Does a Multifaceted Environmental Intervention Alter the Impact of Asthma on Inner-City Children?

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Objective: To evaluate the impact of a multifaceted environmental and educational intervention on the indoor environment and health in 5–12-year-old children with asthma living in urban environments.

Design: Changes in indoor allergen levels and asthma severity measurements were compared between children who were randomized to intervention and delayed intervention groups in a 14-month prospective field trial. Intervention group households received dust mite covers, a professional house cleaning, and had roach bait and trays placed in their houses.

Results: Of 981 eligible children, 410 (42%) were enrolled; 161 (40%) completed baseline activities and were randomized: 84 to intervention and 77 to delayed intervention groups. At the study's end, dust mite levels were 163% higher than at baseline for the delayed intervention group. Overall asthma severity scores did not change. However, the median functional severity score (FSS) component of the severity score improved more in the intervention group (33% vs. 20%) than in the delayed intervention group. At the study's end, the median FSSs for the intervention group improved 25% compared with the delayed intervention group, ($p<0.01$). Differences between groups for medication use, emergency department (ED) visits or hospitalization were not significant.

Conclusions: Despite low retention, the intervention resulted in decreased dust mite allergen levels and increased FSSs among the intervention group. The interventions probably contributed to the improvements; especially among the more severely affected children. This study highlights the complexities of designing and assessing the outcomes from a multifaceted asthma intervention.

Key words: asthma ■ community health worker ■ environment ■ intervention ■ pediatric research

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INTRODUCTION

Background and Rationale

Asthma, the most common chronic pediatric illness, disproportionately affects black and poor children. Black children have higher asthma rates for mortality, hospitalizations, activity limitation and underuse of ambulatory healthcare than do white children.[1-3] Multiple factors—including poverty, urban environment, and limited access or utilization of care—reportedly are associated with the increased impact of asthma in this racial group.[4,5] The lower socioeconomic status of black children does not completely explain the worst disability and functional outcomes.[2] Targeted interventions to reduce the burden of asthma morbidity among black children are likely to reduce disparities in childhood asthma hospitalization and morbidity.

Interventions aimed at modifying the risk factors for asthma have found that a multipronged and individually customized approach can improve outcomes for asthma.[6,7] Use of an asthma counselor or case manager to deliver the intervention has emerged as a key component to implementing and delivering secondary asthma prevention measures.[8,9] Programs that improve care, educate, control the exposure of children to allergens and irritants, and reduce exacerbation of symptoms decrease medical costs related to asthma.[10] Appropriate case management and decreasing exposure to environmental factors may reduce the frequency of acute exacerbations of asthma symptoms.[11]

Asthma has a significant impact on the community health status of children in the Atlanta Empowerment Zone (AEZ).[12,13] The AEZ is a federally designated census tract within the boundaries of the city of Atlanta, where ≥35% of the population is below poverty guidelines. A 1992 Centers for Disease Control and Prevention (CDC)-sponsored study showed that 4% of the children living in poverty (as defined in the 1990 census) in Atlanta visited the emergency department at the main local public pediatric hospital at least once in 12 months for asthma treatment. The asthma hospitalization rate for children <14 from this area is 684/100,000—more than twice the national asthma hospitalization rate for nonwhite children. Since not all children with asthma in these areas would have visited the emergency department for their care, this suggests the prevalence of asthma in the community is likely to be high.[14]

The ZAP asthma project (ZAP) was designed to be implemented in the communities of the AEZ. The ZAP study was one component of a community-based program and involved a multifaceted environmental intervention to reduce asthma triggers and consequently improve pediatric asthma outcomes in the AEZ. We describe here the design and methods of the ZAP intervention trial and quantitatively and qualitatively evaluate its effectiveness.

METHODS

Population

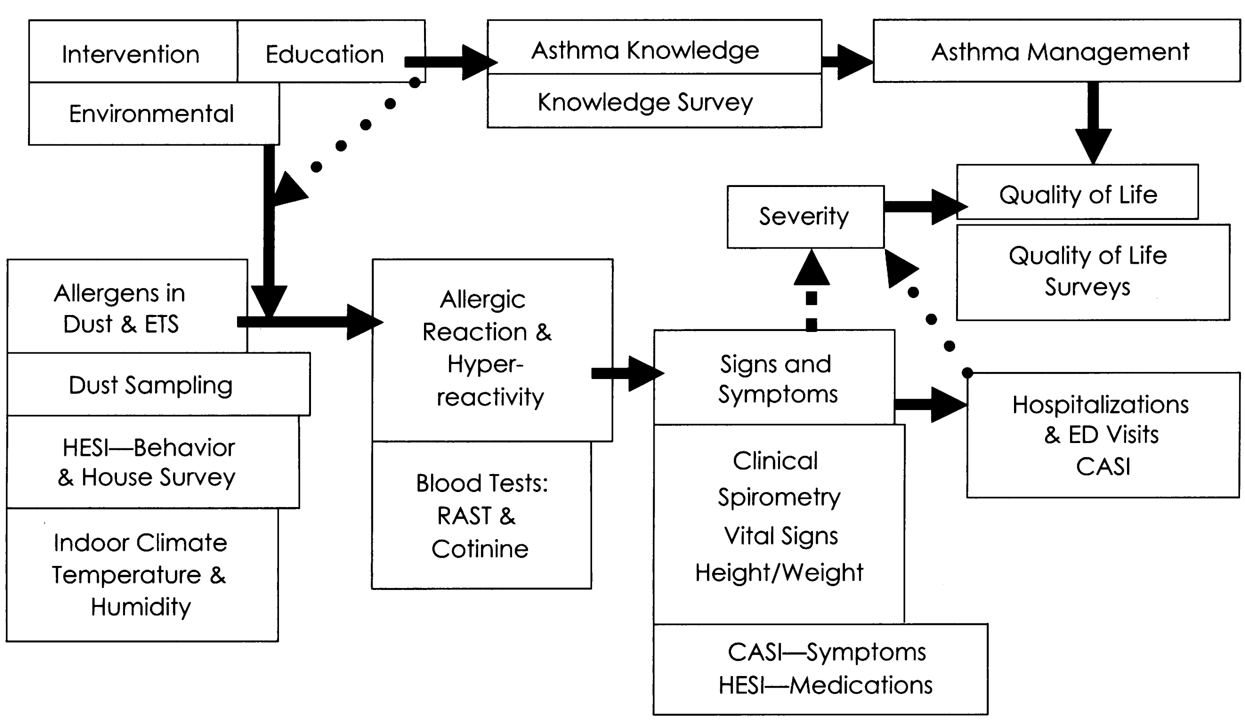
The study targeted English-speaking 5–12-year-old children with asthma and their primary family caregivers who lived within the ZIP codes of the AEZ and presented with an asthma exacerbation to the emergency department of the local major public children's hospital. Community health workers invited families to enroll in the study, evaluated home environments, delivered many of the interventions and were the primary case managers interacting with the children and their families throughout the study.[15,16]

Baseline Evaluation and Randomization

Once the caregiver and child consented to be enrolled in the study, appointments were scheduled for the initial home visit, telephone interview and first clinic visit. After these baseline visits, study participants were randomized into either the intervention or delayed intervention group using previously generated random numbers.

To reduce the risk for overlap between the inter-

Figure 1. Exposure-intervention outcome model for Asthma Intervention Trial, Atlanta, 1998–2000



HESI: Health and environment survey instrument; CASI: Childhood asthma survey instrument; ETS: Environmental tobacco smoke; ED: Emergency department; RAST: Radioallergosorbent Test vention and delayed intervention groups we: 1) limited enrollment to one child from each household and 2) trained community health workers to implement the intervention for the study group and to withhold the interventions for the delayed intervention group. Interventions were delivered to the delayed intervention group at the end of the study (12 months after baseline data collection).

Human subjects' research approval was requested and given by a special community institutional review board convened at the CDC. Written informed consent from all adults and assent from children ≥7 years were obtained before the collection of any information or clinical specimens.

Conceptual Model and Measurement

The working hypothesis for the study was that, at the end of one year of intervention, asthma severity indicators among children aged 5–12 years in the intervention group would improve significantly over those in the delayed intervention group. The intervention was viewed as a two-pronged approach for education and environmental modifications. The targeted education would not only increase the family's and child's knowledge about asthma but would also lead to behavior change and improvement in self-efficacy—and thereby improve asthma management. The education also would augment the proper implementation and sustainability of the environmental modification strategies, resulting in detectable changes in the indoor surroundings, allergic symptoms, and markers of allergy and asthma severity. Data would be collected regularly from the families during telephone interviews and at-home and medical clinic visits. Various standard data collection instruments were used to gather information (Figure 1).

Sample Size Calculations

The sample size was calculated on the basis of previous studies that estimated the variability of peak expiratory flow rate (PEFR) measurements among children and the reductions in PEFR variability as a result of avoidance of house dust mites by allergen-sensitive persons with asthma.[17-20] Three-hundred children with asthma and their families were needed for enrollment (150 in each group) for 80% power to detect 25% increase in PEFR. Assuming a 25% dropout rate because of nonresponse and loss to follow-up, the project aimed to enroll 400 children with asth-

Table 1. Asthma severity scale: items and scoring, Atlanta, 1998–2000

	Asthma Severity+ and Score for Computing Severity Scale				
Scale Items (components)	**None 0**	**Low 1**	**Mild 2**	**Moderate 3**	**Severe 4**
Functional Severity (Weight=1)*					
Frequency of wheeze	None	<1/month	Monthly	Weekly	Daily
Wake at night with cough/wheeze	None	Only with episodes	<1/week	1–3/week	4–7/week
Wake in morning with wheeze	None	Only with episodes	<1/week	1–3/week	4-7/week
Severe attack				Yes	
Home activities limited	None	<1/month	1/month	1/week	Daily
Sport activities limited	None	<1/month	1/month	1/week	Daily
Hospital/Medical Facilities Use (Weight=3)					
ED visits/unplanned urgent care visits	None			1	≥2
Admissions	None				≥1
Medications Taken (Weight=1.33)					
Cromolyn	Not taken		Taken		
Inhaled corticosteroids	Not taken		Taken		
Long-acting theophylline	Not taken			Taken	
Long-acting beta$_2$-agonists	Not taken			Taken	
Short-acting beta$_2$-agonists‡	Not taken	1/day	2/day	3/day	≥4/day
Oral corticosteroids	Not taken				Taken

* Weights assigned so each component contributed equally to the total (each component contributed 24 points); + Represents the level of asthma severity, which generally corresponds to a particular score for an item; ‡ Patients who use short-acting beta2 agonists on as-needed basis will have score on that item between 0 and 1; this equals number of times taken in the past month divided by 30. If computed score is >1, patient will be assigned the score closest to the computed value; Total points possible 72

ma. Because the delayed intervention group also would receive visits from community health workers, placebo and Hawthorne effects were anticipated to decrease the ability of the study to detect differences, because the control group families were likely to change their behavior. An additional control group receiving no community health worker visits was not possible because of the increased number of study participants that would be needed, the resulting increase in cost and the lack of acceptability to the community partners in the project.

Asthma Severity Scores

The asthma severity score was calculated for each participant on the basis of data collected about the frequency of exacerbation of symptoms and medication use, the number of visits to the emergency department and the number of hospitalizations (Table 1). The score had three subcomponents—functional severity, hospital/medical facilities use and medications taken. The functional severity score focused on wheeze frequency, nighttime awakening symptoms, occurrence of a severe asthma attack, and limited home and sports activities. The hospital/medical facilities use score included hospital admissions and emergency-department combined with urgent-care visits. The medication score summarized the various classes of asthma drugs used. Weights were assigned to each score subcomponent so that a child would not receive a lower score because of appropriate use of preventive medications and that each subcomponent category contributed equally to the total overall severity score.

Data for calculation of the asthma severity score were obtained from the periodic health surveys and from the home visits. Assessments to determine asthma severity scores were measured at baseline prior to randomization and at four-month intervals. The instruments for scoring were administered to the primary caregiver of the child with asthma.

Statistical Analyses

Baseline characteristics of the study children and the primary caregivers were compared between study groups by Chi-squared tests. Because the data were not symmetrically distributed, we used Wilcoxon nonparametric test to compare differences in medians between groups. Because of declining enrollment over time, data collected postbaseline were pooled across time points and compared between study groups by t test or Wilcoxon test. Significant variables were then graphed, and those with differences over time between study groups were presented. Wilcoxon two-sample tests and median two-sample tests were performed for serum IgE and selected dust allergens for all of the pooled postbaseline visits. The dust and serum data for all the retained clients measured at the four intervals were included in the analysis.

The Specific Interventions

Children randomized to the intervention group received environmental interventions and specific health education at the start of the study period. Enrolled children who were randomized into the delayed intervention arm of the study received all the same interventions at the end of the study period.

Environmental interventions. Community health workers provided information and assisted families with asthma management and environmental intervention measures in their homes. Previous research in this community had suggested that house dust mite and cockroach allergens were the exposures most often associated with exacerbation of asthma symptoms. Strategies targeted at these two

Table 2. Baseline characteristics of the enrolled and randomized study children ZAP Asthma Intervention Trial, Atlanta, 1998-2000 (N=161)

Characteristic	Total (N=161)	Delayed Intervention (N=77)	Intervention (N=84)	P*
Male	95 (59%)	51 (66%)	44 (52%)	0.07
Race				
Black	1.59 (99%)	75 (97%)	84 (100%)	0.48
Non-Hispanic	156 (98%)	73 (96%)	83 (99%)	0.35
Median age	8 years	8 years	8 years	0.73+
Duration at residence	3 years	2 years	3 years	0.49
Enrollment with CHW present in the ED	125 (78%)	58 (75%)	67 (80%)	0.50
ED enrollment	157 (98%)	74 (96%)	83 (99%)	0.27
HCP seen for regular medical care	157(98%)	74(96%)	83 (99%)	0.1‡
≥1 smoker in house	80 (50%)	36 (45%)	44 (55%)	0.53

* Probability comparison of two groups by χ^2, median+ or Fisher's exact test‡ at the 5% significance level; CHW: community health worker; ED: emergency department; HCP: healthcare provider

allergens were offered to families in the intervention arm.[21] Interventions for individual homes took a comprehensive approach to management but were also guided and focused by the baseline environmental evaluations for that home.

House dust mites. Strategies to reduce exposure to house dust mite included: 1) encasing the mattress, box spring and pillows (used by the affected child) in zippered dust-mite-impermeable covers, and 2) providing instruction on the appropriate care for washing and drying of sheets and blankets, and for carpets, fabrics, upholstered furniture and curtains. Verbal reinforcement on continuing these activities was given at all follow-up home visits.

Cockroach. Hydramethylnon gel was used as the cockroach eradication agent based on standard application protocols.[22] Additionally, the community health workers provided education about proper food-handling practices.

Environmental tobacco smoke (ETS). In all homes, the community health worker provided education about the impact of ETS on the person with asthma.

Professional cleaning of homes. To remove cockroach and other allergens, each family was provided with a one-time professional cleaning of the residence ≥2 weeks after the initial intervention visit but before the four-month follow-up visit.

Other interventions. On the basis of the reports of the house audits and assessment of the pertinent findings for each family, other customized intervention strategies were discussed that could be implemented by the family. These included but were not limited to: controlling moisture and humidity; cleaning areas with obvious signs of fungal growth; removing, or frequent proper cleaning of carpeting, fabric of upholstered furniture and curtains in the child's bedroom; and removing or bathing furry pets.

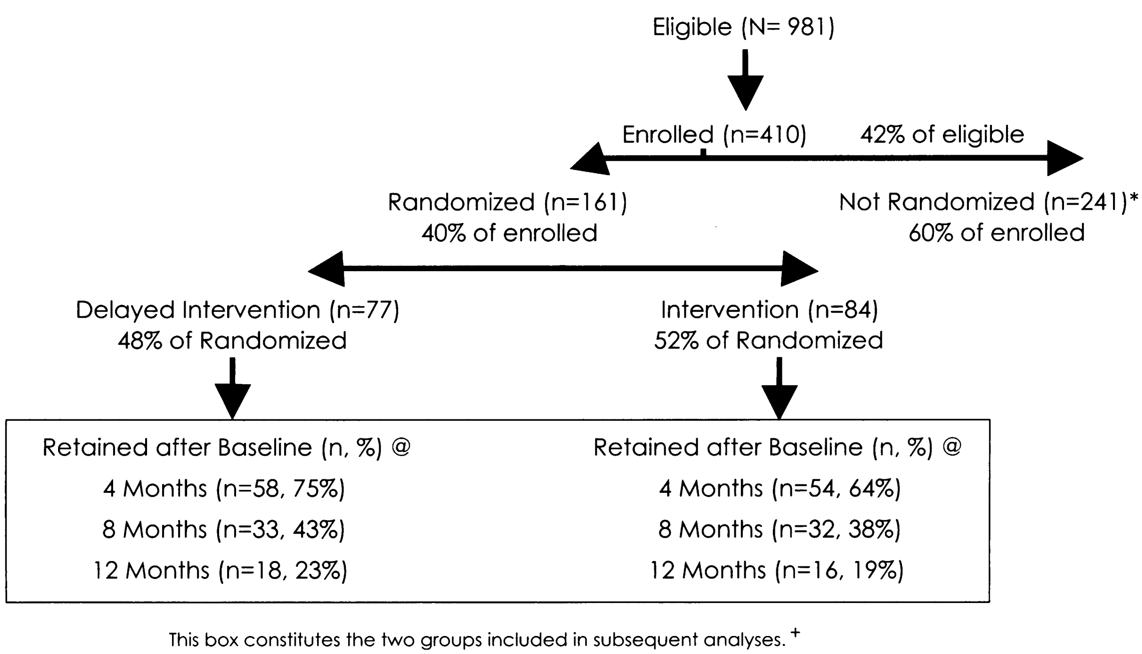
Health education to support the environmental intervention. Along with giving verbal health information specific to the interventions mentioned above, brochures were provided by the community health workers that reinforced the lessons of the environmental interventions at the two-, six- and 10-month visits to the intervention study group.

Monitoring and Assessment

Community health workers collected interview data, home assessment information and laboratory samples (blood and dust) from all study children and homes at baseline and at subsequent monitoring visits four-, eight- and 12 months after the first visit.

Community health workers. In addition to the previously described work, the community health workers were trained to make environmental assessments of homes (described in the community health worker training manual prepared by the Community Health Worker Training Program, Department of Health Education, San Francisco State University, 1600 Holloway Ave., San Francisco, CA 94132). The community health workers used a health and environ-

Figure 2. Profile of enrolled and retained participants in the Asthma Intervention Trial, Atlanta, 1998–2000



This box constitutes the two groups included in subsequent analyses. +

* Children were not randomized because they missed an enrollment activity and were subsequently dropped from the study; + Dust and blood were collected over four points for analysis from all retained participants.

mental survey instrument and conducted in-home measurements of indoor allergens and irritants.

Additionally, the community health workers provided customized information about the management of the child with asthma, the need for specific interventions in the home, and the resources available in the community to the intervention families based on findings from the home visit.

Telephone questionnaire. Participants were interviewed using a standard questionnaire that collected information about health status, healthcare use, asthma knowledge and management skills, and quality of life of caregiver and child. The interview was conducted by telephone four-, eight-, and 12 months after enrollment and in rare instances was conducted face-to-face when the client was available and did not have a working telephone.

Home and clinic visits and laboratory measurements:

- *House dust assays.* House dust was collected from floors, carpets, bedding and upholstered furniture in the child's bedroom, the room where the child spent most of the daytime hours and the kitchen floor. The dust was collected by vacuuming a 1-m^2 sampling site for 2–3 minutes using a portable vacuum cleaner with a sampling dust trap adapter and attachments. Dust samples were stored at -20°C until tested. They were then sieved and weighed and, after aqueous extraction, the content of the allergens from dust mites (*Dermatophagoides farinae*, *D. pteronyssinus*), cat epithelium (Fel d1), dog dander (Can f1) and cockroach (polyclonal mix) was measured using commercially available enzyme-linked immunoassays (ELISA) [ELISA kits from Indoor Biotechnologies in Charlottesville, VA for *D. pteronyssinus*, *D. farinae*, Fel d1 and Can f1 and ELISA kit done by IBT reference lab in Lenexa, KS, for the cockroach (polyclonal mix)].
- *Child serum total IgE and allergen testing.* Blood was collected at all clinic visits, allowed to clot at room temperature for 30 minutes and centrifuged and the serum was aliquoted into CryoVials™ and stored at -70°C until tested. Total serum IgE was measured using the two-site chemiluminescent immunometric assay (Immulite®) from Diagnostic Products Corp., Los Angeles, CA. Specific IgE antibody was measured from serum by the AlaStat® Microplate Allergen-Specific IgE system from Diagnostic Products Corp., Los Angeles, CA, which provided a quantitative radioallergosorbent test (RAST) for dust mites (*D. farinae*, *D. pteronyssinus*), cat epithelium (Fel d1), dog dander (Can f1), cockroach (polyclonal mix), *Alternaria* species mix, tree mix and grass mix allergen. The latter three allergens were measured only at baseline.
- *Serum cotinine.* The blood samples collected at the clinical visits also were analyzed for cotinine—a byproduct of nicotine—to assess for exposure to ETS. The results of this analysis will be presented in another publication.

Table 3. Baseline characteristics of the primary caregivers for the enrolled and randomized children, Asthma Intervention Trial, Atlanta, 1998–2000 (N=158*)

Caregiver Characteristic	Total (N=158) (%)	Delayed intervention Group (N=75) (%)	Intervention Group (N=83) (%)
Education (p=0.66)			
Elementary	3 (1%)	2 (3%)	1 (1%)
Some high school	52 (33%)	22 (29%)	30 (36%)
Completed high school	88 (56%)	43 (57%)	45 (54%)
College	14 (9%)	8 (11%)	6 (7%)
Did not answer	1 (1%)	0	1 (1%)
Current Employment (p=0.5187)			
Yes	78 (49%)	35 (47%)	43 (52%)
No	80 (51%)	40 (53%)	40 (48%)
Monthly Household Income ($) (p=0.3332)			
$<500	53 (33%)	29 (39%)	24 (29%)
$500–1,200	57 (36%)	25 (33%)	32 (38%)
$1,201–1,600	23 (15%)	10 (13%)	13 (16%)
>$1,601	9 (6%)	6 (8%)	3 (4%)
Did not answer	16 (10%)	5 (7%)	11 (13%)

*Information missing for three participants; P: probability comparison of two groups by χ^2 test or Fisher's exact test

RESULTS

Demography: Recruitment, Randomization and Retention

Enrolled versus nonenrolled and intervention versus delayed intervention participants. Of 981 eligible children seen in the emergency department during the study enrollment period, 410 (42%) were initially enrolled into the study (Figure 2). Only 161 (40%) of the initial enrollees completed the baseline activities and were subsequently randomized. Dust and serum data were obtained for most of the retained clients measured at baseline and at four-, eight- and 12 months. Comparing nonrandomized to randomized children, there were no statistically significant differences for age (mean 7.7 vs. 8.1 years) and male gender (56% vs. 59%).

The main reasons for not reaching randomization were children missing the initial enrollment visit, inability of study staff to contact the potential enrollee after the emergency department visit, and the voluntarily withdrawal of parent/primary caregiver due to an inability to continue participating because of other responsibilities.[15]

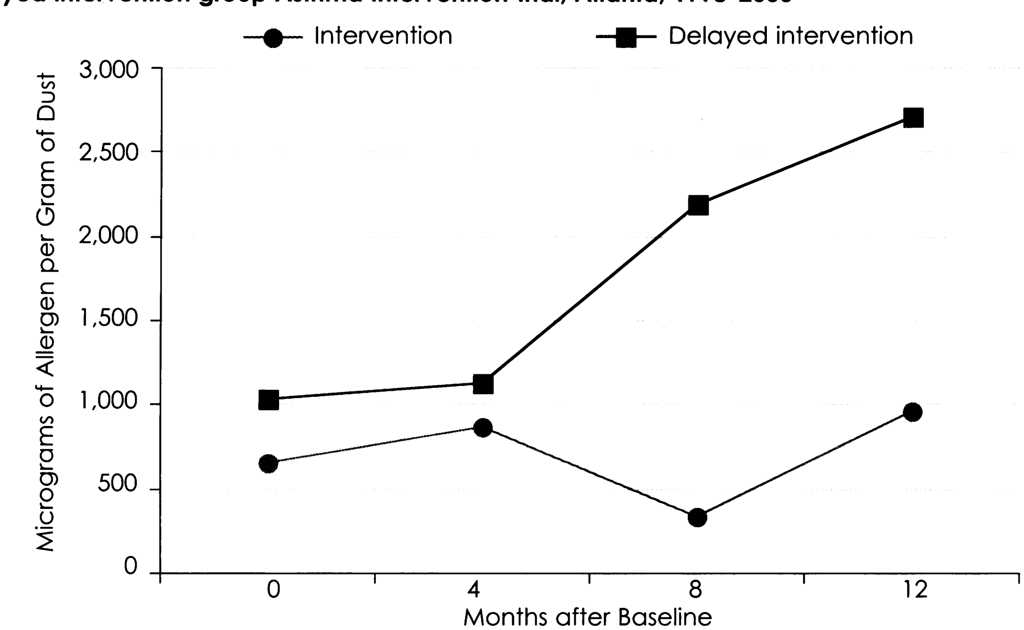
Of the enrolled families who completed the baseline activities, 84 had been randomized to the intervention group and 77 to the delayed intervention group. Most children of these enrolled families were black (99%), non-Hispanic (98%) and male (59%); and median age was 8 years at the time of enrollment. For the variables examined, the delayed and intervention groups had similar proportions for sex, race, ethnicity, age of the enrolled child, residence of ≥1 smoker in the household, likelihood of being enrolled at the emergency department, regular visits to a healthcare provider, and duration of living at the same residence at enrollment (Table 2).

The parents/primary caregivers of children with asthma had mostly completed high school (88/158, 56%) were equally divided between being currently employed (78/158, 49%) and not employed (80/158, 51%), and reported monthly household income <$1,201 (110/158, 69%). Caregivers in the two groups had similar education, employment and monthly household income (Table 3).

Environmental allergen in house dust. At baseline, the homes of 160 children were visited, and house dust was collected and analyzed for dust mite, cockroach, and cat and dog allergens. Dust mite and cockroach allergens from the household dust were analyzed periodically during the study. All retained clients in both arms of the study had dust mite and cockroach allergen data from the four visits and were included in all statistical analyses.

The median levels of dust mite allergens (two species) from the bed surfaces used by the affected children were similar for both study groups at baseline and up to four months later. However, by eight months after baseline, the intervention group had substantially less dust mite allergen than at baseline, and the delayed intervention group households had increasing amounts of dust mite allergens (Figure 3).

Figure 3. Median dust mite antigen levels on children's bed surface over time for intervention and delayed intervention group Asthma Intervention Trial, Atlanta, 1998–2000



Median pooled post baseline antigen levels were significantly different between groups (p<0.05)

At study's end, *D. farinae* levels had increased 163% over baseline in the delayed intervention children's homes but remained stable in the intervention group.

Median levels of cockroach allergens in dust taken from the kitchen floor of the enrolled children's homes were similar at baseline for both study groups but lower for the intervention group at four and eight months after baseline (Figure 4). Median levels of cockroach allergen in the dust taken from the bedroom floors did not differ between groups at the various monitoring times.

Total IgE and specific IgE antibody testing. All retained clients in both arms of the study provided serum RAST data from the four visits and were included in all statistical analyses. The median total IgE for the intervention group at baseline was 334 IU/mL and for the delayed intervention group was 413 IU/mL. Over the study, the median total IgE levels for the intervention group generally declined relative to the delayed intervention for the study period, although the difference was not statistically significant.

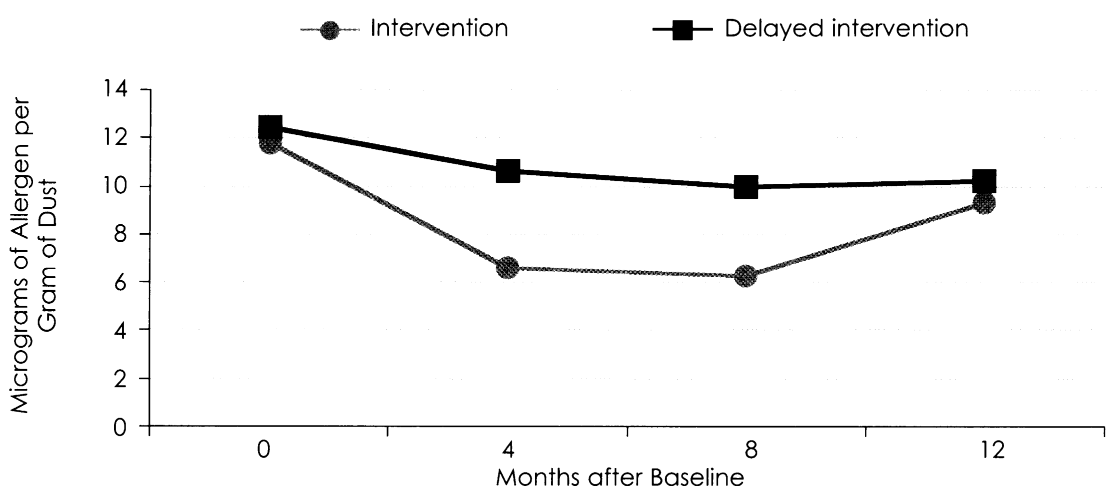
At baseline, seven specific antibodies were assessed by RAST testing of blood specimens. From most to least common, children were allergic to dust mite (93,

Table 4. Radioallergosorbent testing results for randomized children at baseline, Asthma Intervention Trial, Atlanta, 1998–2000, (N=160*)

	Number (Percent) Positive+			
RAST	Total (N=160)	Delayed Intervention (N=77)	Intervention (N=83)	P‡
Dust Mite *D. farinae* (derf1) or *D. pteronyssinus* (derp1)	93 (58%)	46 (60%)	47 (57%)	0.69
Cockroach (polyclonal mix of *B. germanica* and *P. americana*)	58 (36%)	29 (38%)	29 (35%)	0.72
Cat (Fel d1)	29 (18%)	13 (17%)	16 (19%)	0.69
Dog (Can f 1)	24 (15%)	11 (14%)	13 (16%)	0.81
Grass mix	78 (49%)	39 (51%)	39 (47%)	0.64
Tree mix	43 (27%)	24 (31%)	19 (23%)	0.23
Alternaria species	23 (14%)	10 (13%)	13 (15%)	0.62

* Information missing for one participant; + Allergen testing determined and reported by measured level of allergen-specific IgE in serum: negative (<0.35 kU/L), positive (≥0.36 kU/L); ‡ P: p value for test of association: χ^2 test or Fisher's exact test

Figure 4. Median cockroach antigen levels on kitchen floor over time for intervention and delayed intervention group Asthma Intervention Trial, Atlanta, 1998-2000



Median pooled post baseline antigen levels were significantly different between groups (p<0.05)

58%), grass mix (78, 49%), cockroach (58, 36%), tree mix (43, 27%), cat (29, 18%), dog (24, 15%) and *Alternaria* mold species (23, 14%). The percentage of children with positive RAST values did not differ significantly between the two study groups (Table 4).

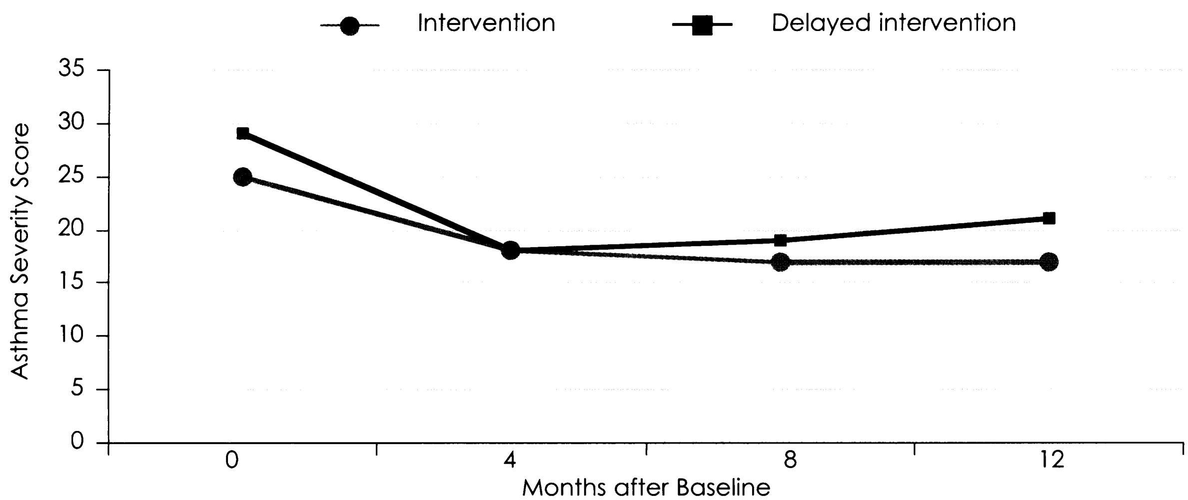
Asthma severity score. Overall, asthma severity scores did not significantly differ over time between the delayed intervention and intervention groups (Figure 5). Components of the asthma severity score also were examined separately between the groups and only the functional component significantly differed between the two groups. This was not an originally planned analysis but was done to identify possible differences anecdotally reported by the community health workers. The difference in functional severity scores was more evident when the 75th percentiles of these scores (i.e., values defining the 25% of children most severely affected) were plotted over time. Both study groups showed decreases in the 75th percentile functional severity from baseline, but the intervention group experienced a larger statistically significant decline over the study period (Figures 6, 7). Although the overall asthma severity scores, relative to baseline, did not change, the median functional severity score (FSS) component declined more in the intervention group (33% vs. 20%) than the delayed intervention group ($p<0.01$). In this regard, the FSS for the intervention group improved 25% compared with the delayed intervention group at study's end ($p<0.01$).

DISCUSSION AND CONCLUSION

This multifaceted environmental intervention study highlights several measurable improvements in the indoor environment and the effects of asthma among children. Dust mite allergen and cockroach allergen levels declined substantially, although the decline in the cockroach allergen levels was not sustained. In contrast to the environment effects, we found no change in overall asthma severity, although FSS improved slightly for the intervention compared with the delayed intervention children. Improvements in FSS were especially evident among the children with higher baseline severity scores. The other major study outcomes for medication use, emergency department visits or hospitalizations, and total IgE and RAST levels appeared to be unaffected by the intervention.

These findings suggest that the community health workers effectively delivered the environmental interventions and that these interventions resulted in lower dust mite and cockroach allergens levels. These results are compatible with prior work demonstrating the feasibility of allergen-reducing strategies.[8,23,24] The reasons for the increase in dust-mite allergen levels in control homes are not known. These may relate to our intervention and the fact that nonintervention homes did not take steps to control humidity and the accumulation of dust in the control homes. In our study, lowered allergen levels—especially for cockroach—were not sustained, possibly although unlikely, because of evolving biologic resistance of the cockroaches to the pesticide agent or more likely because of difficulties by families in maintaining the roach abatement procedures. To decrease cockroach allergen levels over time, the families had to make their homes less attractive to roach infestation by actively controlling leaks, storing foods properly, removing

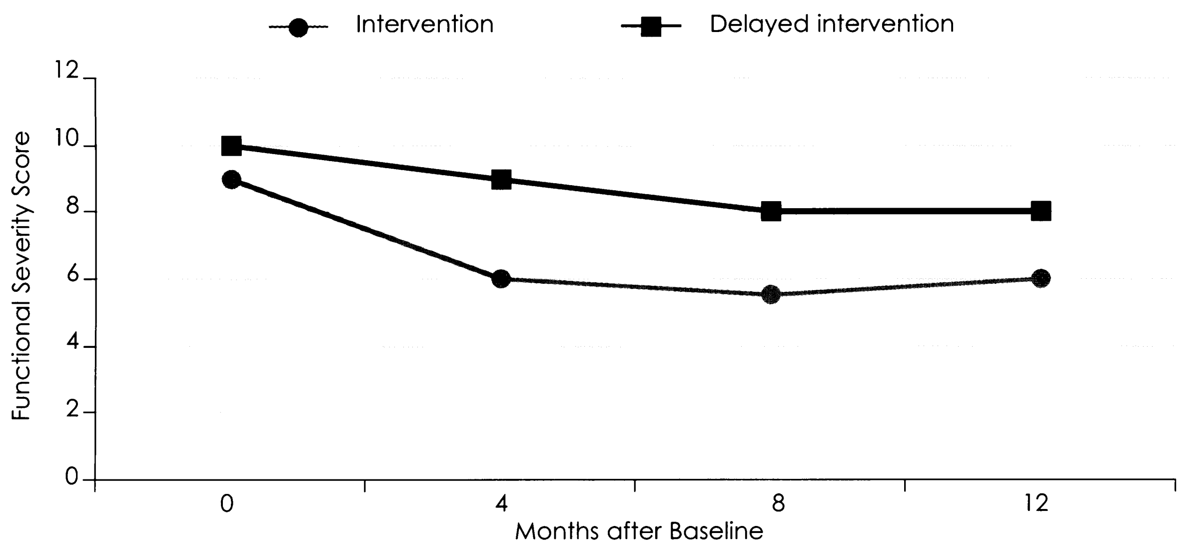
Figure 5. Asthma severity score for intervention and delayed intervention group over time for intervention and delayed intervention group, ZAP Asthma Intervention Trial, Atlanta, 1998-2000



Median pooled post baseline scores were not significantly different between groups food sources (e.g., crumbs, cardboard) and destroying hiding places. If the family did not sustain the necessary intensity for roach abatement after the initial community health worker intervention visits and professional cleaning, the cockroach allergen increased to preintervention levels. We do not know if the families failed to take these measures or not. A relatively brief nonsustained decrease in cockroach allergen also has also been observed in a similar study of children with asthma.[25]

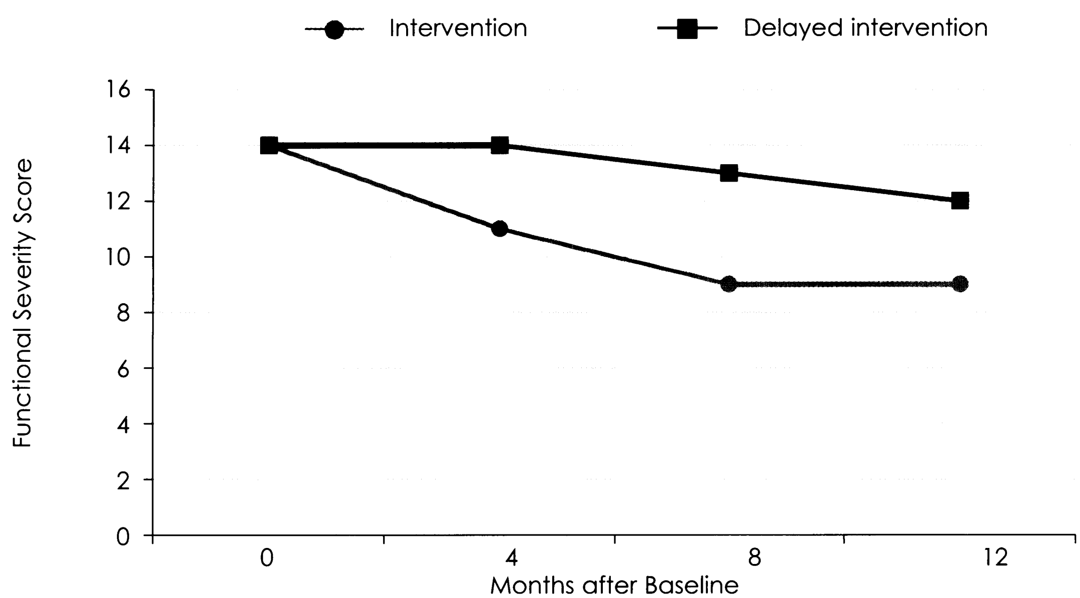
The second finding, improved FSS among the intervention compared with the delayed intervention children, was most evident among the children with the highest overall baseline asthma severity score (implying worse asthma severity). This functional improvement was seen, in spite of no overall change in the asthma severity score between groups. This suggests that even though the children in both groups had no measurable overall change in their asthma severity, the children in the intervention

Figure 6. Functional component of Asthma severity score over time for intervention and delayed intervention group, ZAP Asthma Intervention Trial, Atlanta, 1998–2000



Median pooled post baseline scores were significantly different between groups (p<0.05)

Figure 7. Seventy-fifth percentile of the Functional component of Asthma severity score over time for intervention and delayed intervention group, ZAP Asthma Intervention Trial, Atlanta, 1998-2000



Median pooled post baseline scores were significantly different between groups (p < 0.05) group functioned better (that is, they reported lower wheeze frequency, fewer nighttime awakening symptoms, no severe attack, and no limitations in their home and sports activities). The intervention, which required intense involvement of the community health worker and the families, may have improved the confidence of the parents and children caring for their asthma, even though medication use, rates of emergency department use and hospitalizations did not change. This functional improvement is a hopeful sign for use of this multifaceted environmental intervention over a longer time for the most severely affected children with asthma, since it may be more easily sustained or would translate into an improvement in the total score. Improving function may be a starting place to address the more distal outcomes of decreased medication and healthcare facility use over time among children with asthma. These studies of functional improvement may have been more clearly defined if a concomitant control group (without any interventions) was allowable.

An alternative interpretation of this finding is that the interventions were either clinically ineffective intrinsically or in their application. In the latter case, because the environmental interventions were provided to the intervention children regardless of specific allergen sensitivity, the clinical effects may have been diluted. According to the RAST results, 42% of the children were not sensitive to dust mites and 64% were not sensitive to the tested cockroach allergens. Hence, the two main interventions would have not been effective for substantial fractions of the enrolled children. Concerning the intrinsic effectiveness, at least for dust mite covers, a recent study among adults with asthma found that, as a single measure, dust mite covers did not improve asthma control (as measured by use of beta-agonist inhaler and PEFR) among people with asthma and dust mite sensitivity.[26] Research is ongoing into whether cockroach reduction measures can improve symptoms or lung function in cockroach-sensitized persons with asthma.[27] The design of the current study assumed some a priori effectiveness of the interventions and focused on comprehensively delivering them; thus, the findings speak more to the application of the interventions. A more recent study has shown that customized interventions reduce asthma-related illness among a similar population as our study and speaks to the issue of targeting interventions based on allergic sensitivities and specific needs of the child.[28]

The findings of this study are subject to several limitations. The low retention rate with resulting differential drop-out and subsequent low power was its major weakness, and severely restricted its ability to identify differences between groups, limiting generalizabilty of the findings. However, nonrandomized and randomized children did not differ statistically for the demographic variables assessed. In addition, in an earlier report, persons lost to follow-up were not different from those retained by age or sex, and differed only by residential, staff and logistic factors.[15] Because of the high drop-out rate, the original study period was revised from 22 to 15 months, with the follow-up period shortened from 24 months after baseline to 12 months. The shorter follow-up time may have decreased the ability to see outcome differences between the groups. Those children who dropped out were very similar to those who remained in the study except that participants enrolled in the second year (versus the first year of enrollment) were more likely to be retained. The reasons for the low retention and the implications for the program has been discussed elsewhere.[15]

Nonblinding of the community health workers was another limitation that may have diluted the effect of the intervention since the community health workers had children and families in both arms of the study and knew which arms of the study the clients were enrolled. Blinding the community health worker to the intervention would have been possible only if sham intervention techniques had been devised. Other limitations for the study include the lack of validation of the severity scoring for asthma and the related limited understanding of the clinical significance of score differences. The instruments used to calculate the asthma severity scores were developed for this study and not validated from previous studies.

Despite low retention, this study showed that a multifaceted environmental intervention among poor children with asthma living in an urban environment resulted in lowered dust mite allergens and initially in a nonsustained reduction in cockroach allergen levels in household dust and concomitant improvement in the functional severity of the children's asthma. This study clearly illustrates the complexities involved in asthma care of children, especially in an impoverished urban environment. The findings call for further work in identifying the characteristics of the children and families who may benefit the most from these interventions.

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