

Results of the National Cooperative Inner-City Asthma Study (NCICAS) environmental intervention to reduce cockroach allergen exposure in inner-city homes

Peter J. Gergen MD, MPH,^a Kathleen M. Mortimer, MPH,^b Peyton A. Eggleston, MD,^c David Rosenstreich, MD,^d Herman Mitchell, PhD,^e Dennis Ownby, MD,^f Meyer Kattan, MD,^g Dean Baker, MD, MPH,^h Elizabeth C. Wright, PhD,^b Raymond Slavin MD,ⁱ and Floyd Malveaux, MD, PhD^j Bethesda and Baltimore, Md, Watertown, Mass, Bronx and New York, NY, Chapel Hill, NC, Detroit, Mich, Irvine, Calif, St Louis, Mo, and Washington, DC

Background: Cockroach allergen is important in asthma. Practical methods to reduce exposure are needed.

Objective: We sought to evaluate the effectiveness of house cleaning and professional extermination on lowering cockroach antigen levels in inner-city dwellings.

Methods: As part of the National Cooperative Inner-City Asthma Study intervention, 265 of 331 families with asthmatic children who had positive skin test responses to cockroach allergen consented to a professional home extermination with 2 applications of a cockroach insecticide (Abamectin, Avert) combined with directed education on cockroach allergen removal. On a random subset of 48 homes undergoing cockroach extermination in the intervention group, Bla g 1 was measured in settled dust from the kitchen, bedroom, and TV/living room. The first sample was collected 1 week before extermination, with additional samples after the exterminations at approximately 2, 6, and 12 months after the first sample. Self-reported problems with cockroaches were collected at baseline and after 12 months of follow-up in both the intervention and control group.

Results: The geometric mean kitchen level of Bla g 1 decreased at 2 months (33.6 U/g) relative to preextermination levels (68.7 U/g, $P < .05$). The percent of kitchens with over 8 U/g of Bla g

1 followed a similar pattern, but only the decrease from preextermination to 6-month levels was significant (86.8% vs 64.3%, $P < .05$). By the 12-month visit, the allergen burden had returned to or exceeded baseline levels. Except for an increase in the bedroom at 2 months (8.9 U/g vs 11.1 U/g, $P < .05$), no other significant change was seen. Only about 50% of the families followed the cleaning instructions; no greater effect was found in these homes. Self-reported problems with cockroaches showed no difference between the intervention and control group after 1 year of follow-up.

Conclusions: Despite a significant, but short-lived, decrease the cockroach allergen burden remained well above levels previously found to be clinically significant. (*J Allergy Clin Immunol* 1999;103:501-6.)

Key words: Cockroach, Bla g 1, intervention

Indoor allergen exposure plays an important role in asthma. Much work has focused on the role of house dust mites in the development and exacerbation of asthma. Recently, cockroach allergen has received increasing attention, although cockroach sensitivity has been shown to be associated with asthma for over 30 years.¹⁻³

As our understanding of the role of allergens in the development of allergic sensitization and asthma symptoms increases, it has become apparent that the level of allergen in the environment appears to play an important role. Dust mite allergen exposures as low as 2 µg/g have been determined to cause sensitization to mite allergens, whereas exposures to over 10 µg/g appear to be associated with asthma symptoms.⁴ Decreasing exposure to mite allergen is associated with a decrease in asthma symptoms.^{5,6} Cockroach skin test sensitization develops in susceptible individuals with almost any exposure and quickly maximizes at around 2 U/g,⁷ whereas asthma symptoms occur with increased frequency to exposures of 8 U/g or more among sensitized individuals.⁸ No data are available on the effects of lowering cockroach allergen levels on symptoms.

The Phase I cross-sectional component of the National Cooperative Inner-City Asthma Study (NCICAS) found that cockroach was the predominant allergen with-

From ^athe National Institute of Allergy and Infectious Diseases, National Institutes of Health, Bethesda; ^bNew England Research Institutes, Watertown; ^cthe Department of Pediatrics, Johns Hopkins University, Baltimore; ^dthe Division of Allergy and Immunology, Department of Medicine, Albert Einstein College of Medicine, Bronx; ^eRho Inc, Chapel Hill; ^fthe Division of Allergy, Henry Ford Hospital, Detroit; ^gthe Department of Pediatrics, Mount Sinai School of Medicine, New York; ^hCenter for Occupational and Environmental Health, University of California, Irvine; ⁱthe Division of Allergy and Immunology, Department of Medicine, St Louis University School of Medicine, St. Louis; and ^jHoward University, College of Medicine, Washington.

Supported by grants U01 A1-30751, A1-30752, A1-30756, A1-30772, A1-30773-01, A1-30777, A1-30779, A1-30780 and N01 A1-15105 from the National Institute of Allergy and Infectious Disease, National Institutes of Health.

Presented in part at the Annual Meeting of the American Academy of Allergy, Asthma and Immunology, Washington, DC, March 13-18, 1998.

Reprint requests: Peter J. Gergen MD, MPH, Center for Primary Care and Research, AHCPR, Suite 201, Rm 204, 6010 Executive Blvd, Rockville, MD 20852.

1/1/95633

Abbreviations used

ASU: Asthma study unit
NCICAS: National Cooperative Inner-City Asthma Study

in inner-city homes.⁹ NCICAS Phase II was a broad-based intervention to reduce asthma morbidity. As part of this intervention, a combination of education, cleaning, and extermination with Abamectin (Avert) was used in an attempt to decrease cockroach allergen levels in the homes of the participating asthmatic children who had positive skin test responses to cockroach allergen. This article reports the effectiveness of the intervention on reducing cockroach allergen (Bla g 1) levels.

METHODS**Population**

The NCICAS intervention was conducted at 8 asthma study units (ASUs) located in 7 major metropolitan areas (see Appendix). The NCICAS intervention targeted the families of English- or Spanish-speaking 5 to 11 year old children with moderate-to-severe, physician-diagnosed asthma who were symptomatic or were taking 2 or more medications in the 6 months before recruitment. Potential participants were identified through medical records and logs at emergency departments and primary care clinics that serve the inner-city census tracts in each ASU. Families were eligible only if they lived in inner-city census tracts where at least 20% of the population was below federal poverty guidelines. The research protocol was approved by the institutional review board at each of the 8 clinical sites and the data coordinating center.

Screening telephone calls began in April 1994; formal recruitment began July 1, 1994. Baseline assessments were completed on a final sample of 1033 participants between August 1 and October 31, 1994. After completing the baseline assessment, children were randomized to intervention (n = 515) or usual-care (n = 518) control groups.

Baseline

Children in both the intervention and control groups underwent a 2-hour baseline assessment, which included questions about the child's health care use, asthma symptoms, access to medical care, adherence to medical plans, and characteristics of the home environment. At the time of the baseline interview, skin testing was performed by the prick-puncture method on the volar surface of the forearm with a Multi-test7 device.¹⁰ All participants were skin tested with a 6-allergen panel, which included cockroach mixture (German and American). The resulting wheals were outlined in ink at 15 minutes, and the outline was transferred to paper with plastic tape. Allergen mean wheal diameter was calculated from the orthogonal wheal diameters, and the diameter of the negative wheal was subtracted from the allergen wheal measurements to provide the adjusted wheal diameter. A skin test panel was considered valid if the wheal from the positive control (histamine 1 mg/mL) was at least 1 mm larger than that of the negative control. An allergen skin test response was considered positive if the panel was valid and if the mean wheal diameter of the allergen test was at least 2 mm larger than that of the negative control.

Intervention

The intervention was delivered by master's-level social workers, called "asthma counselors," who were familiar with the problems of

inner-city families and specially trained in asthma management. Parents attended 2 adult group educational sessions and 1 individual meeting with their asthma counselor during November/December 1994. Group sessions provided education on asthma triggers, environmental controls, asthma physiology, and strategies for problem solving and communicating with their child's physician. Children also attended 2 group sessions, in which similar information was provided but at an age-appropriate level. If a group session was missed, topics were covered later at individual sessions. Additional individual sessions were held at monthly intervals by phone or in person during the intervention year.

Environmental intervention

The broad-based environmental intervention included instructions to decrease the environmental exposures to dust, molds, environmental tobacco smoke, and cockroaches.

The cockroach extermination protocol was offered to children in the intervention group who had positive skin test responses to cockroach (331 of 515). The extermination protocol consisted of 2 visits by a professional pest-control technician to apply a cockroach insecticide (Abamectin, Avert). The cockroach insecticide was applied in the kitchen. In addition, cockroach insecticide was applied in any other room with obvious and heavy infestation. This pattern of cockroach insecticide application was the usual and customary practice of pest-control technicians working in the NCICAS cities. Most applications occurred approximately 4 weeks apart in January and February of 1995. Before each extermination visit, the families were encouraged to thoroughly clean the home, especially the kitchen area, to remove all potential sources of food for the cockroaches. The families were asked to clean their homes approximately 2 weeks after the extermination to remove the dead cockroaches and allergen-contaminated dust. During each of the 2 extermination visits, the pest-control technician rated the housekeeping in the homes as below average, average, and above average. The pest-control technicians had previous experience working in the areas in which the NCICAS participants lived. They were asked to use this experience as the basis for their subjective evaluation of the housekeeping. At the baseline visit and during the final phone interview at the end of the intervention year, families in both the intervention and control groups were asked about problems with cockroaches in their homes.

Dust collection

Because of limited funds, allergen levels were not measured in all homes. Rather, from among those in the intervention group who received extermination services, a random subset of 48 homes was selected for Bla g 1 measurement. At each of the 8 ASUs, 6 homes were randomly selected from an average of 41 homes (range, 31 to 51) that received the cockroach extermination. The first dust samples were collected before the first extermination. The subsequent 3 dust samples were collected after the final extermination visit at approximately 2 months, 6 months, and 12 months after the preextermination measurement (Table I). In general, the dust collections occurred in January, March, July, and December of 1995.

Settled dust samples were collected with a hand-held vacuum (Redivac #6735, Douglas manufacturing Co) from 3 sites: the child's bedroom or sleeping area, the family or TV room, and the kitchen. In the bedroom an area of 1 m² beside the bed was vacuumed for 2 minutes, and the sample was combined with a similar sample from the mattress and bedding. In the TV room, a 1 m² area of the floor was sampled for 2 minutes, and the sample was combined with a similar sample from any stuffed furniture in the room. In the kitchen, the entire floor was vacuumed for 4 minutes, with particular attention to the base of counters, the interior of the under-sink cabinets, and the area around the refrigerator. If possible, dust

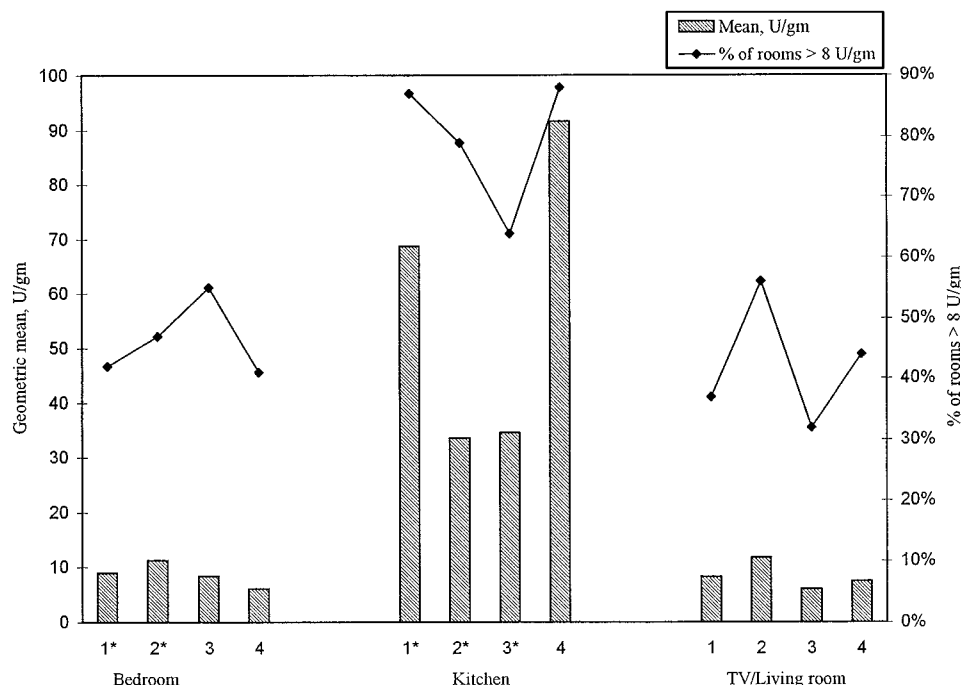


FIG 1. Levels of Bla g 1 by room (visits 1 to 4). Bedroom: $P < .05$ for visit 1 vs visit 2, mean levels; kitchen: $P < .05$ for visit 1 vs visit 2, mean level; $P < .05$ for visit 1 vs visit 3, percent greater than 8 U/g.

behind and underneath the refrigerator was brushed off with a small brush and vacuumed. An aqueous extract of 100 mg of sieved dust specimen was prepared in 2 mL of borate-buffered saline. The extracts were stored frozen at -30°C until they were assayed for Bla g 1 by using an mAb-based ELISA assay.^{11,12} Results were expressed as Bla g 1 U/g of dust. The detection limit of the assay was 1 Bla g 1 U/g of dust.

Statistical analyses

To minimize the effect of extreme values, analyses were based on the logarithms of Bla g 1 levels, and geometric means were used to summarize the data. For each of the 3 rooms, changes in cockroach allergen levels between the preextermination visit and each of the subsequent 3 home visits were compared in terms of their absolute levels and in terms of the proportion exceeding 8 U/g. The Wilcoxon signed-rank test was used to assess the statistical significance of changes in the absolute levels, whereas McNemar's chi-square test was used to compare the difference in proportions. McNemar's test was also used to assess whether there were any changes in home characteristics (eg, room preparation and house-keeping) between the first and second extermination visits. A P value of $< .05$ was used to determine statistical significance.

RESULTS

Of the 331 families in the intervention group with children with cockroach sensitivity who were offered cockroach extermination services, 265 (80%) consented. Both extermination visits were carried out in 230 of 265 (86.8%) homes, 1 extermination visit in 24 of 265 (9%) homes, and no extermination visits in 11 of 265 homes (4.2%). The impact of the cockroach extermination was

evaluated among the subset of the intervention group for whom allergen levels were collected. Forty of the 48 subjects (83.3%) were included in the following analytic sample because they completed at least 3 of the 4 home visits to collect samples and received both extermination applications. In the kitchen the geometric mean level of Bla g 1 decreased relative to preextermination levels at the 2-month and 6-month visits (Fig 1). The only significant difference was found from preextermination (68.7 U/g) to the 2-month visit (33.6 U/g, $P < .05$). The percent of kitchens with over 8 U/g of Bla g 1 followed a similar pattern, but only the decrease from preextermination levels to 6-month levels was significant (86.8% vs 64.3%, $P < .05$). By the 12-month visit, the allergen burden had returned to or exceeded preextermination levels.

In contrast, the geometric mean level of Bla g 1 increased in the bedroom between the preextermination and 2-month visits (8.9 U/g vs 11.1 U/g, $P < .05$). During the 12 months of follow-up, no other statistically significant change was seen in the bedroom or TV/living room, regardless of whether the bedroom or TV/living room data were analyzed as the absolute level of Bla g 1 or the percent of rooms exceeding 8 U/g.

Because a decline in allergen levels was noted only in the kitchen, we evaluated the home visitors' reports of signs of cockroaches in the kitchen during the 4 visits. At the preextermination, 2-month, 6-month, and 12-month visits, cockroach stains were found in 77.5%, 57.5%, 51.3%, and 62.2% of the kitchens, respectively ($P < .05$ for visit 2 vs visit 1 and visit 3 vs visit 1). No statistical-

TABLE I. Chronology of visits to the home for dust collection or cockroach extermination

	No of days since first home visit			
	n	Median	Minimum	Maximum
Dust collection				
Initial	40	—	—	—
Extermination visits				
First	40	7.5	0	34
Second	40	36.5	24	76
Additional dust collection*				
Second	37	55	38	107
Third	39	168	140	237
Fourth	37	326	287	407

*For each household, the second dust collection occurred after the second extermination visit.

TABLE II. Observations during the extermination visits

	First extermination	Second extermination
Preparation before visit*		
All 3 rooms prepared	51.4% (n = 35)	51.3% (n = 39)
No rooms prepared	17.1% (n = 35)	43.6%† (n = 39)
Individual room preparation		
Bedroom	54.1% (n = 37)	52.5% (n = 40)
Kitchen	72.5% (n = 40)	50.0% (n = 37)
TV/living room	65.7% (n = 35)	53.8% (n = 39)
Housekeeping		
Below average	28.2% (n = 39)	23.7% (n = 38)
Above average	23.1% (n = 39)	28.9% (n = 38)

*Preparation for visit required complying with standardized cleaning instructions.

† $P < .05$ (visit 1 vs visit 2)

TABLE III. Effects of complying with preparation instructions on subsequent Bla g 1 (U/g) levels (geometric means) in the kitchen

Prepared for both visits*	n	Before extermination	After extermination†‡		
			2 mos	6 mos	12 mos
No	27	46.9 (21.9, 99.4)	24.3 (11.2, 51.3)	28.1 (9.9, 77.2)	58.9 (23.1, 47.9)
Yes	11	174.1 (76.3, 395.6)	63.9 (22.5, 178)	57.9 (7.1, 429.2)	294.6 (116.1, 745.7)

Values in parentheses are 95% CIs.

*Preparation for visit required complying with standardized cleaning instructions.

†Approximate months of the visits were January, March, July, and December.

‡Time relative to the preextermination visit.

ly significant change was noted in the percent of kitchens having living cockroaches during the 4 visits (30%, 22.5%, 30.8%, and 35.1%, respectively), although the drop from visit 1 to visit 2 suggests some impact occurred in the kitchen.

Next we examined whether the impact of the intervention differed on the basis of whether the families prepared the home before the extermination visit. On the basis of the pest-control technicians' reports, only about half the households complied with the instructions to prepare for the extermination by having all rooms cleaned and food sources eliminated (Table II). The number with no rooms prepared increased from the first (17.1%) to the second visit (43.6%). The pest-control technician rated the housekeeping as below average in 28.2% of the homes during the first extermination visit and 23.7% during the second extermination visit and above average in 23.1% and 28.9% for extermination visits 1 and 2, respectively. A similar short-term decrease in cockroach antigen levels was seen when comparing the effects of the intervention in households that were not prepared for both visits versus those homes that were prepared for both visits (Table III).

To further evaluate the impact of the cockroach intervention, we compared the responses to questions asked at the baseline interview and repeated during the 12-month follow-up phone call among all children with positive

skin test responses to cockroach allergen in both the intervention and control groups. Although the intervention group reported a decrease in reported problems with cockroaches (baseline of 67.6% to 12-month follow-up of 42.2%), a similar drop was noted by the control group (baseline of 72.2% to 12-month follow-up of 38.5%). The decrease seen in both groups may be partially explained by the difference in the recall period for reports of problems with cockroaches (open-ended at baseline; 2-month time frame at the 12-month follow-up).

DISCUSSION

In this study cockroach mitigation was part of a comprehensive environmental intervention. The NCICAS intervention did appear to lower Bla g 1 levels in the kitchen but only for a few months. Even with the decrease, levels still were well above those reported to cause respiratory symptoms among asthmatic subjects. Compliance with our cleaning instructions did not increase the effectiveness of the intervention. The non-significant increase in allergen levels for those who prepared for both visits relative to those who did not prepare most likely reflects sampling variation.

A number of factors could have contributed to the lack of effect on cockroach allergen levels. Addressing these possibilities might improve the effectiveness of future

interventions. The majority of these dwellings (80% or 32 of 40) were multifamily units. Reinfestation from other units could have occurred soon after the exterminations. Because only the kitchen was consistently treated with Abamectin (Avert), reinfestation from other parts of the same apartment could also have occurred. The transient increase in roach levels in the bedroom after the extermination could reflect the movement of roaches out of the kitchen to other parts of the apartment.

Another potential factor influencing our results is the amount of cockroach allergen present in the environment. Levels as high as those found in this study may require more cleaning and additional extermination visits over an extended period of time to decrease the home reservoir of allergen. Extensive contamination of homes may create reservoirs of allergen in carpets and rugs, as well as in inaccessible spaces around appliances and furniture. These reservoirs might result in continued detection of allergen over a course of repeated vacuum samplings at the same location. Studies of cat allergen have found that antigen levels in the environment decrease slowly. Twenty to 24 weeks after cat removal, only 50% of homes had cat antigen levels similar to homes without cats. Extensive and repeated cleanup efforts appeared to make the levels fall faster.¹³

The concentration of Bla g 1 in the dust, rather than the absolute quantity of allergen in a given area, was measured in this study. Although the reporting of allergen levels as amount of allergen per gram of dust is still the most common reporting method used, the Third International Workshop on Indoor Allergens and Asthma¹⁴ recommended that, if possible, allergens should also be reported as amount of allergen per unit area (m²) because simply reporting the concentration of allergen may not convey the change in exposure to allergen after an intervention study. The dust collection methodology used in the NCICAS does not allow the calculation of the amount per unit area.

Finally, only 1 (Bla g 1) of the 2 known allergens from the German cockroach was measured. Previous reports have noted that Bla g 2 has a higher rate of skin test positivity than Bla g 1.¹⁵ However, the levels of the 2 allergens have been found to be highly correlated ($r = 0.92$; $P < .01$),¹⁶ and thus it is unlikely that the measurement of Bla g 2 would change our findings.

Compliance with the cleaning instructions was poor. Lack of compliance could have resulted from a number of factors. The inner-city families participating in this study may have little control over their environment and resources, and despite their intentions, were unable to sufficiently implement adequate environmental control. Environmental control of allergen levels may require the cooperation of other household members and even neighbors and therefore may be less likely to be adequately implemented without extensive family and community involvement. It may also be that motivation to implement environmental change must be approached with different techniques than those used to achieve attendance at intervention sessions.

There are a number of potential limitations of these data. The lack of a control group prevents a clear understanding of what would have happened to the cockroach allergen levels without the intervention. The combination of the small sample size and the high variability in allergen levels make it likely that only large differences would be noted. However, large differences may be all that are clinically important because previous work has shown that symptoms occur at levels as low as 8 U/g of Bla g 1.⁸

Previous attempts to eliminate cockroach allergen from the environment had limited success. A short-term effect of extermination and cleaning on cockroach antigen levels was noted in a study conducted in a college dormitory.¹⁷ Bla g 2 levels were found to have markedly decreased from 2 weeks before (5.2 U/g) to 2 weeks after extermination and cleaning (0.95 U/g). The effect was transitory because random samples taken throughout the year found high levels of Bla g 2 despite this cleaning procedure being done twice per year in the dormitory. Other studies have found that the number of cockroaches seen in a dwelling can be drastically reduced with roach insecticides such as hydramethylnon.^{18,19} However, the elimination of cockroach sightings with hydramethylnon traps did not decrease the levels of Bla g 1 and Bla g 2 in vacuumed kitchen and bath dust over the next 6 months in single-family dwellings in North Carolina.¹⁹ No extra cleaning was performed in these homes during this time.

Seasonal variation has been reported in cockroach infestation. A year-long study of 6 inner-city apartments in Virginia with monthly sampling noted that the number of sighted cockroaches appeared to peak in June, whereas the measured allergen level (Bla g 2) did not peak until August.²⁰ However, levels of Bla g 2 allergen remained above clinically significant levels during all times of the year. No seasonal variation of cockroach levels were noted in the NCICAS study. However, it is possible that the intervention blunted the summer increase in cockroaches because the intervention and cleaning occurred during the winter.

The results of this study demonstrate that removal of cockroach allergen from the home environment will not be an easy task. It is likely that treatment of all rooms will be needed, and the cleanup may have to be continued over a period of months to decrease the allergen level. The development of techniques to prevent reinfestations, especially in multiunit dwellings, will also be necessary.

REFERENCES

1. Bernton HS, Brown H. Insect allergy. Preliminary studies of the cockroach. *J Allergy* 1964;35:506-9.
2. Mendoza J, Snyder RD. Cockroach sensitivity in children with bronchial asthma. *Ann Allergy* 1970;28:1529-63.
3. Kang B. Study on cockroach antigen as a probable causative agent in bronchial asthma. *J Allergy Clin Immunol* 1976;58:357-65.
4. Platts-Mills TA, Thomas WR, Aalberse RC, Vervloet D, Champman MD. Dust mite allergens and asthma: report of a second international workshop. *J Allergy Clin Immunol* 1992;89:1046-60.
5. Murray AB, Ferguson AC. Dust-free bedrooms in the treatment of asthmatic children with house dust or house dust mite allergy: a controlled trial. *Pediatrics* 1983;71:418-22.

6. Ehnert B, Lau-Schadendorf S, Weber A, Buettner P, Schou C, Wahn U. Reducing domestic exposure to dust mite allergen reduces bronchial hyperreactivity in sensitive children with asthma. *J Allergy Clin Immunol* 1992;90:135-8.
7. Eggleston PA, Rosenstreich D, Lynn H, Gergen P, Baker D, Kattan M, et al. Relationship of indoor allergen exposure to skin test sensitivity in inner city children with asthma. *J Allergy Clin Immunol* 1998;102:563-70.
8. Rosenstreich DL, Eggleston P, Kattan M, Baker D, Slavin RG, Gergen P, et al. The role of cockroach allergy and exposure to cockroach allergen in causing morbidity among inner-city children with asthma. *N Engl J Med* 1997;336:1356-63.
9. Kattan M, Mitchell H, Eggleston P, Gergen P, Crain E, Redline S, et al. Characteristics of inner-city children with asthma: the National Cooperative Inner-City Study. *Pediatr Pulmonol* 1997;24:253-62.
10. Berkowitz RB, Tinkelman DG, Lutz C, Crummie A, Smith K. Evaluation of the Multi-Test device for immediate hypersensitivity skin testing. *J Allergy Clin Immunol* 1992;90:979-85.
11. Chapman MD, Aalberse RC, Brown MJ, Platts-Mills TAE. Monoclonal antibodies to the major feline allergen Fel d I. II. Single step affinity purification of Fel d I, N-terminal sequence analysis and development of a sensitive two-site immunoassay to assess Fel d I exposure. *J Immunol* 1988;140:812-8.
12. Pollart S, Smith TF, Morris EC, Gelber LE, Platts-Mills TAE, Chapman MD. Environmental exposure to cockroach allergens: analysis with monoclonal antibody-based enzyme immunoassay. *J Allergy Clin Immunol* 1995;87:505-10.
13. Wood RA, Chapman MD, Adkinson NF Jr, Eggleston PA. The effect of cat removal on allergen content in household-dust samples. *J Allergy Clin Immunol* 1989;83:730-4.
14. Platts-Mills TAE, Vervollet D, Thomas WR, Aalberse RC, Chapman MD. Dust mite allergens and asthma: report of the Third International Workshop. *J Allergy Clin Immunol* 1997;100:S1-24.
15. Chapman MD. Cockroach allergens: a common cause of asthma in North American cities. *Insights Allergy* 1993;8:1-8.
16. Pollart SM, Smith TF, Morris EC, Gelber LE, Platts-Mills TA, Chapman MD. Environmental exposure to cockroach allergens: analysis with monoclonal antibody-based enzyme immunoassays. *J Allergy Clin Immunol* 1991;87:505-10.
17. Sarpong SB, Wood RA, Eggleston PA. Short-term effects of extermination and cleaning on cockroach allergen Bla g 2 in settled dust. *Ann Allergy Asthma Immunol* 1996;76:257-60.
18. Patterson RS, Koehler PG. Peridomestic cockroach suppression with hydramethylnon bait. *J Agric Entomol* 1989;6:37-42.
19. Williams LW, Reinfried PS. Eradication of cockroaches does not rapidly reduce cockroach (CR) allergen in vacuumed dust [abstract]. *J Allergy Clin Immunol* 1998;101:S156.
20. Mollet JA, Vailes LD, Avner DB, Perzanowski MS, Arruda LK, Chapman MD, et al. Evaluation of German cockroach (Orthoptera: Blattellidae) allergen and seasonal variation in low-income housing. *J Med Entomol* 1997;34:307-11.

APPENDIX.

The National Cooperative Inner-City Asthma Study, Phase II was a collaboration of the following institutions and investigators. Principal investigators are indicated by asterisks.

Johns Hopkins University, Baltimore, Md: P. Eggleston,* R. A. Wood, A. Walker, M. Bailey-Kloch; *Albert Einstein School of Medicine, Bronx, NY:* E. Crain,* L. Bauman, D. Rosenstreich; *Children's Memorial Hospital, Chicago, Ill:* R. Evans III,* J. Lavigne, Y. D. Senturia, C. M. Weil, H. J. Bins, L. Bronsky, N. Torres; *Cook County Hospital, Chicago, Ill:* M. Sullivan; *Rainbow Babies and Children's Hospital, Cleveland, Ohio:* C. Kerckmar,* S. Redline, S. Wade; *Henry Ford Hospital and Medical Center, Detroit, Mich:* J. A. Anderson,* D. R. Ownby, C. L. M. Joseph, C. Johnson, L. Sylvester; *The Mount Sinai School of Medicine, New York, NY:* M. Kattan,* C. Lamm, M. T. Tin, E. Luder, M. Kimmel, J. Golomb, D. Baker; *Washington University Medical School, St Louis, Mo:* H. J. Wedner,* R. G. Slavin, R. Peabody; *Howard University, Washington, DC:* F. Malveaux,* W. Winters, M. Richard; *National Institute Allergy and Infectious Disease, National Institutes of Health, Program Office, Bethesda, Md:* P. Gergen, E. Smartt; *New England Research Institutes, Data Coordinating Center, Watertown, Mass:* H. E. Mitchell,* E. Wright, K. M. Mortimer, H. Lynn, S. Islam, M. Roudier.