Home intervention in the treatment of asthma among inner-city children

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Background: In Atlanta, as in other major urban areas of the United States, asthma is a leading cause of school absenteeism, emergency department use, and hospitalization. Recent guidelines for asthma management recommend reducing exposure to relevant allergens, but neither the feasibility nor the efficacy of this form of treatment has been established for children living in poverty.

Objective: We sought to investigate allergen avoidance as a treatment for asthma among inner-city children.

Methods: One hundred four children with asthma living in the city of Atlanta were enrolled into a controlled trial of avoidance without being skin tested. The children were randomized to an active avoidance group, a placebo avoidance group, and a second control group for which no house visits occurred until the end of the first year. Avoidance included bed and pillow covers, hot washing of bedding, and cockroach bait. Eighty-five children completed the study, and the outcome was measured as unscheduled clinic visits, emergency department visits, and hospitalization for asthma, as well as changes in mite and cockroach allergen levels.

Results: There was a significant decrease in acute visits for asthma among children whose homes were visited ($P < .001$). However, there was no significant difference between the active and placebo homes either in the effect on asthma visits or in allergen concentrations. When the children with mite allergy were considered separately, there was a significant correlation between decreased mite allergen and change in acute visits ($P < .01$). The avoidance measures for cockroach allergen appeared to be ineffective, and the changes observed did not correlate with changes in visits.

Conclusions: Applying allergen avoidance as a treatment for asthma among children living in poverty is difficult because of multiple sensitivities and problems applying the protocols in this environment. The current results demonstrate that home visiting positively influences the management of asthma among families living in poverty. Furthermore, the results for children with mite allergy strongly suggest that decreasing relevant allergen exposure should be an objective of treatment in this population. (J Allergy Clin Immunol 2001;108:732-7.)

Key words: *Asthma, allergen avoidance, dust mite, children, inner city*

Asthma is the most frequent diagnosis leading to the hospitalization of children living in the cities of North America. In some studies hospital admission rates for asthma among African American children living in poverty have been 3 times higher than those in the suburbs.[1,2] Although many factors may have contributed to the differences, treatment for asthma can be adversely affected by factors related to poverty, such as limited access to medical care, poor continuity of care, and decreased likelihood of receiving prescriptions for prophylactic anti-inflammatory agents.[3,4] On the other hand, studies from many parts of the world have established that sensitization to one or more of the indoor allergens is strongly associated with asthma.[5-9] In Atlanta, because of the climate, most patients are exposed to high levels of allergens derived from dust mites, fungi, and seasonal pollens.[10,11] However, in keeping with other inner cities, cockroach allergens are thought to play a more important role than animal dander.[7,10-12]

The current study was designed to investigate whether implementing low-cost measures for indoor allergen avoidance could reduce the number of sick days and unscheduled visits to health care facilities for asthma. It seemed likely that exposure in the child's bedroom was an important factor. In addition to time spent sleeping in the bedroom, 82% of the children with asthma had a television set in their bedroom, and the children in this study reported spending 2 to 4 hours per day watching television. Control of exposure to dust mites is recommended as part of the treatment for asthma among patients with mite allergy.[13-16] Although there is still some controversy about the efficacy of avoidance treatment for asthma, those studies that have decreased dust mite allergen have consistently resulted in clinical improvement, including decreased bronchial hyperresponsiveness.[17,18] Only a handful of studies have been carried out among children living in poverty. A recent study from Seattle reported success in reducing mite allergen and bronchial reactivity in a predominantly white population living in poverty.[19] Successful controlled trials of avoidance measures for cockroach allergens have not been reported.[17,20]

The present study on allergen avoidance for asthma was conducted with a population of children whose primary health care is provided by a clinic in Northwest Atlanta; care for acute episodes is provided by the clinic or at Hugh Spaulding Children's Hospital. It is believed that intervention in patients' houses, including home visits, can have a major (placebo or Hawthorne) effect on housekeeping, as well as on other aspects of asthma care.[21] For this reason, the study was designed with 3

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arms: an active intervention group; a placebo group; and a second control group for which no house visit was conducted until the end of the first phase of the study. In addition, the children were not skin tested until after the first year of the study, so that neither the families nor the staff of the clinic knew which patients were allergic.

METHODS

The Northwest Grady Clinic, which is a satellite clinic of Grady Memorial Hospital, provides outpatient care for a population that is 92% African American, of whom 80% are living in poverty. Two hundred forty-two children (age range, 5-16 years) were identified from the database as being treated for asthma. Of these, 142 were offered enrollment in a study on asthma care as they came into the clinic, and 104 accepted. At this point, the children were randomized to one of 3 groups for a single-blinded protocol. Patients were randomized to either the avoidance, placebo, or control group and enrolled as they came in for care. The study was approved by the Human Investigation Committee of Emory University.

Patient groups and treatment

Avoidance measures for the intervention group included allergen-impermeable mattress and pillow covers provided by Allergy Control Products (Danbury, Conn), effective roach bait (Combat), and instructions to wash the bedding once a week in hot water.[13-16] Parents of children in the active group were also given instructions about cleaning measures to control dust mites and cockroaches. The placebo group received allergen-permeable mattress and pillow covers, ineffective roach traps, and instructions to continue their normal practice of washing the bedding in cool or cold water. The children in the control group continued to have their routine medical care provided at the clinic, but allergen-control measures in the home were not discussed. Because it was believed that a home visit would alter the behavior of families in this group, a home visit was only carried out 1 year after enrollment in the study. Thirty-five patients were initially enrolled in each group (34 in the placebo group) after informed consent had been obtained from a parent or guardian.

Exposure in the homes

For the active and placebo groups, homes were visited at enrollment and again at 3, 8, and 12 months after enrollment. The homes of children in the control group were visited for dust collection after 12 months. Dust samples were obtained from the bed, bedroom floor, kitchen, and living-family room by using a hand-held vacuum with a dust trap (Fussnecker, Springfield, Ohio).[10,11] Dust samples were sieved and assayed for dust mite, cockroach, and cat allergen by using 2-site mAb-based ELISAs.[22-25] Allergen concentrations were expressed as micrograms of allergen per gram of dust. During the initial home visits, active or placebo mattress and pillow covers were put on the beds of the children. At subsequent visits, these covers were checked and replaced if they had been removed or, in one case, punctured. In addition, cockroach bait traps (up to 6 per house) or ineffective traps (placebo) were provided, together with advice about where to place them and about cleaning the house.

Sensitization

In previous studies patients have been skin tested before enrollment, which inevitably meant that both the active and control groups knew what they were allergic to. Children were not skin tested until the end of the study to avoid this problem, and enrollment was not dependent on sensitization results. Ten milliliters of blood were collected at the initial visit and frozen at –20°C. Sensitization was also assessed by means of serum IgE antibodies to dust mite, cockroach, cat, *Alternaria* species, rat urine, and mouse urine by using in vitro assays (Pharmacia CAP or RAST).[26-28] Results were considered positive if there was 0.7 IU of IgE antibody or greater. Although serum was collected at the beginning of the study, the results were not revealed to either the staff in Atlanta or the parents until the completion of the study. Skin testing was carried out with lancets and extracts of *Dermatophagoides farinae, Dermatophagoides pteronyssinus*, cat dander, cockroach mixture (American, German, and Oriental; Hollister-Stier, Spokane, Wash), southern grass pollen mix, southern tree mix, ragweed, and *Alternaria* species (Greer, Lenoir, NC), along with histamine and diluent controls. Wheals with a mean diameter of 4 mm or greater after 15 minutes of observation were considered positive.

Assessment of asthma symptoms

Response to intervention was evaluated by hospitalization, emergency department visits, and unscheduled clinic visits for asthma. Families were questioned about all visits for asthma care, and none of the subjects reported any other than those to the clinic or to Grady Memorial Hospital. In addition, for each patient, hospital and clinic charts were examined, and the number of unscheduled visits was recorded over a 2½-year period, including the year before enrollment and the following 18 months. Visits occurring within 2 days of each other were counted as one visit, and the most severe event occurring within a 2-day period was recorded. Results for acute visits were evaluated in two 15-month periods, from 1 year before enrollment to the 3-month visit (before) and for the subsequent 15 months (after). These time periods were chosen because the response to treatment in previous controlled studies of avoidance has taken 3 months or more.[6,13,14] We assume this is in part due to the time taken to decrease allergen levels and in part due to slow reversal of inflammation in the lungs.[29,30] Patients in the 2 intervention groups were given a peak flow monitor, peak flow charts, and a history sheet for symptoms and medication use; they were requested to fill these in for 2 weeks after each home visit. These children were also given an age-appropriate book to review with their parents: *I am a Meter Reader* by Nancy Sander or *One Minute Asthma* by Thomas Plaut.

Statistical methods

The Pearson χ^2 test was used to compare the numbers of children with a decrease in acute visits between allergen exposure groups. The Student *t* test was used to compare the number of acute visits before and after intervention, as well as the mean percentage changes in allergen between the avoidance groups. Geometric means were calculated for allergen concentrations in Fig 1, and means were compared by using nonparametric Mann-Whitney *U* analysis.

RESULTS

Sensitization and exposure

One hundred four children were enrolled and provided serum samples, house visits were possible in 92 cases, and 85 children completed the study. Dust samples were analyzed for dust mite, cat, and cockroach allergens, and the highest level found in the house was used as the index of exposure. In most houses (72/85) the highest level of mite allergen was found in the bedroom. Cockroach allergen of 1 μg/g dust or greater was found in 60 homes; in all but 3 cases, the highest level was found in the kitchen. Cockroach allergen was found in the bedrooms, but the concentrations were 10-fold lower than those in

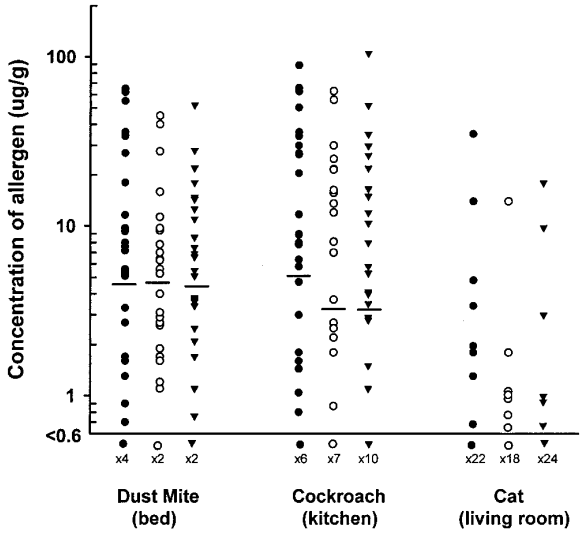

FIG 1. Concentrations (in micrograms per gram) of dust mite (Der f 1 and Der p 1), cockroach (Bla g 2), and cat (Fel d 1) allergens for the active *(filled circles),* placebo *(open circles),* and control *(inverted triangles)* groups, with geometric mean bars. For cat allergen, the geometric means for the 3 groups were each less than 0.6 μg/g. There was no significant difference in allergen concentrations between the active, placebo, and control groups for any of the allergens. Values below the line indicate the number of houses in each group with allergen concentrations of less than 0.6 μg/g.

TABLE I. Sensitization of children with asthma (n = 85) to common indoor and outdoor allergens in Atlanta

	Serum IgE antibody (%)*	Skin test (%)†	Sensitization (%)‡
Dust mite	64	70	74
Cockroach	47	48	56
Cat	18	24	26
Alternaria species	22	28	28
Aspergillus fumigatus	18	ND	18
Mouse urine	2	ND	2
Rat urine	4	ND	4
Seasonal only	ND	2	2
Seasonal with indoor	ND	45	45

*Serum IgE antibodies of 0.7 IU/mL or greater by using Pharmacia CAP or RAST (see "Methods" section).
†Skin tests based on a 4-mm diameter or larger wheal by using a lancet. Four of 85 children had positive results to dog allergen. Overall, 80% of the children had a positive skin test response to one or more allergens.
‡Sensitization on the basis of either a positive skin test response or a positive assay result for IgE antibody.

the kitchens. In keeping with previous results, the concentrations of mite and cockroach allergens were high.[10,11] Sensitization, as determined with skin tests or IgE antibody, was not analyzed until the end of the study. The highest prevalence was to dust mite, cockroach, *Alternaria* species, and cat allergen (Table I). However, sensitization was also found for *Aspergillus* species, pollens, and rodent urine (Table I). The combination of sensitization and significant exposure to dust mite or cockroach allergen was present in 59% and 43% of the cases,

TABLE II. Exposure and sensitization of children with asthma (n = 85) to common indoor allergens in Atlanta

	Exposure*			
	Moderate (%)	High (%)	Sensitization (%)†	Sensitization and exposure (%)‡
Dust mite	68	24	74	59
Cockroach	70	41	56	43
Cat	17	9	26	5

*Exposure on the basis of the highest allergen sample at the first visit. Moderate exposure equals 1 μg/g or greater Bla g 2, 1 μg/g or greater Fel d 1, or 2 μg/g or greater combined Der f 1 and Der p 1 for cockroach, cat, and dust mite allergens, respectively. High exposure equals 10 μg/g or greater Bla g 2, 8 μg/g or greater Fel d 1, or 10 μg/g or greater combined Der f 1 and Der p 1.
†Sensitization on the basis of either 4-mm diameter or greater wheal by lancet skin prick test or positive serum antibody test result (see "Methods" section and Table I).
‡Children with both sensitization and moderate exposure.

respectively. By contrast, the combination of sensitization to cat allergen and exposure to 1 μg of Fel d 1 or greater was present in only 4 cases (Table II). Thus the results confirm that the dominant indoor allergens in this population were dust mite and cockroach.

Home intervention

Patients were randomized to one of the 3 groups. Concentrations of cockroach, mite, and cat allergen are shown in Fig 1. There were no significant differences in allergen concentrations among the 3 groups. Furthermore, the mean ages of the 3 groups were similar: active, 11.1 years (range, 6-16 years); placebo, 10.6 years (range, 6-16 years), and control, 11.0 years (range, 6-16 years). The number of children receiving inhaled controller medicines was very similar in the 3 groups: active, 13 of 30; placebo, 13 of 25; and control, 16 of 30. Children in the active or placebo group received bed covers and relevant cockroach treatment at the first visit. In addition, help was given in applying mattress and pillow covers, as well as education about cleaning. After active or placebo intervention, homes were visited 3 further times over the first year to collect samples and inspect the house. Home visits were carried out by 2 of the authors (M.C.C. and A.R.), who were familiar with both the area and the patients. Decrease in allergen concentration was judged significant if the concentration was decreased by 70% over the 4 visits (Table III). A decrease of mite allergen was only seen in one third of the homes. There was no difference between the active and placebo groups.

Effect of home visiting and changes in allergen concentration on acute visits for asthma

For the children in the 2 intervention groups, there was a significant decrease in acute visits when compared with numbers in the control group ($P < .001$, Table IV). However, in keeping with the results found for changes in allergen exposure, the decrease was similar in the placebo and active groups. Neither the patients nor the medical

TABLE III. Changes in allergen exposure during intervention

	Significant decrease in cockroach allergen		Significant decrease in dust mite allergen	
	Yes (%)*	No (%)†	Yes (%)	No (%)
Avoidance (n = 30)	41‡	38	37‡	55
Placebo (n = 25)	32	40	32	44

*Yes: Improvement determined by at least a 70% decrease in allergen concentration between a prestudy house visit and a sample collected 12 months after intervention.
†No: Includes those houses in which the allergen remained positive or failed to decrease by 70%.
‡For cockroach allergen, 11 homes remained negative throughout the study, and for mite allergen, 9 homes remained negative throughout the study. Those houses were not included in the values.

TABLE IV. Acute visits for asthma among children enrolled in the active avoidance, placebo avoidance, or control groups

	Before enrollment (15 mo)*			After enrollment (15 mo)			
	Hospital	ED	Clinic	Hospital	ED	Clinic	Change (%)
Active (n = 30)	1	7	43	1	5	28	Down 33%
		51			34		
Placebo (n = 25)	2	10	52	0	8	37	Down 30%
		64			45		
							($P \leq .001$)†
Control (n = 30)	0	5	40	1	14	33	Up 6%
		45			48		

ED, Emergency department.
*Twelve months before and 3 months after enrollment. The enrollment date was the first house visit for active and placebo groups and first serum collection for control subjects.
†Significant difference between intervention and control groups (χ^2 analysis).

staff in Atlanta knew which of the children were allergic nor which allergens they had in their houses. Analyzing the outcome for children who were specifically allergic to mite or cockroach demonstrated a significant effect for decreased mite allergen but not for cockroach. Those children allergic to and exposed to mite who had a significant decrease in mite allergen concentration showed a significant decrease in acute visits (11/17 compared with 3/12, $P = .035$). Furthermore, among the 14 children with mite allergy who had a decrease in visits, the mean change in mite allergen was –22.4% compared with +30.1% among the 15 children without a decrease in visits ($P < .01$, Student t test). Although there was a visible decrease in cockroaches, as reported by parents, decreases in cockroach allergen were not associated with a change in acute visits. For the children allergic to cockroach, only 7 of 14 children with a decrease in allergen concentration showed a decrease in acute visits for asthma. By contrast, 6 of the 10 children without a decrease in cockroach allergen had a decrease in acute visits. Many of the children were sensitized to multiple allergens; however, 8 of the exposed children were only allergic to mite, and 1 patient was only allergic to cockroach. Of these 9 patients, the 5 who had a fall in relevant allergen concentration had a decrease in acute visits. The 4 who did not have a decline in allergen concentration did not have a decrease in acute visits.

DISCUSSION

The patients in this study were recruited from an outpatient unit, where 25% of the actively treated population has a diagnosis of asthma. Of these, 104 were randomized, and 85 completed the study. In keeping with previous results from Atlanta, a large proportion of the children were sensitized and exposed to mite, cockroach, or both of these allergens. However, because of the design of the study, this information was not available to the patients or the staff in Atlanta. Thus the significant decrease in acute visits among children with mite allergy who had a decrease in mite allergen strongly supports the relevance of allergen avoidance as an objective of treatment in this population.

The focus of this study was on dust mite and cockroach allergens; however, many of the children were also sensitized to other allergens. We carried out both skin tests and serum assays to gain as much information about sensitization as possible. The prevalence of sensitization to *Alternaria* species and seasonal pollens was not surprising because outdoor counts for pollen and mold spores are high in Atlanta. Exposure to these allergens may be particularly important in this city because most homes keep their windows open. The prevalence of sensitization to rodent urinary proteins reported here is lower than that recently reported for children in the National Cooperative Inner City Asthma Study. This

probably reflects lower rodent infestation in the homes in Atlanta.[31] In this study we used a 4 × 4–mm wheal as a positive skin test result because of our experience that responses of this size are more consistently repeatable and correlate better with in vitro assays. The prevalence of sensitization to cat allergen (ie, 26%) was higher than we would have predicted from the number of families that kept a cat. However, recent results have shown that indirect exposure to cat allergens (eg, in other houses and schools) can result in a high prevalence of sensitization.[32-34] What is not resolved and could be relevant to the present study is how much indirect exposure contributes to symptoms.

The protocol for controlling dust mite exposure has been extensively used in other socioeconomic groups.[13-16,35] The possible reasons why it was less successful in this study include poor maintenance of the child's bedroom, even when covers were in place; children sleeping in other rooms or houses; and the complex effects of sensitization to other allergens. At follow-up visits, only 50% of the homes were judged to have complied with the protocol. The most frequent deviations from the protocol were warm instead of hot washing of bedding by patients in the avoidance group and increased cleaning, removal, or both of dust mite habitats in the placebo group. It seems likely that house visiting has effects in terms of compliance with medicines and more careful observation of the children, as well as in terms of house cleaning. The outcome variable used in the present study was acute visits to the clinic or hospital. In keeping with other studies, the compliance with peak flow monitoring was very poor in this population.[7,36] Indeed, only a minority of the children completed any of the 2-week charts, and therefore these results could not be used in the assessment of the outcome.

Asthma is very common among African American children living in poverty and appears to be becoming more severe. Furthermore, there are special problems in implementing asthma care in this population.[36,37] Recent data from state Medicare records showed that in keeping with national trends, only 20% of prescription claims for asthma in Atlanta were for preventive or controller medications. Hospitalization for asthma in Atlanta (48.2/100,000) is more than twice the national average (18/100,000). In the present studies there was a highly significant decrease in acute asthma visits among the intervention group. Within the 2 intervention groups, children with mite allergy had mite allergen concentrations of 1 μg/g dust or greater at the beginning of the study. Because of the design of the study, the result on the correlation between decreases in mite allergen and decreased acute visits was double blind because neither the staff nor the patients knew which houses had a reduction in allergen nor which children were allergic.

The current study was designed with 2 features that allowed us to evaluate the true effects of decreasing exposure. First, sensitization was not a requirement for enrollment. Second, there was a placebo group for home visiting, as well as a true control group. The positive result for home intervention may reflect increased compliance with all forms of treatment. However, the specific focus of the visit (ie, bedding) inevitably provides increased awareness of the significance of controlling the child's environment. The results for mite (and cockroach) allergens clearly indicate that there is room for improvement in the design and application of the avoidance protocols. Nonetheless, the significant decrease in acute visits associated with decreased exposure among the children with mite allergy strongly supports the relevance of avoidance in the treatment of asthma among children living in poverty and the need to develop better methods for reducing allergen exposure.

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