

Exposure and sensitization to environmental allergen of predominantly Hispanic children with asthma in San Diego's inner city

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Background: Environmental living conditions co-sorting with economic status may influence the disease morbidity rate of childhood asthma in ethnic minority urban poor populations.

Objectives: This study was carried out to assess exposure and sensitization to environmental allergens in southeast San Diego children with current asthma-related symptoms and to determine the utility of environmental control measures.

Methods: Children, 9 to 12 years old, with current asthma-related symptoms were identified and enrolled at four school sites. Skin prick testing with aeroallergens was performed, and allergen in collected dust (from mattresses, pillows, and bedroom carpets) was quantified by enzyme immunoassay. Environmental control instruction and products were provided.

Results: Of 41 subjects who underwent skin testing, 51.2% were reactive to environmental allergens (39% to mite, 22% to cockroach, and 9.8% to cat). Mean allergen levels for sensitized subjects were: Der p 1 (11 subjects), 18,722 ng/gm dust; Der f 1 (8 subjects), 5345 ng/gm dust; Fel d 1 (3 subjects), 214 ng/gm dust; Bla 1 (8 subjects), 7.15 U/gm dust; and Bla 2 (8 subjects) 7.13 U/gm dust. Environmental allergen exposure levels were not significantly different between sensitized and nonsensitized subjects. Environmental control measures for mite exposure were completed in six homes of sensitized subjects. One month after treatment, allergen levels fell 91.2% for Der p 1, 98.9% for Der f 1, and 88.2% for Fel d 1. One year after treatment, mite and cat allergen levels remained low. Environmental control had no consistent impact on cockroach allergen levels.

Conclusion: Environmental allergen sensitization and exposure may be cofactors contributing to increased disease severity in urban poor populations. (*J Allergy Clin Immunol* 1996;98:288-94.)

Key words: Asthma, Hispanic, socioeconomic, environmental, mite, sensitization

Childhood asthmatic disease has escalated in prevalence, morbidity, and mortality over the past decade.¹⁻⁶ Lower socioeconomic groups and ethnic minorities appear to be at enhanced risk for severe

disease.^{4,6,7} A prospective study in African Americans demonstrated a 1.7 relative odds of asthma compared with white children.⁸ However, the increased prevalence could not account for the disproportionate asthma mortality rate among African American youth.⁷ The explanation for the discrepancy may lie in other factors that co-sort with socioeconomic status.

In children, atopy has been related to increased asthma severity.^{9,10} Environmental home dampness has also been linked to enhanced severity of childhood asthma, presumably because of increased environmental allergen exposure.¹¹ Exposure to increased levels of both mite and cockroach allergen has been identified in urban poor populations¹² and may provide a partial explanation for the increased morbidity and mortality rates in

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these groups. The magnitude of exposure to environmental mite allergen¹³ has been specifically associated with an increased risk for asthma. Cockroaches are also potent allergens, causing asthmatic reactions on exposure in sensitized individuals. Cockroach sensitization appears to occur in conjunction with substandard housing, which sustains cockroach infestation.¹⁴

We have recently reported a high current prevalence of asthma-related symptoms in inner-city children in southeast San Diego.¹⁵ This area is predominantly inhabited by Hispanic Mexican Americans with incomes below the poverty line. The home environment of these children may represent both an identifiable risk factor for disease and a practical avenue for cost-effective intervention. In this study we present the results of investigation for exposure and sensitization to environmental allergens in this population. The impact of environmental control measures to reduce environmental allergen exposure is also presented.

METHODS

Study population

The study population consisted of fourth grade students (9 to 12 years old) enrolled at four schools in the San Diego Unified School District. Schools were selected for their preponderance of minority and low socioeconomic status children in the student body. The demographics of the four schools have been previously presented.¹⁵ We have reported a high current prevalence of asthma-related symptoms in this population, 14.7% in the 998 students surveyed.¹⁵ The ethnic breakdown of the schools for the 1993 to 1994 academic year showed an average of 74.2% Hispanic, 19.1% African American, 6.6% Asian, and 5.9% white students. Over 90% of the students are living below the poverty line.

Procedure

Approval for conducting the study was obtained from the San Diego City Schools and the Institutional Review Board of Scripps Clinic and Research Foundation. Students with current asthma-related symptoms were identified and enrolled through a parent survey questionnaire, follow-up student questionnaire, physical examination, and interview conducted by the authors as described previously.¹⁵ Likelihood of asthma was independently evaluated by study personnel using the detailed student interview and examination data to determine whether there was a consistent history indicating reversible obstruction of the airways, typical pattern of episodic inducible symptoms, and response to medications. Disease was classified as mild, moderate, or severe on the basis of frequency of symptoms; nocturnal awakenings; impact on activities (including school absence); type and frequency of medication use; and need for urgent physician, emergency department, and

hospital care as outlined in published guidelines.² Immediate family history (mother, father, sibling) of hay fever and asthma was also requested.

Determination of atopic status and environmental allergen exposure

Prick testing (with parental permission) was performed at the school sites according to published methods¹⁶ with Morrow Brown prick test needles (Alerguard, Topeka, Kansas) for determination of atopic status in subjects with asthma. The skin testing panel included: histamine, saline, and glycerine controls; and southwestern tree and weed group pollen, grass pollen, dust mites (*Dermatophagoides farinae* and *D. pteronyssinus*), cat, and cockroach allergens. Allergen extracts were obtained from Bayer Corporation, Allergy Products (West Haven, Conn.). A wheal size of 3 mm greater than that produced by saline/glycerine controls with surrounding erythema was considered a positive response.

A Mighty Mite vacuum cleaner with an ALK adapter/collector (ALK America, Inc., Milford, Conn.) and filter was used for dust sample collection. Two-minute collections were taken from 2-square-foot areas of the pillows and mattresses and bedroom carpets. Both allergen quantification and environmental control intervention were focused on the bedroom, which was judged to be of greatest relevance regarding the asthmatic child's exposure to allergens.

An environmental home survey was completed from parent interviews. The survey yielded a composite of relevant home exposures for each student. These include the presence of pets in the home, age of bedding and carpet, identification of cockroach infestation, and presence of smokers in the residence. Additional information was obtained concerning the presence of environmental control measures including encasements, carpet treatments, and filter devices.

Quantification of allergens was performed in the homes of both atopic and nonatopic asthmatic subjects. Dust mite, (*D. farinae*, Der f 1, and *D. pteronyssinus*, Der p 1), cat (Fel d 1), and cockroach (Bla 1 and Bla 2) allergens were selected. Studies were performed by Dr. Robert Hamilton at Johns Hopkins Dermatology, Allergy and Clinical Immunology laboratory in accordance with published methods.¹⁷⁻²⁰ Dust was sieved and weighed, followed by aqueous extraction for analysis. Bovine serum albumin (5%), which has been shown to minimize interference by tannic acid in aeroallergen enzyme immunoassays, was added to the standard extraction buffer.²¹

Environmental allergen control measures

A cohort of patients with allergen-sensitive asthma received additional instruction in allergen avoidance on the basis of individual home exposures, as delineated in the environmental survey questionnaire. Specific instructions included: exclusion of an animal to which the patient was sensitized, regular vacuuming and dusting, and hot water washing of bedding and pillows. Addi-

tional counseling regarding the importance of control measures for cockroach allergen, as described by Chapman,¹⁴ was provided when appropriate. Mattress, pillow, and blanket covers and tannic acid spray to denature allergens were used in a targeted high-yield effort to reduce allergen exposure in the bedroom. Subjects had the application of these products demonstrated at the time of baseline allergen quantification. Printed literature on allergen avoidance was distributed. All allergen control products (encasements and tannic acid spray) were kindly provided in a cooperative agreement with Allergy Control Products, Inc. (Ridgefield, Conn.) at no cost to the subject.

Repeat assessment of environmental allergen quantification in the subjects receiving education and allergen control products was performed 1 month after the program and in 1 year for five of the six subjects. The environmental questionnaire was also repeated at this time.

Data analysis

Statistical analysis was performed by using the Macintosh software package, Statview 4 (Abacus Concepts, Berkeley, Calif.), exclusively with nonparametric techniques. All results are presented as the median and mean $\pm$ the standard error.

RESULTS

Study population

Forty-one students with current asthma-related symptoms were identified and enrolled in the study. All students were reviewed as described previously.¹⁵ Nineteen of these students had been previously diagnosed with asthma by a physician. Self-identification of ethnic category yielded the following: 22 Hispanics, 9 African Americans, 1 Filipino, 1 white, and 8 unidentified students (no response entered). Sixteen of the students reported an immediate family history (mother, father, sister, brother) of asthma; 24 students reported a negative history, and one student answered "don't know." Twelve students reported a positive immediate family history for hay fever (18 with a negative history and 11 "don't know" responses). Twenty-four of the students had mild asthma, 14 had moderate asthma, and three had severe asthma.

Frequency of sensitization to aeroallergens

All 41 students with asthma were tested for sensitivity to aeroallergens by prick puncture technique: 34.2% were nonreactive to the panel of tree, grass, weed pollen, dust mite, cockroach, and cat allergens; 14.6% were reactive to pollen alone; and 51.2% were reactive to environmental allergens. Of the environmentally sensitized students, 39%

were reactive to dust mite (*D. farinae* and *D. pteronyssinus*), 22% were reactive to cockroach allergen, and 9.8% were reactive to cat allergen.

Levels of home allergen exposure

Home environmental allergen exposure was quantified in the bedrooms of 31 of the students with asthma who were available for sampling (the remaining 10 subjects had relocated out of the school district). No statistically significant differences in allergen levels were found between sensitized and nonsensitized students (Mann-Whitney U test). Mean Der p 1 levels in homes of 11 students sensitized to *D. pteronyssinus* were $18,722 \pm 4122$ ng/gm dust (median, 17,613 ng/gm). In homes of 20 nonsensitized students, mean Der p 1 levels were $16,008 \pm 3662$ ng/gm dust (median, 13,633 ng/gm). In homes of eight students sensitized to *D. farinae*, mean Der f 1 levels were 5345 ± 3748 ng/gm dust (median, 1003 ng/gm). Mean Der f 1 levels were 1563 ± 775 ng/gm dust (median, 62 ng/gm) in homes of 23 nonsensitized students. There were only three students sensitized to cat, and mean Fel d 1 levels in their homes were 214 ± 120 ng/gm dust (median, 237 ng/gm). In the homes of 28 nonsensitized students (including a single sample with a level of 1,973,902 ng/gm), the average Fel d 1 levels were $94,161 \pm 72,230$ ng/gm dust (median, 206 ng/gm). In the homes of eight cockroach-sensitized subjects, mean Bla 1 levels were 7.15 ± 4.95 U/gm (median, 1.25 U/gm), and mean Bla 2 levels were 7.13 ± 5.33 U/gm (median, 0.50 U/gm). In the the homes of 23 nonsensitized students, mean Bla 1 levels were 4.54 ± 1.88 U/gm (median, 1.40 U/gm), and mean Bla 2 levels were 2.70 ± 1.03 U/gm (median, 0.00 U/gm).

Although Der p 1 allergen was present in approximately equal amounts in the pillow and mattress samples (mean = $17,946 \pm 4848$ ng/gm dust) and carpet samples ($15,518 \pm 3347$ ng/gm) ($p = \text{NS}$), Der f 1 concentrations were significantly higher in pillow and mattress samples (2215 ± 919 ng/gm dust) than in carpet samples (324 ± 140) ($p = 0.0043$ by Wilcoxon signed-rank test). Both cockroach allergens were significantly higher in carpet samples than in pillow or mattress samples (4.87 ± 1.89 vs 0.56 ± 0.20 for Bla 1, $p = 0.009$; 4.31 ± 1.68 vs 0.43 ± 0.26 for Bla 2, $p = 0.0058$). Fel d 1 concentrations were slightly higher in carpet samples ($35,090 \pm 27,798$) than in pillow or mattress samples ($26,511 \pm 16,712$) ($p = \text{NS}$). Fig. 1 shows the net difference in allergen concentration between pillow or mattress samples and carpet samples for each of the allergens.

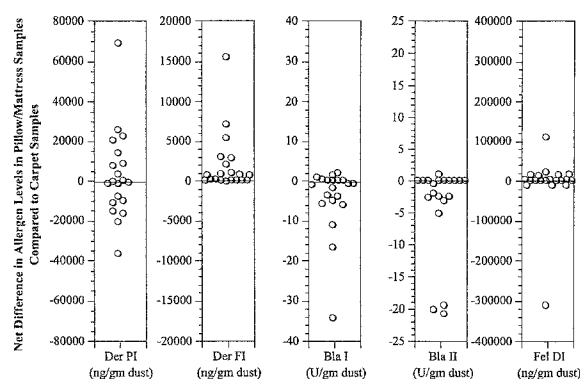


FIG. 1. Net difference in concentrations for Der p 1, Der f 1, Bla 1, Bla 2, and Fel d 1 allergens between matched pillow or mattress samples and carpet samples in 20 asthmatic subjects. All values are derived by subtracting the allergen concentration in the carpet sample from the matched pillow or mattress sample. Points above 0 indicate a preponderance of allergen in the pillow or mattress sample, whereas values below 0 indicate a preponderance of allergen in the carpet sample.

There was no significant correlation between atopic status and levels of exposure to the individual allergens (Mann-Whitney test). No correlation was found between the levels of cat or cockroach allergen and mite allergen levels in the samples (Mann-Whitney test).

Environmental surveys were completed for the 31 subjects. Average reported ages of items in years were: mattresses, mean = 3.3, median = 3; pillows, mean = 3.1, median = 3; and carpets, mean = 4.3, median = 4. Cockroaches were seen by the occupants in 21 homes. Ten homes had pets: three with a cat only, two with a dog only, one with a rodent only, one with a bird only, two with a dog and a bird, and one with a cat and a dog. Eleven homes had a smoker in residence. One home had a tile floor in the bedroom, residents of five homes did not answer the question, and the remaining homes had carpeted bedrooms. Before initiation of the study, none of the households were using any environmental allergen control measures or products.

Effect of environmental control intervention

Environmental control measures for mite exposure were completed in homes of six sensitized subjects; and the levels of mite, cockroach, and cat allergens were re-measured. Results are presented in Fig. 2. All subjects in this group reported cockroaches in the residence. A single home had a cat that was eliminated after instruction. Mean values for levels of allergen before and after the

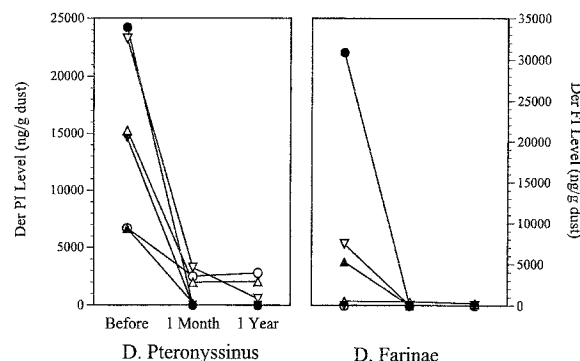


FIG. 2. The effect of environmental control measures on mite allergen concentrations in six homes. Combined pillow and mattress plus carpet sample levels of Der p 1 and Der f 1 before, 1 month after, and 12 months after environmental control instruction was given are shown. All six homes had samples taken before and 1 month after instruction; five homes had samples taken after 1 year.

study were: *D. pteronyssinus*, 15,105.2 ng/gm dust before to 1321.9 ng/gm dust after (91.2% reduction); *D. farinae*, 7366.9 ng/gm dust before to 76.2 ng/gm dust after (98.9% reduction); Fel d 1, 545.9 ng/gm dust before to 64.5 ng/gm dust after (88.2% reduction); Bla 1, 7.23 U/gm before to 4.6 U/gm after (36.4% reduction); Bla 2, 3.3 U/gm before to 7.6 U/gm after (increased by 130%). For these calculations, a value of 0 was assigned in those instances in which, despite identical procedure, a sufficient quantity of dust could not be obtained to measure the allergen. Comparison of the allergen levels in the samples obtained before and after the study by Wilcoxon signed-rank test showed a significant decrease for *D. pteronyssinus* ($p = 0.0277$) and *D. farinae* ($p = 0.0431$). In contrast, repeat samples taken from a home at a 1-month interval without environmental control measures demonstrated an overall increase in levels of mite allergen (Der p 1, 53,757.5 ng/gm dust before the study and 79,103 ng/gm dust after the study; Der f 1, 59 ng/gm before and 36 ng/gm after), cat allergen (Fel d 1, 196.5 ng/gm dust before the study and 268.5 ng/gm after), and cockroach allergen (Bla 1, 196.5 U/gm before the study and 268.5 U/gm after; Bla 2, 0 U/gm before and 1.9 U/gm after).

Samples were reexamined in five homes 1 year after the intervention. Mean levels of allergens in the samples after 1 year were: Der p 1 = 1086.8 ng/gm dust, Der f 1 = 50.9 ng/gm dust, and Fel d 1 = 43.8 ng/gm dust, showing no increase compared with the 1-month levels. Cockroach levels did increase, however, with mean values of 6.88 U/gm for Bla 1 and 10.9 U/gm for Bla 2.

DISCUSSION

Factors that trigger or sustain airway inflammation in asthmatic subjects may contribute to disease severity through heightening the inherent tendency for hyperreactivity of the tracheobronchial tree.²² Viral illness,²³⁻²⁵ aeropollutants,²⁶ and exposure to allergen²⁷ in an atopic individual are representative examples. Among the important promoters of airway inflammation, exposure to relevant allergens in atopic individuals is the most approachable from an intervention standpoint. Sporik et al.²⁸ have shown that in a cohort of British children (at increased risk for allergic disease because of family history), exposure in early childhood to house dust mite allergen was an important determinant for the subsequent development of asthma. The efficacy of avoidance measures in reducing nonspecific bronchial reactivity has also been demonstrated.²⁹⁻³² The potential relevance of environmental allergens contributing to asthma morbidity in inner-city children was highlighted in a study conducted in Atlanta, Georgia. There, 3- to 15-year-old children, recruited through the Grady emergency department, were evaluated by means of RAST and shown to have a marked increase in sensitization to environmental allergens. A high degree of allergen exposure was verified by home quantification. It can be suggested, although not proven, in such studies that heightened sensitization and exposure contribute to asthma severity.¹²

In this report we have examined the frequency of environmental allergen sensitization and exposure in a cohort of 41 9- to 12-year-old socioeconomically disadvantaged children with asthma from southeast San Diego. When tested with a panel of pollen and environmental aeroallergens, 65.4% of the subjects were found to be atopic. Of this group, 51.2% were reactive to environmental allergens (39% to dust mite [*D. farinae* and *D. pteronyssinus*], 22% to cockroach allergen [Bla 1 and Bla 2], and 9.8% to cat allergen [Fel d 1]). Frequency of sensitization to allergen by skin testing has been compared in children with chronic asthma in low and higher socioeconomic status groups. A higher frequency of sensitization to mite allergen was demonstrated in the low socioeconomic status group (77% vs 65%). Reactivity to animal protein, pollen, and mold was more frequent in the higher socioeconomic status group. Examination for cockroach allergen sensitization or home quantification of allergen exposure was not presented in the investigation.³³

A group I mite allergen level of 2000 ng/gm dust

has been accepted as the demarcation between low and significant levels of exposure and an increasing risk of sensitization. Levels of 10,000 ng/gm dust are related to an increased risk of asthmatic symptoms.¹³ Our investigation did not include a reanalysis of exposure and sensitization without asthma or the thresholds of exposure in nonsensitized nonasthmatic individuals in the community. In this study average mite allergen levels were well in excess of the thresholds for sensitization and asthmatic symptoms for both sensitized and nonsensitized individuals. The lack of significant differences in levels of allergen exposure between the sensitized (positive skin prick test results) and nonsensitized subjects may be related to the age range of the study group. In a prospective study, asthma risk correlated most closely with levels of mite allergen exposure during infancy.²⁸ Quantification of mites in 25 homes of patients with mite-sensitive asthma has been previously reported in the San Diego area.³⁴ Counts were made of *D. farinae*, *D. pteronyssinus*, and *Blomia tropicalis* species. In our investigation average combined level of exposure for patients with mite-sensitive asthma was 24,066 ng/gm dust. This value is greater than the average exposure in the previous study (equating nanograms of allergen per gram of dust, 100 mites = 2000 ng) even without the inclusion of the *B. tropicalis* measurement. Mattress and pillow samples appeared to contain the greatest quantity of Der f 1 mite allergen as opposed to carpet samples in the homes selectively sampled in this study, with Der p 1 in approximately equal amounts. Only three students sensitized to cat were identified in this study, with average levels of exposure of 214 for the Fel d 1 allergen. A cat allergen Fel d 1 level of 8000 ng/gm dust has been proposed as the level at which high exposure is present. Levels above 80,000 ng/gm dust are considered very high and important in development of sensitization and allergic symptoms.³⁵ In only five homes was the 8000 ng/gm level exceeded; three of these had levels over 80,000 ng/gm. Cats were reported as pets in only four homes in the survey.

A cockroach allergen level of 2 U/gm dust of Bla g 2 has been reported as a threshold level for increased risk of sensitization.¹⁴ Unlike the case with Fel d 1, cockroach appeared to be an important indoor allergen in this study group. The majority of homes reported cockroach infestation. The major source for the cockroach allergen appeared to be carpets in the homes sampled separately (Fig. 1). Again, there was no significant correlation between atopic status and levels of

exposure to the individual allergens. No correlation was found between the levels of cat or cockroach allergen and mite allergen levels in these samples. Further, there was no relationship between the cat and cockroach allergen levels, which have been reported to inversely correlate in previous reports.

Environmental control measures for mite exposure were completed in six homes of sensitized subjects. The levels of mite allergen and the influence on cockroach and cat allergen were re-analyzed. Mean pre- and posttreatment levels of allergen showed a dramatic reduction for Der p 1 and Der f at 1 month, which was sustained 1 year after the intervention. These same measures reduced Fel d 1 levels as well in 1-month and 1-year follow-up samples. There was no consistent impact on cockroach allergen with a reduction in Bla 1 at 1 month, whereas Bla 2 allergen increased. Both cockroach allergens had increased over baseline by 1 year.

In summary, we have demonstrated a high rate of allergen sensitization in minority socioeconomically disadvantaged youth. Further, we have provided evidence of dramatically increased exposure to dust mite in these individuals. Cockroach exposure and sensitization was also substantial. Simple environmental measures provided to the students were successful in reducing exposure to mite allergen. Environmental allergen sensitization and exposure may be cofactors contributing to increased disease severity in these populations. As demonstrated in this report, reduction of environmental allergens can also be approached by simple cost-effective interventions.

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