comparisons of these were made by using analysis of variance and Student's *t* test (paired and unpaired as appropriate). The corresponding 95% confidence intervals were calculated in the log scale and back-transformed to the original data. Linear regression analysis revealed a high correlation ($r = 0.89$) between the log-transformed Der p 1 $\mu\text{g/gm}$ of fine dust and log-transformed Der p 1 $\mu\text{g/m}^2$, and therefore only the former data are presented.

RESULTS

Patient numbers

One hundred seven homes were entered into the study. Seven were withdrawn after the first visit, and 12 were withdrawn after the second. Among these withdrawals, 11 families moved, five were unwilling to follow the trial's protocol, and three were difficult to contact for further sampling for logistical reasons. Consequently, 88 dwellings were available for analysis at the end of the study.

Meteorologic data

The study was conducted within 15 km of the central business district of Melbourne, a capital city in southeast coastal Australia. Dust samples were obtained from homes within 3-week periods in winter (July), early spring (September), and late spring/early summer (November). The mean daily temperatures in each of these periods ranged from 7.7 to 14.1°C, 8.8 to 17.0°C, and 11.2 to 22.2°C, respectively. The mean relative humidity values, outdoors at 3:00 PM each day for these periods, were 63%, 55%, and 44%, respectively; and mean monthly rainfalls were 50.6 mm, 74.2 mm, and 25.4 mm, respectively (data from Melbourne Meteorological Bureau).

Mattresses

No samples were taken from mattresses with more than one cover or with covers that parents were unwilling to remove for the duration of the study. As a consequence, at visit 1, 81 mattresses were sampled; at visit 2, 75; and at visit 3, 65. The mean age of mattresses was 6.3 years (range, 1 to 13 years), and impermeable encasements had been in place for a mean period of 2.6 years (range, 3 months to 4 years).

Der p 1 concentrations on the surface of mattress coverings at visit 1

At visit 1 the GM concentration of Der p 1 per microgram per gram of fine dust on the surface of impermeable encasements (0.4) was much lower than those on the surfaces of sheepskin, cotton, or wool coverings on mattresses (all >15) (Table I). The GM concentrations of Der p 1 from mattress surfaces underlying these permeable covers, as well as from uncovered mattresses, all exceeded 15 $\mu\text{g/gm}$, which was greater than those obtained from mattress surfaces underlying impermeable encasements (0.7 μg) (Table II).

TABLE I. Geometric mean Der p 1 concentrations on the surface of children's impermeable mattress covers and other mattress covers at visit 1

Type of mattress cover at visit 1	No. of mattress covers	Der p 1 concentration ($\mu\text{g/gm}$ of fine dust)	95% CI
Impermeable encasement	20	0.4	(0.1, 1.3)
Cotton	27	19*	(6, 61)
Wool	5	113*	(12, 1080)
Sheepskin	6	116*	(15, 910)
No cover	21	27*	(9, 82)

Levels on surface of mattresses without covers (i.e., no covers) are also shown.

CI, Confidence interval.

* $p < 0.001$ for comparison between impermeable encasement and other mattress covers.

Longitudinal effect of mattress cover removal on measurements from mattress surfaces

The concentrations of Der p 1 detected on mattress surfaces at visits 1, 2, and 3 are summarized in Table II. A very high Der p 1 concentration in the mattresses formerly covered in sheepskin and wool remained very high until the final visit (79 and 65 $\mu\text{g/gm}$, respectively). In contrast, the concentration of Der p 1 obtained from mattresses formerly encased in impermeable material increased between visit 1 (0.6) and visit 3 (3.1) ($p = 0.05$); but these levels remained lower than those obtained from other mattress surfaces throughout the study (Table II).

Floors

Paired comparisons were made between the children's bedrooms and other rooms in the same dwelling according to whether the child's bedroom was carpeted or uncarpeted (Tables III and IV). Because of withdrawals and sampling problems, the number of floor samples available for analysis was reduced.

Carpeted children's bedrooms

At the commencement of the study, there were 85 dwellings in which the child's bedroom was carpeted; and from these, 83 sets of samples were available for analysis at visit 1, 75 at visit 2, and 64 at visit 3. In all the dwellings in which the child's bedroom was carpeted, the parents' bedroom was also carpeted; but in 12 of these dwellings, the living room was not carpeted. The GM concentration of Der p 1 in a carpeted child's bedroom, carpeted adjacent parents' bedroom, and living room in the same dwelling exceeded 10 $\mu\text{g/gm}$ of fine dust throughout the study period (Table III). However, at visit 3 the concentrations of Der p 1 in carpeted children's bedrooms was significantly lower (16 $\mu\text{g/gm}$) than at visit 1 (40 $\mu\text{g/gm}$) and visit 2 (45 $\mu\text{g/gm}$) ($p < 0.001$). There was no significant difference between the Der p 1

TABLE II. Geometric mean Der p 1 concentrations on child's mattress surface (after removal of plastic and other mattress protectors)

Child's mattress (according to type of cover at visit 1)	Visit 1 (winter)			Visit 2 (early spring)			Visit 3 (late spring)		
	No. of mattresses	Der p 1 conc. ($\mu\text{g/gm}$ of fine dust)	95% CI	No. of mattresses	Der p 1 conc. ($\mu\text{g/gm}$ of fine dust)	95% CI	No. of mattresses	Der p 1 conc. ($\mu\text{g/gm}$ of fine dust)	95% CI
Impermeable encasement	22	0.6	(0.2, 1.9)	19	0.5	(0.1, 2.5)	17	3.1	(0.9, 11)
No protector	21	27*	(9, 82)	20	17†	(4, 77)	20	14	(4, 46)
Cotton	27	20*	(7, 53)	27	14‡	(4, 50)	21	9.7	(3, 31)
Wool	5	38‡	(4, 370)	4	53*	(2, 1520)	3	65	(6, 687)
Sheepskin	6	142*	(18, 1140)	5	88*	(4, 1750)	4	79†	(6, 1110)

conc., Concentration; CI, confidence interval.

* $p < 0.001$, † $p < 0.01$, ‡ $p < 0.05$, for comparison at each visit between mattresses initially encased in impermeable encasement and other mattress covers.

TABLE III. Paired comparison of GM levels of Der p 1 between child's bedroom and other rooms in the same house, where child's bedroom has carpet

	Visit 1 (winter)		Visit 2 (early spring)		Visit 3 (late spring)	
	No. of houses	Der p 1 conc. ($\mu\text{g/gm}$ of fine dust)	No. of houses	Der p 1 conc. ($\mu\text{g/gm}$ of fine dust)	No. of houses	Der p 1 conc. ($\mu\text{g/gm}$ of fine dust)
Child's bedroom (carpeted)	83	40	75	45	64	16
Parent's bedroom (carpeted)		43		56		30
Child's bedroom (carpeted)	71	39	64	41	55	16
Living room (carpeted)		19*		16†		11
Child's bedroom (carpeted)	12	48	11	88	9	25
Living room (uncarpeted)		0.1*		0.5*		0.9†

conc., Concentrations.

* $p < 0.001$, † $p < 0.01$, for paired comparison with child's bedroom.

TABLE IV. Paired comparison of GM levels of Der p 1 between child's bedroom and other rooms in the same house, where child's bedroom has uncarpeted floor

	Visit 1 (winter)		Visit 2 (early spring)		Visit 3 (late spring)	
	No. of houses	Der p 1 conc. ($\mu\text{g/gm}$ of fine dust)	No. of houses	Der p 1 conc. ($\mu\text{g/gm}$ of fine dust)	No. of houses	Der p 1 conc. ($\mu\text{g/gm}$ of fine dust)
Child's bedroom (uncarpeted)	7	0.2	5	1.5	5	1.4
Parents' bedroom (uncarpeted)		0.4		13		0.1
Child's bedroom (uncarpeted)	10	0.6	12	0.5	10	0.3
Parents' bedroom (carpeted)		70*		42†		27†
Child's bedroom (uncarpeted)	5	0.3	2	Insufficient samples for analysis	5	0.6
Living room (uncarpeted)		1.8				0.5
Child's bedroom (uncarpeted)	12	0.5	14	0.7	11	0.6
Living room (carpeted)		29*		25†		46‡

conc., Concentration.

* $p < 0.01$, † $p < 0.001$, ‡ $p < 0.05$ for paired comparison with child's bedroom.

concentrations in the children's and parents' carpeted bedrooms, but the carpeted living room Der p 1 concentrations were significantly lower at visits 1 and 2 (Table III).

In 12 dwellings the living room was uncarpeted, but the adjacent children's and parents' bedrooms were

carpeted. In these dwellings at each assessment, the living room GM Der p 1 concentrations were less than 2 $\mu\text{g/gm}$ of fine dust; whereas values in adjacent carpeted rooms were significantly greater, with means exceeding 10 $\mu\text{g/gm}$ of fine dust ($p < 0.01$) (Table III).

The levels of Der p 1 from carpeted floors adjacent to

TABLE V. Paired comparison of GM levels of Der p 1 between child's bedroom and other rooms in the same house, where child's bedroom has uncarpeted floor

	Visit 1 (winter)		Visit 2 (early spring)		Visit 3 (late spring)	
	No. of houses	Der p 1 conc. ($\mu\text{g/gm}$ of fine dust)	No. of houses	Der p 1 conc. ($\mu\text{g/gm}$ of fine dust)	No. of houses	Der p 1 conc. ($\mu\text{g/gm}$ of fine dust)
Child's bedroom (uncarpeted)	3	2	3	14.7	1	Insufficient samples for analysis
Parents' bedroom (uncarpeted)		6.7		9.1		
Child's bedroom (uncarpeted)	5	6.3	6	5.6	5	2.4
Parents' bedroom (carpeted)		62*		47		36*
Child's bedroom (uncarpeted)	2	Insufficient samples for analysis	1	Insufficient samples for analysis	2	Insufficient samples for analysis
Living room (uncarpeted)						
Child's bedroom (uncarpeted)	6	4.6	8	5	6	2.8
Living room (carpeted)		13.2†		17		9.8†

Comparisons restricted to dust samples >10 mg (see text for explanation).

* $p < 0.05$, † $p < 0.01$ for paired comparison with child's bedroom.

mattresses encased in impermeable material and those not encased were not significantly different (data not shown).

Uncarpeted children's bedrooms

There were 22 dwellings with uncarpeted children's bedroom floors; and from these, 17 sets of samples were available at visit 1, 17 at visit 2, and 16 at visit 3. In seven of the 22 houses, the parents' bedrooms were uncarpeted; and in five additional houses, the living rooms were also uncarpeted, creating a total of five dwellings in which all three rooms were uncarpeted.

The concentrations of Der p 1 in uncarpeted children's bedrooms, uncarpeted parents' bedrooms, and uncarpeted living rooms were predominantly less than $2 \mu\text{g/gm}$ of fine dust. At visit 1 Der p 1 concentrations in uncarpeted children's bedrooms ($0.6 \mu\text{g/gm}$ of fine dust) were significantly lower than those in adjacent carpeted parents' bedrooms ($70 \mu\text{g/gm}$ of fine dust) and adjacent carpeted living rooms ($29 \mu\text{g/gm}$ of fine dust). These differences persisted throughout the study period (Table IV).

The high concentrations of Der p 1 from carpeted parents' bedrooms and living rooms in the 22 dwellings in which children's bedrooms had uncarpeted floors were similar to those in the 71 houses in which these three rooms were carpeted throughout. Low levels of Der p 1 in uncarpeted living rooms from 12 dwellings in which both the parents' and the children's bedrooms were carpeted were similar to the low levels of Der p 1 recorded in the five dwellings without carpets in these rooms (Tables III and IV).

For statistical purposes, samples that were less than 10 mg were assigned an arbitrary value of Der p 1 of $0.005 \mu\text{g/gm}$ of fine dust (i.e., half the minimal detectable concentration). This has a potential artificially lowering effect on GM levels of Der p 1 in these samples. Therefore in a further analysis the levels of Der p 1 from children's bedrooms with uncarpeted floors but with adjacent carpeted parents' bedrooms and/or living

rooms were re-analyzed with only those dust samples that exceeded 10 mg (i.e., within the threshold of sensitivity of the assay). These data are shown in Table V. In all cases the GM levels of Der p 1 in uncarpeted children's floors were less than those in adjacent carpeted parents' bedrooms or living rooms. However, the number of samples available for this analysis was small, and the differences reached statistical significance for only three comparisons (see Table V).

DISCUSSION

Two major findings from this study have public health implications in terms of controlling house dust mite allergen exposure. First, the concentration of Der p 1 in these domestic dwellings of mite-sensitive patients with asthma are among the highest in the world, being similar to those from Sydney¹⁸ and some dwellings in the United Kingdom^{19, 20} but up to 100 times higher than levels in Sweden,^{21, 22} The Netherlands,^{23, 24} Canada,²⁵ and other parts of Australia.²⁶ Second, the only dwellings to have low bedroom allergen exposure levels were those with no bedroom carpet and impermeable mattress encasements in use even when adjacent rooms were carpeted.

The low concentrations of Der p 1 that we observed in uncarpeted bedrooms compared with carpeted bedrooms in the same dwelling can be attributed to the absence of carpeting. Although others have documented the effect of carpet exclusion from flooring in reducing house dust mite allergen exposure in different dwellings²³ over a prolonged period,²⁷ it is unclear to what extent these observations were influenced by the different physical characteristics of the individual dwellings concerned such as ventilation, heating, and moisture content or fluctuating seasonal conditions over a long period. In addition, our findings highlight the limitation of attempting to reduce mite-induced asthma symptoms by removing carpets in one room when adjacent rooms remain carpeted. The observation that carpeted living rooms all had lower concentrations of Der p 1 than carpeted bedrooms was in contrast to that of another

study.²³ It is unclear whether this reflects differences in human habitation time in bedrooms with increased skin shedding or different cleaning frequencies. The gradual reduction in mite concentrations from carpeted floors over the study period may reflect seasonal factors, with lower mite levels in late spring, or subconscious changes in cleaning behavior.^{27, 28} Unfortunately, we were unable to measure indoor relative humidity in the dwellings for logistical reasons. However, there is good evidence that indoor relative humidity does influence house dust mite levels. In this study the concentrations of house dust mite antigen in different rooms in the same dwelling was examined, and concentrations were lower in those rooms with bare floorboards compared with adjacent rooms with carpeting. It would seem unlikely that within a single dwelling the relative humidity would vary significantly from room to room in the same house to such an extent that it would influence mite growth directly. Currently, it is unclear what the relation is between indoor relative humidity and humidity at the base of carpets and the effect on antigen loads, but it is likely that the relative humidity in carpeting does influence mite growth. Thus from a public health point of view, it would seem more appropriate to exclude carpeting from homes than to attempt to modify relative humidity by making major structural changes in dwellings.

The concentrations of house dust mite allergen obtained from the surface of impermeable mattress encasements and the underlying mattress surfaces were below the threshold considered important for mite sensitization.^{8, 29, 30} Possibly, the impermeable encasements influenced the microenvironment of the underlying mattress and/or food source for mites. Although the low mite antigen levels on these mattresses persisted throughout the study, the concentration increased from 0.7 to 3.1 $\mu\text{g/gm}$ of fine dust from the first to the final visit. This suggests that the generation time of mite allergen is approximately 3 months and would be in keeping with the known life cycle of the mite.³¹ In contrast to the impermeable encased mattresses, the unprotected mattresses contained very high concentrations of mite allergens, sufficient to provoke asthma symptoms.^{8, 29} The concentrations were particularly high in mattresses initially covered with wool or sheepskin, findings consistent with previous observations of increased mite numbers in the sheepskin bedding of infants.³² These very high concentrations of Der p 1 persisted throughout the study period despite removal of the mattress coverings. There was no difference in the concentration of Der p 1 in house dust between samples taken from floors adjacent to plastic-covered mattresses and those adjacent to nonencased mattresses. This suggests that it is unlikely that mite allergen concentrations from floors simply reflect the concentrations in adjacent bedding and mattresses.

From a public health perspective, the implications of this study are clear. Total exclusion of carpets from homes and the application of impermeable encasements to mattresses are likely to result in lower exposure to

house dust mite allergen in dwellings in temperate climates. Carpet exclusion appears superior to the application of acaricides in reducing allergen concentrations^{31, 33, 34}; and it is simpler to implement than alterations in building design intended to influence internal temperature, humidity, and ventilation, thereby diminishing mite growth.³⁵ The application of impermeable encasements to mattresses reduces asthma severity and bronchial reactivity,¹⁴ and preliminary evidence suggests that infants at high risk for the development of atopic disease benefit from measures aimed at reducing allergen exposure including those aimed at mites.^{36, 37} Large-scale, community-based studies are required to determine whether these relatively simple measures will influence the development and severity of asthma in children.

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