Risk factors for asthma in inner city children

Robert S. Call, MD,
Thomas F. Smith, MD,
Elsie Morris, MD,
Martin D. Chapman, PhD,
and
Thomas A. E. Platts-Mills, MD, PhD

From the Division of Allergy and Clinical Immunology, University of Virginia Health Sciences Center, Charlottesville, and the Division of Allergy, Immunology, and Respiratory Medicine, Emory University School of Medicine, Atlanta, Georgia

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From the Division of Allergy and Clinical Immunology, University of Virginia Health Sciences Center, Charlottesville, and the Division of Allergy, Immunology, and Respiratory Medicine, Emory University School of Medicine, Atlanta, Georgia

Inner city children have the highest prevalence and the highest mortality rates for asthma in the United States. The purpose of this study was to evaluate sensitization and exposure to common indoor allergens among children aged 3 years to 15 years seen for treatment of asthma at Grady Memorial Hospital, Atlanta, Ga. Eighty children in this study were enrolled in the emergency department and 64 in hospital clinics. Dust from 57 homes, assayed for three indoor allergens (dust mite, cat, and cockroach), revealed similar exposure for asthma and control groups. Sixty-nine percent of the children with asthma had IgE antibodies to dust mite, cockroach, or cat; only 27% of the control subjects were similarly sensitized ($p < 0.001$). Of 35 children with asthma 21 had both sensitization and significant exposure to the relevant allergen; this was true for only 3 of 22 control subjects (odds ratio, 9.5; $p < 0.001$). Neither sensitization nor exposure to cat allergen was common in this population. The results show that black children in inner city Atlanta are exposed to high levels of mite and cockroach allergens and that a high proportion of the children with asthma are sensitized to these allergens; the combination of sensitization and exposure is a major risk factor for asthma in this population. (J PEDIATR 1992;121:862-6)

Hospital admission rates for children with asthma and also the mortality rate for asthma among the black population, particularly among inner city children, are increasing.[1] Studies on the increasing morbidity of asthma have focused on causes such as air pollution,[2, 3] overuse of beta-agonist medication,[4] inadequacy of health care,[5] and inflammation after exposure to inhaled allergens.[5] Children from many countries who have asthma also have a high prevalence of dust mite sensitization.[6, 7] A prospective study confirmed that mite sensitization is a major risk factor for asthma and suggested that exposure of infants to high levels of mite allergen could lead to earlier onset of asthma.[8] In cities across the United States the level and type of allergen found in houses vary greatly with regard to climate and living conditions. In New Orleans, dust mite is the predominant indoor allergen and is present in high levels year-round.[8a] In a study of adult patients, houses in the inner city of Wilmington, Del., had high mite and cockroach levels with low cat allergen levels, whereas in the suburbs, dust mite and cat allergen levels were high and cockroach levels were low.[8b]

ELISA	Enzyme-linked immunosorbentassay
RAST	Radioallergosorbent test

There are currently few data on sensitization or exposure to allergens among inner city children in the United States. Our primary objective was to compare allergen levels in dust and specific IgE antibody levels in serum of children with asthma and of control children to identify whether these were risk factors for asthma among inner city children. Ad-

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Reprint requests: Robert S. Call, MD, Division of Allergy and Clinical Immunology, Box 225, University of Virginia, Charlottesville, VA 22908.

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ditionally, we used a questionnaire to evaluate other contributing factors.

METHODS

Subjects. Approval was obtained from the human investigation committee at Grady Memorial Hospital, Atlanta, Ga. A total of 144 children from age 3 through age 15 years were enrolled into the study between the years 1985 and 1990. In keeping with the normal population seen at this hospital, all of the children came from black families. Forty patients who had been seen for acute wheezing and 40 patients who had been seen for any other diagnoses were enrolled from the pediatric emergency department during the fall of 1990. All patients who agreed to be studied were enrolled, and the diagnosis of asthma was made by history and physical examination. In addition, 41 patients from the asthma clinic at Grady Memorial Hospital and 23 patients who were control subjects from a surgery clinic were enrolled between 1985 and 1987. After informed consent was given, blood was drawn from the child and details of housing and demographic data were obtained from a parent by questionnaire. Six of the control patients also had asthma, which had been previously diagnosed by a physician. Serum was stored at −20° C until tested.

Home visits and dust assays. House dust was collected from 57 homes by vacuuming each site with a hand-held cleaner for a total of 2 minutes. Each home had a bedroom sample collected, and most had a living room and a kitchen sample collected as well. Bedroom dust was obtained from mattresses, pillows, rugs, and any furniture present. Rugs and furniture were vacuumed for the living room samples; floors, cabinets, and countertops were vacuumed for the kitchen dust. Dust was stored at −20° C until tested. Each sample of dust was sieved and 100 mg was extracted in 2 ml of borate buffered saline solution overnight at 4° C. Group 1 allergens from the dust mite, *Bla g* II from the German cockroach *(Blatta germanica)* and *Fel d* I from the cat *(Felis domesticus)*, were each measured separately in the dust extracts by using a two-site monoclonal antibody–based ELISA as previously described.[9-12] As an additional control, 26 homes of white patients from suburban Atlanta who were seen at Eggleston Hospital with asthma had dust collected for cockroach allergen level determination.

Immunoassays for total IgE and specific IgE Antibodies. Total serum IgE was measured with a two-site ELISA. Monoclonal anti-IgE antibody (CIA/7.12 and CIA/E4.15, kindly provided by Dr. Andrew Saxon, University of California, Los Angeles) was applied to microtiter plates (Removawell; Dynatech Laboratories, Inc., Chantilly, Va.), the unknown or standard was applied, and the bound IgE was detected with an enzyme-linked colorimetric change. Specific IgE antibody was measured by quantitative RAST with allergen bound to cyanogen bromide–activated cellulose disks (catalog No. 541, 0.6 cm in diameter, Whatman, Inc., Clifton, N.J.).[13, 14] Allergen extracts (Miles Inc., Hollister-Stier Division, Spokane, Wash.) were extensively dialyzed and were standardized by measurement of major allergens.[15] The allergens used were the dust mites *Dermatophagoides farinae* and *Dermatophagoides pteronyssinus*, cat epitherlium, short ragweed pollen, ryegrass pollen, and mixed cockroach extract with ~0.1 to 0.5 μg of major allergen (i.e., *Der p* I, *Der f* I, *Fel d* I, *Amb a* I, or *Lol p* I) per disk.[13] In each assay a standard curve was included with *D. farinae* disks and serial twofold dilutions of a serum containing 2500 RAST units of IgE antibody to *D. farinae*. Fifty percent horse serum was used as a diluent to reduce nonspecific background. The RAST units for specific IgE have been described previously and were standardized by reference to a serum pool established at the National Institute of Biological Standards and Control, London, England (NIBSC No. 82/528), and containing 1800 RAST units of IgE antibody to *D. farinae*.[15, 16] In addition, three negative sera and three positive sera were run in parallel with each assay. Direct comparison of the anti-IgE antibody bound in the two assays suggested that the unit of IgE antibody in the RAST was equivalent to ~0.1 ng of IgE.

Table I. Total IgE in 81 children with asthma and 63 control subjects seen at Grady Hospital, 1985 through 1987 and 1990

Total IgE (IU/ml)	Asthma group (n = 81)		Control group (n = 63)	
	No.	%	No.	%
<40	5	6	26	41
≥40 <199	29	36	25	40
≥200	47	58*	12	19*

*p <0.001.

Statistical analysis. Prevalence of IgE antibody in groups of patients and in control subjects was compared with the chi-square test. The odds ratio that represents the odds that the disease will occur in exposed individuals relative to the odds that the disease will occur in unexposed individuals was calculated as described by Schlesselman.[17]

RESULTS

Total IgE and specific IgE antibodies. The geometric mean for total IgE among the children with asthma who were seen at Grady Hospital was 270 IU/ml, whereas the comparable figure for control subjects was 60 IU/ml. Fifty-eight percent of the patients with asthma had a total IgE >200 IU/ml; 81% of the control subjects had a total IgE <200 IU/ml (Table I). Specific IgE antibodies to dust mite,

Table II. IgE antibody to any of three indoor allergens in 1990 and 1985 through 1987

IgE (RAST units/ml)	Asthma group				Control group			
	A (n = 40)		B (n = 41)		A (n = 40)		B (n = 23)	
	No.	%	No.	%	No.	%	No.	%
<40	8	20	11	27	22	55	12	52
40-199	3	7	3	7	7	18	5	22
≥200	29	73	27	66	11	27	6	26

A, 1990 assessments; *B*, 1985–1987 assessments.

Table III. Subjects with both sensitivity to indoor allergens (IgE antibody ≥200 RAST units/ml) and significant exposure at home to the relevant allergen

	Mite	Cat	Cockroach	Any indoor allergen
Asthma group (n = 35)	14	1	9	21*
Control group (n = 22)	3	0	1	3*

*p <0.001.

cockroach, and cat allergens were measured in both groups of sera (i.e., from 1985 through 1987 and from 1990). The results for the indoor allergens as a group showed similar results for both parts of the study and indicated that >200 RAST units provided the highest level of specificity in separating patients with asthma from control subjects (Table II). Forty percent of the children with asthma (32/81) had IgE antibodies to dust mite alone and another 25% had IgE antibodies to dust mite and cockroach. Cat sensitivity was present in three children with asthma and two control subjects, but in each case the children were also sensitive to one of the other indoor allergens. Thus cat sensitivity was uncommon among inner city children in Atlanta. Because allergic patients were not excluded from the control group, some highly allergic children were found in this group; 12 of 63 control children had a total IgE level >200 IU/ml and 17 had >200 RAST units of IgE antibody.

Allergen levels in house dust. The homes of 57 children were visited and their house dust assayed for dust mite, cockroach, and cat allergens; the results are expressed as micrograms per gram of sieved dust for cat and dust mite allergens and as units per gram for cockroach allergen (Figure). The percentage of homes with high levels of each allergen (and in particular cockroach allergen) was very similar for patients with asthma and control subjects. None of the patients or control subjects had a cat in the house, and only two houses had >8 ug *Fel d* I/gm dust. Some patients did not have dust samples taken because they did not agree to visits or their neighborhoods were not safe to visit. Dust was also available from the houses of 26 children seen for asthma in the pediatric pulmonary clinic at Eggleston Hospital. None of those samples (n = 85) had significant cockroach allergen (0/85 >2 units *Bla g* II per gram of dust).

Sensitization and exposure. Both sensitization and significant exposure to at least one of the three indoor allergens was present in 21 of 35 patients with asthma and in only 3 of 22 control subjects (Table III); this combination gave an odds ratio of 9.5 (confidence interval, 2.0 to 34) for patients with asthma compared with control subjects. In this sample of children from the inner city, those with sensitization and exposure were approximately nine times more likely to have wheezing than children were without this combination.

Questionnaire. From the emergency department questionnaire, medicines being taken were predominantly beta agonists and theophylline (64% and 33%, respectively). One patient was receiving inhaled steroid therapy, and one was receiving cromolyn. Twenty-eight percent of the patients were receiving no medications at all, and only 8% of the patients had a new diagnosis of asthma. Approximately half of the enrolled children had at least one relative living in the house who smoked; however, this was similar for the children with asthma (19/37) and for the control subjects (19/36).

DISCUSSION

Our investigation showed that 86% of the inner city houses sampled had significant levels of either mite or cockroach allergen. Thus most children with asthma *and* most control children lived in homes containing levels of allergen previously recognized as high enough to induce sensitization.[6, 18, 19] The high levels of dust mite allergen found are not surprising given the high mean humidity levels in Atlanta, the use of wall-to-wall carpeting in government-subsidized housing, and the lack of a vacuum cleaner in many of these dwellings. Previous data from suburban Atlanta have shown very high dust mite allergen content in carpets, sofas, mattresses, and pillows.[19] Cockroaches were observed predominantly in the kitchen area, and the high-

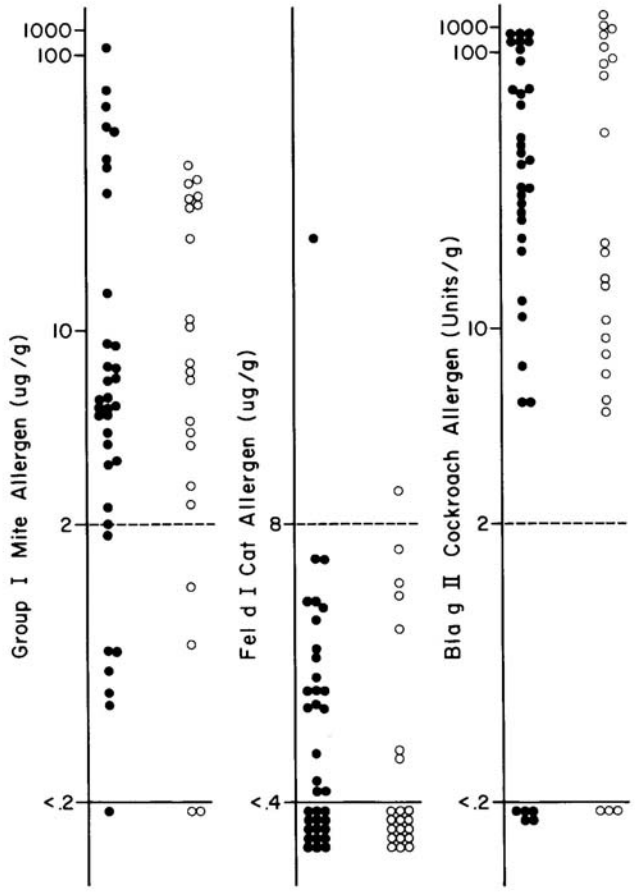

Figure. Dust mite (group I), cat (*Fel d* I), and cockroach (*Bla g* II) allergen levels in dust collected from the homes of 35 children with asthma (●) and 22 control subjects (○). *Dashed lines* indicate proposed threshold levels for each allergen; also indicated are the lower levels of sensitivity for each assay *(solid lines)*.

est allergen levels were found in kitchen samples, but high levels were found in other rooms as well. It was not surprising to find a low prevalence of cat allergen because none of the families stated that they had an indoor cat. Significant cat allergen was found in two houses, which may have remained from a previous occupant or resulted from passive transfer on clothing. The low prevalence of sensitization to cat allergen in these children suggests that the levels found were generally not sufficient to cause sensitization. Ragweed and ryegrass IgE antibodies were present in sera from some of the children who were seen in the spring and early summer. Sensitization to fungi, rodents, or insects other than cockroach also may have been present in these children, but we focused on those indoor allergens for which accurate assays are available. Our results support the findings of previous studies indicating a correlation between more than threshold levels of dust mite and cockroach allergens at home and asthma in children who are sensitized to one or both of those allergens.[18, 19] Data from outside the United States show that a reduction in the symptoms of asthma occurred when dust mite allergen levels were significantly lowered.[20-24]

Our data indicate that controlling asthma morbidity and mortality rates among inner city children will require several changes. Many of the children had inadequate health care before admission to the emergency department. Adequate control of the disease will probably require not only use of action plans to respond to increased symptoms and to increased use of antiinflammatory medicines (e.g., cromolyn sodium and inhaled steroids) but also measures to reduce exposure to allergens. It is essential that the children and their parents receive specific advice about the role that sensitization plays in the disease and about approaches to reduction of exposure. More research is needed to define regimens effective for reducing exposure to both cockroach and dust mite allergens. Advice will have to be tailored to suit the socioeconomic conditions of the patients, and controlled trials of avoidance measures in this population should be carried out.

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