

House dust mite avoidance for children with asthma in homes of low-income families

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Background: Home exposure to high levels of house dust mite allergen has been shown to aggravate airways reactivity and asthma.

Objective: The purpose of this study was to determine whether specific house dust mite control measures could reduce exposure levels and asthma severity.

Methods: This double-blinded, randomized trial compared asthma progression over 1 year in children whose homes received standard environmental control intervention with those whose homes received aggressive intervention for dust mite elimination. The primary end point was doubling in PD₂₀ methacholine.

Results: Symptom scores and quality-of-life scores were similar for the standard and aggressive intervention groups. PD₂₀ methacholine doubling occurred in 9 members of the aggressive intervention group vs 4 control patients ($P < .05$). Dust mite levels decreased in the aggressive intervention homes compared with the standard intervention homes ($P < .05$).

Conclusion: Aggressive dust mite intervention decreased dust mite levels and improved bronchial hyperresponsiveness. (*J Allergy Clin Immunol* 1999;103:1069-74.)

Key words: Asthma, dust mite, bronchial hyperresponsiveness, environmental controls

There is growing concern in the medical and lay communities that asthma should be treated more aggressively from both an environmental and pharmacotherapeutic point of view. Continuous exposure to high levels of environmental allergens, in particular house dust mites, has been shown to aggravate airways reactivity and may be a critical factor in the development and perpetuation of asthma.¹⁻⁴

The goal of this study was to determine whether specific house dust mite control measures could reduce exposure levels to this allergen and, subsequently, reduce the severity of asthma in children. The primary end point was change in airways reactivity to methacholine because this response can be roughly correlated with air-

Abbreviation used

PEFR: Peak expiratory flow rate

ways inflammation and clinical disease.⁵⁻⁹ Secondary variables included assessment of symptoms, quality of life, spirometry, urgent care, and hospital visits, as well as prednisone courses for acute exacerbations.

METHODS

Patient selection and clinical measures

This study represents a double-blinded, randomized clinical trial; only the home dust collector was unblinded, and he did not communicate home information to others. Children aged 6 to 16 years with asthma were recruited from clinics that serve lower socioeconomic neighborhoods. The children had been diagnosed by a physician as having asthma and satisfied the definition of having mild-to-moderate persistent disease according to criteria set forth in the National Heart, Lung, and Blood Institute guidelines.¹⁰ These criteria included 1 or more of the following: cough or wheeze more than once a week, nocturnal symptoms, documentation of peak expiratory flow rate (PEFR) at 60% to 80% of predicted level, and current asthma symptoms causing some impairment to normal activity, including school performance. In addition, patients had to meet all of the following inclusion criteria: (1) at least 1 urgent care visit caused by asthma in the previous 6 months; (2) history of required albuterol at least 5 times per month; (3) positive methacholine challenge response at a concentration of 10 mg/mL or less; and (4) positive skin prick test response to *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae*, or both (ie, wheal diameter at least 3 mm greater than that produced by the saline control). Patients were excluded if their families were already carrying out environmental control measures in the home as reported by the field staff on the first home visit.

Parents and older children consented (and younger children assented) to be randomized to either a standard or aggressive environmental control program. The trial was approved by the Investigational Review Board of Children's Hospital and Regional Medical Center, Seattle, Washington.

At the initial visit, all patients provided a history and underwent physical examination, quality-of-life assessment, and skin prick tests to dust mites, cat, cockroach, and regional pollens. Spirometry was performed, with short-acting β -agonists having been withheld for at least 4 hours. Patients were instructed on peak flow techniques and charting of peak flow and symptoms, which was to be done morning and night. Patients received cromolyn, nedocromil, or triamcinolone metered-dose inhalers at the discretion of the investigator, with the inhaled steroid (ie, triamcinolone) being reserved for those with more severe disease, as determined by history of albuterol use and pulmonary function.

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TABLE I. Baseline characteristics of the study population

	Standard	Aggressive
No. of patients (M/F)	9/8	5/14
No. of patients completing the study	17	19
Ethnic composition		
White	10 (58.8%)	11 (57.9%)
African American	4 (23.5%)	5 (26.3%)
Asian-Pacific	2 (11.8%)	1 (5.3%)
Hispanic	—	1 (5.3%)
Other	1 (5.9%)	1 (5.9%)
Age $\pm$ SD (y)	9.9 $\pm$ 3.7	9.3 $\pm$ 2.2
Age range (y)	6-15	6-13

Four weeks later, patients returned for methacholine challenge, and diaries were reviewed. A home visit occurred soon after this at which patients were randomized to the standard or aggressive environmental intervention arms. Patients were again seen in the clinic after 6 and 12 months for history, physical examination, quality-of-life assessment, spirometry, and methacholine challenge. Peak flow and symptom diaries were collected, and families were questioned regarding their children's asthma severity in this interval compared with baseline values. Sequential pulmonary function and methacholine challenges were done at approximately the same time of day and at least 30 days after steroid bursts.

Home intervention and analysis

Standard intervention included a general discussion of the need to dust and vacuum the house weekly and avoid clutter in the bedroom. The home visit to patients in this group involved vacuuming of pillow and mattress, application of tannic acid placebo to the child's bedroom carpet every 4 months, and phone call reminders to families to spray tannic acid placebo on carpets at 2, 6, and 10 months. Aggressive intervention consisted of the application of dust mite-impermeable covers (donated by Allergy Control Products, Inc, Ridgefield, Conn) to mattress, box spring, and pillow; laundry service delivery of a clean blanket and 4 sets of bed linens every month; and tannic acid application to the bedroom and living room carpet every 2 months. Families were instructed to dust and vacuum weekly and to avoid clutter. A vacuum cleaner was provided if a family in either group lacked one, which occurred in only one instance. With each delivery of bedding, compliance with environmental intervention (eg, special covers on beds) was confirmed.

Dust samples were collected from all homes at baseline and 4, 8, and 12 months after randomization. The collection procedure consisted of 2 minutes of vacuuming of the following areas: 2 m² of the upper surface of the child's mattress (sheets removed but special encasings in place), 1 m² of carpet near and underneath the child's bed, a major piece of upholstered furniture in the family area, 1 m² of carpet underneath a major piece of upholstered furniture in the family area, and 1 m² of the kitchen floor. The technique for preparation, storage, and analysis of the samples has been described.¹¹

Statistical analysis

Logistic regression was used to detect a significant effect of the aggressive household intervention compared with standard treatment. A doubling in PD₂₀ dosage units, determined by using baseline and 12-month follow-up results, was compared between groups after adjusting for baseline concentrations of dust mite in the home and baseline levels of bronchial hyperresponsiveness (in PD₂₀ dosage units). The chi-squared statistic was used to detect significant differences between groups for categorical measures, including the incidence of patient exacerbation during the course of the study (emergency department visits, hospitalizations, and steroid courses), change in FEV₁ levels (classified as mild, moderate, or severe), and changes in household dust mite concentration (classified as low, moderate, or high). In each of these analyses, *P* values of less than .05 were considered indicative of statistically significant group differences.

TABLE II. Doubling PD₂₀ methacholine

	Yes	No
Standard	4 (23.5%)	13 (76.5%)
Aggressive	9 (47.4%)	10 (52.6%)

Chi-square, *P* = .049.

es), change in FEV₁ levels (classified as mild, moderate, or severe), and changes in household dust mite concentration (classified as low, moderate, or high). In each of these analyses, *P* values of less than .05 were considered indicative of statistically significant group differences.

RESULTS

Patient sample

Forty-four patients were randomized, and 36 completed the evaluation. Five patients (3 in the standard and 2 in the aggressive intervention groups) failed to complete the trial because of noncompliance with medications and visits. Three (2 in the standard and 1 in the aggressive intervention groups) failed to complete the study because of worsening asthma: 1 patient withdrew on the advice of his primary care doctor, and 2 were withdrawn when FEV₁ values were too low to allow methacholine challenge on repeated occasions.

Mean age and racial distribution were similar between groups. Racial minorities are overrepresented in this sample compared with the composition of the greater Seattle area, where the minority population is approximately 13% (communication from Chamber of Commerce) (Table I).

Medication profiles of the groups were similar, with 9 and 11 of the standard and aggressive intervention patients, respectively, taking cromolyn; 5 standard and 7 aggressive intervention patients taking triamcinolone; and 3 standard and 1 aggressive intervention patient using albuterol only in spite of anti-inflammatory recommendations. This changed little during the trial.

Diaries and symptoms

Attempts to collect daily symptom and peak flow diaries were futile. Although patients were encouraged to mail these, there were no reminder calls built into the protocol. Symptom scores and quality-of-life outcomes were assessed at baseline and at 6- and 12-month visits. Parents rated their child's asthma severity as mild, moderate, or severe. There were no significant changes from baseline to 12 months for each group nor were there any differences between the groups. Quality of life was measured on a 14-point scale, with 0 representing no symptoms and 14 representing many symptoms. These scores were similar for the groups and did not change during the year. Exacerbations measured in terms of hospitalizations, emergency department visits, and steroid bursts were similar for the 2 groups. Although there were more steroid bursts for the standard than for the aggressive intervention group (11 vs 5), this did not reach statistical significance.

TABLE III. Medication use of patients with PD₂₀ doubling

Patient no.	Baseline medication	PD ₂₀ (dosage units)	12-month medication	PD ₂₀ (dosage units)
Standard				
1	Triamcinolone, 3 puffs bid	2.27	Albuterol prn	>100
2	Cromolyn, 2 puffs bid	3.74	Cromolyn, 2 puffs bid	54.58
3	Cromolyn, nebulized tid	2.22	Triamcinolone, 3 puffs bid	>100
4	Cromolyn, 3 puffs bid	1.81	Triamcinolone, 3 puffs bid	8.28
Aggressive				
1	Beclomethasone, 2 puffs bid	9.78	Beclomethasone, 3 puffs bid	58.69
2	Cromolyn, 2 puffs qid	16.90	Cromolyn, 2 puffs qid	>100
3	Triamcinolone, 3 puffs bid	4.62	Flunisolide, 4 puffs bid	21.39
4	Cromolyn, nebulized tid	23.02	Cromolyn, 2 puffs bid	>100
5	Cromolyn, 2 puffs tid	9.02	Cromolyn, 2 puffs qd	19.74
6	Albuterol prn	3.74	Cromolyn, 3 puffs bid	11.85
7	Cromolyn, 2 puffs bid	36.45	Cromolyn, 2 puffs bid	78.85
8	Cromolyn, 2 puffs tid	11.72	Cromolyn, 2 puffs tid	>100
9	Triamcinolone, 4 puffs bid	1.72	Triamcinolone, 4 puffs bid	18.31

prn, As required; qd, daily; bid, twice daily; tid, three times daily; qid, four times daily.

Pulmonary function and methacholine reactivity

Pulmonary function was similar between groups at the beginning and end of the trial. Mean FEV₁ (L/sec) was 1.93 ± 0.97 for the standard intervention group and 1.85 ± 0.56 for the aggressive intervention group at baseline, with little change during the year. Describing asthma on the basis of prebronchodilator FEV₁ as mild (>80% of predicted value), moderate (60% to 79% of predicted value), or severe (59% or less of predicted value), the groups had a similar composition, which was constant for the year.

Bronchial hyperresponsiveness, measured as PD₂₀, showed initial similarity between the groups. The 12-month challenge showed a more pronounced increase in PD₂₀ for the aggressive intervention group than the standard intervention group. There was a doubling of PD₂₀ for 4 members of the standard intervention group and 9 members of the aggressive intervention group ($P = .049$). Changes in PD₂₀ are seen in Tables II and III. Changes in daily asthma therapy, including controlling for inhaled steroid use, did not account for this difference.

Antigen content of dust samples

Antigen content of samples showed abundant quantities of dust mite, cat, and dog allergen. The quantities of cockroach allergen were very low. Dust mite (pooled Der p 1 and Der f 1) concentration was categorized as low (<2 µg/g dust), moderate (2 to <10 µg/g dust), or high (≥10 µg/g dust). A change in designation to a lower category occurred in 16.7% of the standard intervention homes and 50% of the aggressive intervention homes ($P = .03$; Fig 1). From randomization to 12 months later, the standard intervention group had a mean 33% increase in dust mite levels, whereas the treatment group had a mean 19.6% decrease in dust level ($P = .2$).

Levels of Fel d 1 were moderate (<8 µg/g dust) or high (≥8 µg/g dust) in almost all homes at each visit regardless of cleaning regimen or the presence of a cat in the home.

The same was true for Can f 1 (dog antigen). Table IV lists the relative amounts of pet antigen in homes. For cat antigen, the number of patients with a positive skin prick test response and the number of patients with a cat in the home in addition to having a positive skin test response are noted. Skin testing for dog antigen was not performed.

Cockroach antigen concentration (Bla g 2) was measured as being low (<1 µg/g dust), moderate (1 to <8 µg/g dust), or high (≥8 µg/g dust). Only 3 samples contained moderate levels; the rest were low.

Correlation of PD₂₀ doubling, dust mite concentration, and cat antigen concentration

There was no direct correlation between changes in PD₂₀ and dust mite level (Fig 2). No threshold determination appeared to change this. The 13 patients (4 in the standard and 9 in the aggressive intervention groups) who experienced a doubling of PD₂₀ had a mean decrease in house dust mite concentration of 5.4 µg/g, and those who did not had a mean decrease of 2.4 µg/g.

The presence of cats did not have a predictable effect on dust mite environmental control outcome. The 7 patients with positive skin test responses to cat antigen and a cat in the home had a mean increase in PD₂₀ of 10.9 dosage units, and those without cat had a mean increase of 7.8 dosage units, showing that the presence of a cat did not prohibit improvement in PD₂₀. Removing the 7 patients with positive skin test responses to cat antigen and a cat in the home from analysis reduces the power substantially. The relationship between doubling PD₂₀ and dust mite intervention becomes a trend ($P = .17$). The removal of patients with a positive skin test response to cat and cat antigen in the home without a cat reduces the sample too drastically for meaningful analysis.

DISCUSSION

This trial began with the hypothesis that aggressive environmental intervention directed at house dust mite

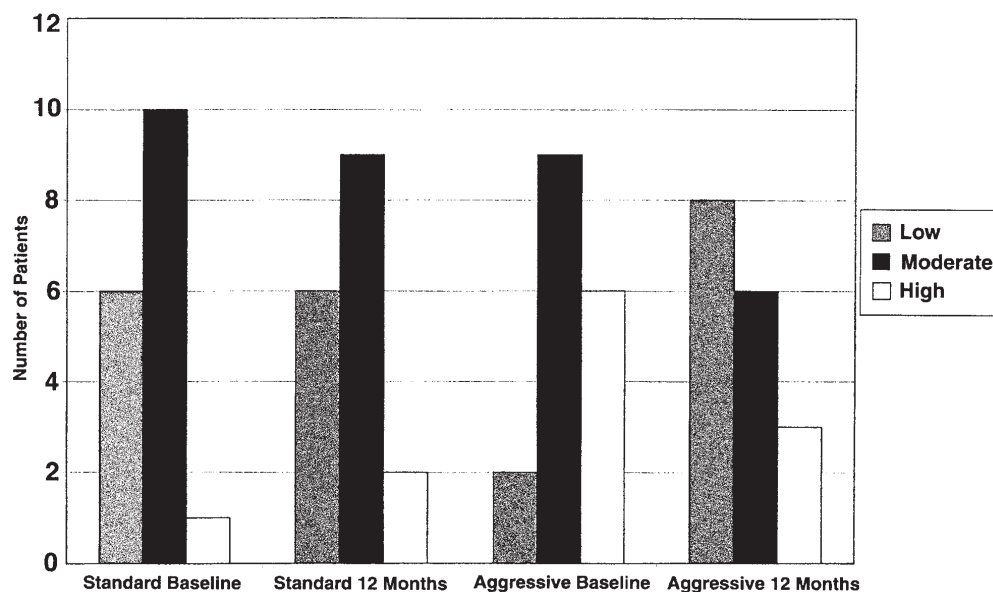


FIG 1. Changes in dust mite concentration levels by group (low, <2 µg/g; moderate, 2 to 10 µg/g; and high, ≥10 µg/g). The number of patients with household dust mite concentrations in the low, moderate, and high range are depicted at the baseline and 12-month collection periods. The change to a lower concentration range was significant for the aggressive compared with the standard intervention groups ($P < .03$).

TABLE IV. Cat/dog antigen levels

	Low		Moderate		High	
	Standard	Aggressive	Standard	Aggressive	Standard	Aggressive
Cat antigen (Fel d 1)						
No. of patients	0	0	6	5	11	14
No. with cat in home	0	0	0	0	8	7
No. with positive SPT response	0	0	4	3	7	6
No. with positive SPT response and cat	0	0	0	0	5	2
Dog antigen (Can f 1)						
No. of patients	1	1	9	8	7	10
No. with dog in home	0	0	1	0	6	6

All values are from the first home visit.
SPT, Skin prick test.

elimination could have a positive effect on asthma in dust mite-sensitive children from homes of lower-income families. The change in the primary outcome variable, doubling of PD_{20} , confirmed this premise. Along with this change, a decrease in dust mite antigen in home samples was demonstrated.

It is disappointing that home symptom diaries and peak flows were not available. Had we built in more patient visits or phone contacts, we might have been more successful with this. However, other studies on asthma among low-income patients have had similar difficulties in obtaining peak flow or symptom diaries.¹² Parental reporting of overall asthma severity and quality of life at 6-month visits failed to show intergroup differences. Although there were differences in the number of prednisone courses (standard intervention group, 11

courses; aggressive intervention group, 5 courses), this did not reach statistical significance.

The concentrations of cat and dog antigens in these homes were impressive. The number of homes with moderate and high levels of pet antigen and no resident pet is in keeping with the findings of others.¹³ Cleaning practices directed at dust mite mitigation did not significantly decrease these levels. Some of our subjects had positive skin test responses to cat antigen and had substantial concentrations of antigen in the home, a situation that could have obscured more dramatic benefits of dust mite environmental control. We cannot prove, however, that cat antigen decreased the benefit of dust mite intervention.

The literature to support dust mite intervention for asthma control is extensive.¹⁴⁻²⁰ Nonintervention studies

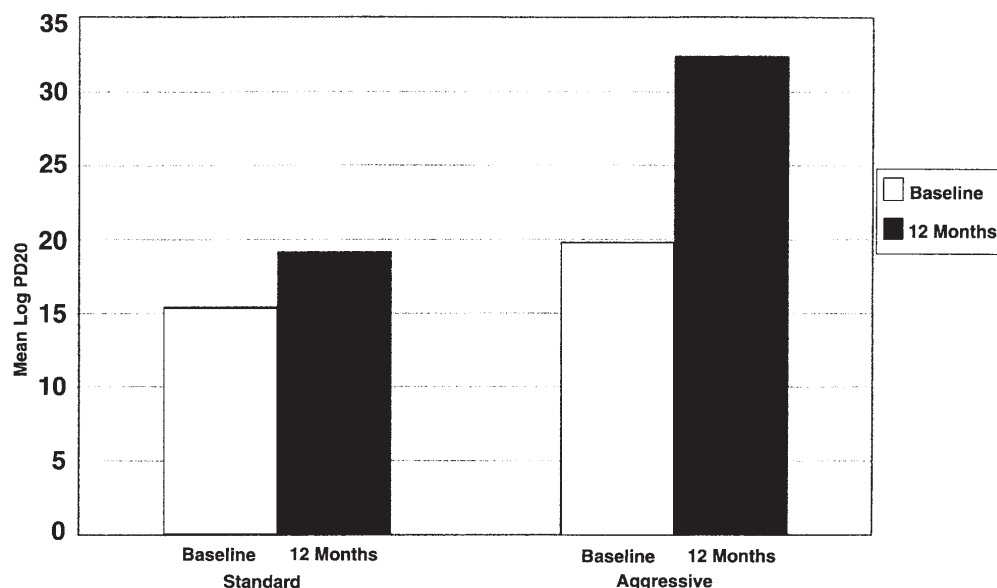


FIG 2. Changes in mean PD₂₀ before to 12 months after initiation of dust mite intervention. Mean PD₂₀ is expressed for the standard and aggressive intervention groups at baseline and 12 months later. The standard group showed a mean increase in PD₂₀ of 24.2%, whereas the aggressive intervention group showed a mean increase of 63.3%.

show correlations between antigen levels and clinical markers of disease severity.⁴ Custovic et al¹ described a correlation between mite exposure, methacholine reactivity, and decreased FEV₁ in adults. Chan-Yeung et al² noted that dust mite–sensitive asthmatic children showed a positive relationship of mean daily symptom score to total mite allergen level and a negative relationship of daily mean PEFR to dust mite level. Sensitization to dust mites has been associated with acute childhood asthma requiring emergency treatment.⁴

Australian investigators have reported that changes in allergen concentration in bedding were significantly correlated with bronchial hyperresponsiveness to histamine and to symptom scores.¹⁶ They cited small within-patient variations in PD₂₀ explained by antigen levels and failed, as we did, to see significant changes in peak flow or FEV₁. European investigators have documented the value of impermeable mattress covers combined with use of filters in improving bronchial hyperresponsiveness.¹⁷ Reduction in mite antigen correlated with a significant change in PD₂₀, but peak flow, FEV₁, and symptoms were unchanged, as with our evaluation.

These more recent studies reinforce other trials from the last decade. Murray and Ferguson¹⁹ studied asthmatic children in dust-free bedrooms that included impermeable covers for pillows, mattress, and box spring; no carpets; and limited toys. Children living in these special rooms compared with children living in standard bedrooms showed fewer days of wheezing, fewer days requiring medication, and fewer days with abnormal peak flow rates. Walshaw and Evans²⁰ evaluated adult asthmatic subjects and compared those living in bedrooms with special bed covers, weekly laundered bedding, and cleaned

or removed carpeting and upholstery with those living in standard bedrooms. Patients with aggressive environmental control had significant improvement in the FEV₁/forced vital capacity ratio, PEFR, and bronchial hyperresponsiveness (histamine), but not FEV₁, compared with the standard group.

Our trial represents the first demonstration of the positive effect of dust mite reduction measures in a low-income US population. It confirms previous observations in more affluent communities of a correlation between decreased dust mite concentrations and improvement in bronchial hyperresponsiveness.²¹ In concert with other trials, bronchial hyperresponsiveness appears to be more sensitive to change with environmental intervention than FEV₁, PEFR, or symptoms.^{16,17} The contribution of other antigens in the home and the complexity of dealing with them in American homes, particularly pet antigens, remains a challenge.

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