Published in final edited form as:
Health Educ Behav. 2008 June ; 35(3): 376–395. doi:10.1177/1090198106290622.

Evaluation of Community Action Against Asthma: A Community Health Worker Intervention to Improve Children's Asthma-Related Health by Reducing Household Environmental Triggers for Asthma

Edith A. Parker, DrPH, MPH, **Barbara A. Israel, DrPH, MPH**, **Thomas G. Robins, MD, MPH**, **Graciela Mentz, PhD**, **Xihong Lin, PhD**, **Wilma Brakefield-Caldwell**, **Erminia Ramirez, MSW**, **Katherine K. Edgren, MSW**, **Maria Salinas**, and **Toby C. Lewis, MD, MPH**
Edith A. Parker and Barbara A. Israel, Department of Health Behavior and Health Education, University of Michigan School of Public Health, Ann Arbor. Thomas G. Robins, Department of Environmental Health Sciences, University of Michigan School of Public Health, Ann Arbor. Graciela Mentz, Department of Health Behavior and Health Education, University of Michigan School of Public Health, Ann Arbor. Xihong Lin, Department of Biostatistics, Harvard School of Public Health, Boston. Wilma Brakefield-Caldwell, Community Partner at Large, Community Action Against Asthma, Detroit. Erminia Ramirez, Community Health and Social Services (CHASS), Detroit. Kathy K. Edgren, Student Health Services, University of Michigan, Ann Arbor. Maria Salinas, National Community Development Institute, Detroit. Toby C. Lewis, Department of Pediatrics, University of Michigan School of Medicine, Ann Arbor.

Abstract

This article describes the evaluation of a community-based participatory research (CBPR) community health worker (CHW) intervention to improve children's asthma-related health by reducing household environmental triggers for asthma. After randomization to an intervention or control group, 298 households in Detroit, Michigan, with a child, aged 7 to 11, with persistent asthma symptoms participated. The intervention was effective in increasing some of the measures of lung function (daily nadir Forced Expiratory Volume at one second [$p = .03$] and daily nadir Peak Flow [$p = .02$]), reducing the frequency of two symptoms ("cough that won't go away," "coughing with exercise"), reducing the proportion of children requiring unscheduled medical visits and reporting inadequate use of asthma controller medication, reducing caregiver report of depressive symptoms, reducing concentrations of dog allergen in the dust, and increasing some behaviors related to reducing indoor environmental triggers. The results suggest a CHW environmental intervention can improve children's asthma-related health, although the pathway for improvement is complex.

Keywords

asthma intervention; community partnership; environmental triggers

---

Address correspondence to Edith A. Parker, University of Michigan, School of Public Health, Ann Arbor, MI 48109-2029; phone: (734) 763-0087; edithp@umich.edu.

Ethnic minority children residing in urban areas with high concentrations of poverty disproportionately suffer the burden of asthma (American Lung Association, 2003; Mannino et al., 2002). Exposure to indoor allergens often plays a key role in asthma exacerbation (Custovic, Murray, Gore, & Woodcock 2002; Gold, 2000). Because children with allergic asthma tend to be sensitive to more than one allergen (Eggleston & Bush, 2001), interventions to reduce indoor allergens are beginning to focus on multiple triggers for asthma. Although there are reports of the success of home-visiting interventions involving professionals focusing on reducing multiple indoor environmental triggers (Carter, Perzanowski, Raymond, & Platts-Mills, 2001; Evans et al., 1999; Morgan et al., 2004), evidence about the effectiveness of such interventions using community health workers (CHWs) instead of trained professionals is just beginning to emerge (Krieger, Song, Takaro, & Weaver, 2005). CHWs, who are often from the community in which they work, may be particularly effective in working with underserved populations because of their knowledge of both the cultural context for health and illness and the community's history of interactions with the service delivery system (Eng, Parker, & Harlan, 1997). We report the health outcomes of the Community Action Against Asthma (CAAA) 1-year household intervention implemented in eastside and southwest Detroit, Michigan. CAAA sought to improve asthma-related health status of children by reducing indoor environmental triggers to asthma through multiple activities delivered by CHWs.

A distinguishing feature was CAAA's use of a community-based participatory research (CBPR) approach (Edgren et al., 2005; Parker et al., 2003; Parker et al., 2005). CBPR is a collaborative approach to research involving all partners, such as community members, organizational representatives, and researchers in all project components (Israel, Schulz, Parker, & Becker, 1998). In CAAA, a steering committee composed of representatives of eight community-based organizations, one health service agency, one state agency, one academic institution, and a community member at large guided all phases of the research (see the acknowledgments for list of partner organizations). The steering committee representation is based on organizational affiliation, and each organization identifies, at minimum, a primary and alternate representative for the steering committee. There was one CAAA steering committee member who did not have an organizational affiliation but who expressed interest in, and was asked to remain on, the steering committee after retiring from her organization. Although the steering committee primarily used a consensus model of decision making, each organization had one vote should a vote be necessary. More than one member from each organization could attend the steering committee meetings, and often the University of Michigan had more than two organizational representatives attending because their presence was required to answer and explain different aspects of the research process. The steering committee met monthly and was active in defining the research questions, designing survey instruments, hiring key staff, and designing research and intervention activities such as educational materials and incentives for participants, copresenting at conferences and meetings, and coauthoring manuscripts (Edgren et al., 2005). To ensure the partnership operated in a participatory fashion, the CAAA steering committee adopted a set of CBPR principles to guide the work of the partnership (Parker et al., 2003). Examples of the principles include the following: All members are involved in all major phases of the research process, research is conducted in a way that strengthens collaboration among partners and community institutions/organizations, and findings are presented to the community in clear and respectful language.

METHOD

Population and Recruitment

CAAA recruited children who resided in southwest or eastside Detroit and who were identified as likely having persistent asthma through completion of a screening questionnaire by their caregiver. These two geographic communities were chosen as areas of focus by the community-academic research partnership that created CAAA, the Detroit Community-Academic Urban Research Center (URC; Israel et al., 2001). These two communities were selected on the basis of statistics highly relevant to general child and family health, evidence of community strengths and efforts to address local health concerns, and preexisting relationships among the initial partners of the URC. The eastside intervention area has approximately 100,000 residents and is predominantly African American (89%), whereas the southwest area has approximately 65,000 residents and is the part of the city where the largest percentage of Latinos reside (approximately 35% Latino, 40% African American, and 15% White) (Wayne State University Center for Urban Studies, 2000). The southwest has historically contained most of the industrial facilities of Detroit, including iron-steel manufacturing, chemical plants, sewage sludge incineration, and coal-fired utilities. These two communities reflect a mix of moderately high to very high infant asthma hospitalization rates, with consistently high proportions of households living below the poverty level.

Asthma screening questionnaires were mailed and/or hand delivered to caregivers (N = 9,627) of all children ages 7 to 11 who attended one of the 44 elementary schools in the neighborhoods of interest (Lewis et al., 2004). We decided to recruit through the schools, rather than, for example, through doctors' offices or clinics, mainly because our community partners on the steering committee wanted to ensure that our eligible study population would include children who may be undiagnosed and/or not be under any regular medical care.

The screening questionnaire, derived from the American Thoracic Society respiratory questionnaire for adults (Hopp, Townley, Biven, Bewtra, & Nair, 1990), was designed to operationalize the National Asthma Education and Prevention Program (NAEPP) Classification of Asthma Severity (National Asthma Education Program, 1997, p. 20). The core questions had been validated in prior assessments of asthma prevalence among children in Detroit (Clark et al., 2002). The screening questionnaire was available in Spanish and English language versions. For schools in which there was a high enrollment of Spanish-speaking children, we distributed English and Spanish versions of both a cover letter and the questionnaire together to allow the parents to choose the language they preferred for responding to the questionnaire. Children eligible for enrollment in the study were those with persistent asthma, defined as any of following being true: (a) one or more daytime symptoms reported as being present "more than two times per week," (b) sleep disturbance reported "more than two times per week," and (c) daily use of doctor-prescribed medicine for respiratory symptoms. Once enrolled in the study, some children were recategorized on the basis of their answers when the screening questions were repeated on the interviewer-administered baseline questionnaire.

If more than one eligible child was identified in a household, the child exhibiting more symptoms served as the reference child (caregivers were informed that reduction of household triggers should be of benefit to all children in the home with asthma). Children who lived outside of the defined geographic area or were monolingual in a language other than Spanish or English were excluded from the study. The intervention was explained in person to the caregiver of the eligible children, and informed consent was obtained.

Participants who completed informed consent and participated in at least one of the following baseline assessments: caregiver interview, skin testing for allergen sensitization, or seasonal lung function assessment, were randomized into either the intervention or control group by a random number generator method, stratified on household location (southwest or eastside).

Intervention

The CAAA intervention, adapted from the Seattle-King County Healthy Homes Project (Krieger et al., 2002), consisted of a planned minimum of nine household visits over a 1-year period by CHWs called community environmental specialists (CESs). The aim was to work with the family in making environmental changes in the home to reduce the child's exposure to multiple common asthma triggers. The applicants for these CES positions were interviewed and chosen by a hiring subcommittee that included community and academic members of the steering committee. The four CESs hired were all Detroit residents with a minimum of a high school education; two of the CESs were bilingual (Spanish and English). The CESs completed an intensive 4-week training prior to beginning their duties and participated in ongoing training activities throughout the year of the study. The training included topics such as clinical aspects of asthma; allergens (dust mites, cockroaches, pets, rodents, mold, and mildew) and their relationship to asthma; environmental tobacco smoke (ETS) risks and strategies to reduce exposure; household chemicals and their risks and uses; strategies for reducing environmental triggers (both ETS and allergens) for asthma; tenants' rights; accessing the medical care system; and provision of referrals for a range of issues, such as enrollment in medical care, tenants' rights, food banks, and help with paying electricity bills. The community partners on the steering committee suggested the CESs be trained on the provision of referrals because caregivers might be experiencing challenges with resources, which would in turn affect their ability to manage their child's asthma.

The CESs were also trained in strategies for behavior change, drawing from several health behavior theories, including empowerment and social cognitive theory (Anderson & Funnell, 2000; Baranowski, Perry, & Parcel, 2002). In addition, the CESs were trained and certified in application of integrated pest management, a method for eradication of rodents and pests without the use of chemical products that maybe harmful to children with asthma. This method includes the use of roach baits and rodent traps and structural changes in the home to prevent entry of rodents and pests.

A single CES was assigned to each family, and each CES had a caseload of around 40 households. The child's regular health care provider was informed of the child's enrollment in the intervention, but no recommendations were made to either the family or the physician regarding medical care. Because the CESs were not clinically trained health professionals, the CESs referred caregivers to their health care providers for all questions regarding symptoms and medication use.

The initial CES home visit included delivery of general information on asthma and the role of environmental triggers. At this visit, an assessment was made of the families' major social service needs, including whether the child had a primary care physician and health insurance coverage. Referrals to clinics, public health insurance programs, and social service agencies were made when appropriate.

At the second intervention visit, a household action plan was developed jointly between the CES and the caregiver. In the first step of developing this plan, information from the baseline caregiver questionnaire, the skin prick allergy test, and analysis of bedroom dust allergen concentrations were reported back to the families along with a suggested list of the priority triggers upon which to focus (based on the family's data) that had been developed by the CAAA pediatric pulmonologist. For example, if the child was sensitized to dust mites and there was a moderate to high level of dust mite allergen present in the dust sample, the reduction of this allergen would be suggested as a high priority. Reduction in ETS was always included as a recommended high-priority item if this exposure was present. The CESs and the caregiver together reviewed this list, and on the basis of the caregiver's choice, they finalized an initial prioritized list of environmental triggers upon which to focus. In some cases, this list was similar to the one developed by the pediatric pulmonologist. In other cases, the caregiver decided to focus initially on something ranked further down the list. Because the action plan was reviewed on each visit, the caregivers and CESs monitored progress on the plan, and the CESs would suggest returning to those topics the caregiver rated initially as lower priority. Although the emphasis and ordering of the topics for the visits were tailored to the family's situation, all topics were covered with all families on at least one visit at some point during the intervention. Thus, after the initial two visits, subsequent visits covered strategies and methods to reduce dust mites, environmental tobacco smoke, cockroaches, pet dander, rodents, and mold. Visits were planned every 6 weeks. If either the environmental or social needs of the family were large, the CESs had flexibility to schedule additional visits to assist with particular environmental issues or social service referrals.

Materials that all intervention participants received during the subsequent home visits included a Eureka SmartVac® upright vacuum cleaner with HEPA filter (Model V4464), mattress and pillow allergen-impermeable covers, and household cleaning supplies, such as gentle unscented cleaners that were readily available at neighborhood stores, mops, and buckets. ETS exposure reduction activities consisted of educational messages by the CES (both in oral form and written materials distributed) on the dangers of ETS exposure for children with asthma and strategies for reduction of exposure and information on smoking cessation (if caregiver was a smoker). Intensive integrated pest management services were offered to the 48 families with (a) positive child skin test for cockroach, or (b) visible roaches during visit by interviewer or initial visit by CES, or (c) cockroach allergen concentration in dust ≥ 8 U/g. Twenty-seven families agreed to participate in this component of the intervention. The project manager and field coordinator coordinated the IPM services with the CESs—with the CESs providing services and education themselves and working with professional exterminators on homes with major infestations.

As mentioned earlier, information from a skin prick test was used in developing the individualized action plan. As part of the baseline activities, children were skin prick tested against nine common aeroallergens, including mixed roach (Bla gI and Bla gII), mixed dust mite (Der p 1 and Der fI), cat, dog, mouse, rat, ragweed, mixed grasses, Alternaria, plus histamine as a positive control and saline as a negative control. A positive test result was defined as a wheal diameter 2 mm or more that was greater than that of the negative (saline) control (Evans et al., 1999; Morgan et al., 2004).

To address ethical concerns about control group children with undiagnosed asthma receiving inadequate medical care, families in both groups were given the Global Initiative for Asthma booklet of basic information on asthma (Global Initiative for Asthma, 1995). In addition, at the end of the 1-year intervention trial, the participants in the control group received the same household intervention.

Health Outcome Measures

The AirWatch® (iMetrikus, Inc., Carlsbad, CA; www.medicompass.com) digitized airway monitoring device was used to measure peak expiratory flow (PF) and forced expiratory volume at one second (FEV_1) of each participant. Each child was asked to complete three consecutive expiratory maneuvers in the morning and again in the evening on 14 consecutive days, repeated across four seasons. All children received initial and seasonally repeated training in forced expiratory maneuvers. To evaluate the intervention, lung function measures of the spring and summer seasons of 2000 (which represented baseline) and the spring-summer seasons of 2001 (which represented follow-up after the 1-year intervention) were used. Data from the two seasons (28 days total measurement) were analyzed together to reflect the baseline and follow-up lung function scores. Although some of the participants had begun the intervention before the summer lung function measurement period, we included this period because the families had received no more than two visits from the CESs. Because the introductory visits focused on further introduction of the research project, referrals to outside social service agencies, and general asthma information, we did not believe that these initial visits would result in substantial change in caregiver behavior toward reducing environmental triggers.

During the preintervention seasons of spring and summer 2000, all children were asked to complete lung function maneuvers unobserved at home. Preliminary review of the data raised concerns about the quality of these expiratory maneuvers. Therefore, during the postintervention seasons of spring and summer 2001, the morning blows were observed by a trained technician at the child's school, and a newer model of the device (AirWatch 2) with instantaneous error messages for improper technique was used to improve the quality of data. We restricted participation to those 86 children who attended a school with at least 2 other study participants because of a limited number of technicians. Other than being on average 6 months younger, these 86 children did not differ significantly in demographic characteristics or in intervention group assignment from those who did not continue with pulmonary function measures. These protocol changes resulted in substantial improvement in the quality of the expiratory maneuvers. Although the lung function protocol changed between the initial and follow-up periods, any changes in assessment technique applied equally to the intervention and control groups and thus would not be expected to affect intergroup differences.

Measures of lung function examined for intervention effects were as follows: intraday variability in FEV_1 and PF, and the lowest ("nadir") valid values for FEV_1 and PF on a given day. Intraday variability for FEV_1 was defined as follows:

$$100\left(\frac{\text{BestFEV}_1 - \text{NadirFEV}_1}{\text{BestFEV}_1}\right)$$

where the "Best FEV_1" is the highest valid FEV_1 value of the three exhalations for that half-day (morning or evening) for that day and the "Nadir FEV_1" is the highest valid FEV_1 value of the three exhalations for the other half-day measurement on that same day. Intraday PF and daily nadir PF were defined analogously. Values considered valid were those between 30% and 140% of predicted based on normative data (Hankinson, Odencrantz, & Fedan, 1999).

Other health status outcomes were measured annually through questionnaires administered to the caregivers by trained interviewers. These questionnaires were available in Spanish and English versions, and interviewers fluent in Spanish were used to interview caregivers for whom Spanish was their primary language. These questionnaires included symptoms (cough, wheeze, shortness of breath, chest tightness or heaviness, and sleep disturbance) and unscheduled medical visits (doctor's office, emergency room, hospital admission) for asthma. Symptom frequencies during the past 12 months were measured on a 6-point scale (1 = *never*, 2 = *1 or 2 times in the whole year*, 3 = *3 to 12 times in the whole year*, 4 = *more than 1 time per month*, 5 = *more than 2 times per week*, 6 = *every day*) (Clark et al., 2004).

We also estimated the intervention effect on inadequate use of asthma controller medication, which we hypothesized may result from education and encouragement to the caregiver by the CES to approach the child's physician with any medical questions. A child was considered undertreated if the caregiver reported any of seven symptoms independent of respiratory infection occurring more than twice a week, and the child was not on a controller asthma medicine (inhaled or oral corticosteroid, a leukotriene receptor antagonist, a long-acting beta-agonist, cromolyn or nedocromil, or theophylline prescribed to be taken daily).

Intermediate Outcome Measures

To assess allergens in household dust, we collected dust samples in the child's bedroom at baseline and 1-year follow-up using a hand-held vacuum (Oreck XL) with a dust collection filter using a standard protocol (Platts-Mills, Vaughan, Carter, & Woodfolk, 2000). The dust samples were analyzed for the following allergen concentrations (two types of cockroach: Bla g1, Bla g2; two types of dust mite: Der p1, Der f1; cat: Fel d1; dog: Can f1; and Alternaria, mixed grass and ragweed) using enzyme-linked immuno sorbent assay (ELISA) methods (Custovic, Simpson, & Woodcock, 1998).

We also measured the proportion of families reporting behaviors related to reduced exposure to allergens and irritants, such as “used the vacuum cleaner,” “dusted room,” “changed sheets,” “washed bedcovers,” “used an allergen cover on child’s pillow and mattress,” and altered smoking/ETS practices. These were measured by items on the caregiver questionnaire that asked the caregivers to respond yes or no to having undertaken a certain behavior.

To assess a possible association between a caregiver’s emotional state and management of the child’s asthma, we also measured caregiver depressive symptoms. We used the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977), which is an 11-item scale (each item receives a score of 1 [*low*] to 3 [*high*]) that is summed and divided for a mean score. Scale items assess the frequency with which respondents reported that, for example, they felt depressed, everything they did was an effort, or their sleep was restless. Finally, we included measures of instrumental and emotional support that we adapted from validated measures of instrumental and emotional support (Strogatz et al., 1997). Five items were combined to make a 4-point instrumental support scale, and 6 items were used to measure both instrumental and emotional support combined (1 = *lowest support*, 4 = *highest support*).

Incentives

With the guidance of the steering committee, the following incentives were used in the study. The caregivers who returned the screening questionnaire were given a $4 gift certificate to a local shoe store. Those families participating in the intervention were given the following incentives: $15 gift certificates at completion of each annual interview (baseline and follow-up); small reward items (such as pens, erasers) at the end of the week for the children who completed Airwatch lung function tests in the schools; gift certificates to a local restaurant for a successful record of Airwatch blows depending on the degree to which children followed data collection instructions; and, at the project’s end, each family received $50.

Timeline

The distribution of the screening questionnaires began in January 1999, with the skin testing and enrollment beginning in June 1999. The initial baseline measurement began in fall 1999 and lasted until enrollment was complete in March 2000. The intervention was conducted April 2000 through May 2001. The follow-up measurements were collected May through August 2001. Because of the number of participants, it took 6 weeks (or until mid-May) for all families to receive their initial visit by the CES. This meant that families had received no more than two visits by the time the summer seasonal lung function measurement (which was combined with the spring measurement as a lung function baseline measure) had taken place.

Data Analysis

Statistical analysis was performed using SAS (Version 8.0, SAS Institute, Cary, NC). Baseline characteristics were compared between the intervention and control groups using the *t* test or the Wilcoxon test for continuous outcomes and the chi-square test for discrete outcomes.

To examine possible intervention effects on health status outcomes, we used generalized estimating equations (GEEs; Zeger & Liang, 1986), a multivariate analog for linear and logistic regression, that adjust for lack of independence of repeated measures on the same individual, through the SAS procedure PROC GENMOD. GEE regression coefficients have population-average interpretation and are ideal for assessing the intervention effects. GEE calculates robust standard errors using the sandwich method, which does not require a correct specification of the correlation matrix among repeated measures over time. These properties of GEE made it more suitable for the structure of our data than other alternatives, such as mixed models. We used GEE linear models for continuous outcomes (with identity link and exchangeable working correlation matrix) and GEE logistic regression for binary outcomes (with logit link and exchangeable working correlation matrix). Models included dummy variables for group (intervention vs. control) and time (pre- vs. postintervention) and their interaction (product) term. This Group × Time interaction term is directly interpretable as the intervention effect comparing intervention with control groups, adjusted for any change in the control group over time. These models can use data from all children, including children having pre- but not postintervention measurements. By using all available data, these models have increased statistical power over alternatives that include only those having both pre- and postintervention measurements (Yang & Tsiatis, 2001). For continuous outcomes, such as lung function, the intervention effect is in the same units as the variable. For dichotomous outcomes, the intervention effect is the odds for change in the outcome from pre- to postintervention among the intervention group divided by the odds for change among the control group: ($OR_{\text{postintervention vs. baseline for intervention group}}$/ $OR_{\text{postintervention vs. baseline for control group}}$). Thus, values < 1.0 suggest a beneficial intervention effect for measures of unscheduled medical care and inadequate medication. Age, gender, location of residence, ethnicity, and household income were included as covariates in all GEE models.

We also examined models that included potential effect modifiers, such as the child's baseline asthma severity, presence of smoker in the household, and depressive symptoms in the caregiver. Because there was no consistent, statistically significant evidence of effect modification, these results are not shown.

Although multiple outcomes are being assessed, we felt that correcting for multiple comparisons would be more misleading than informative. A priori we identified several distinct outcomes of interest, effecting separate research questions. In this situation, prominent epidemiologists have asserted that correction for multiple comparisons is unnecessary (Rothman, 1987). Furthermore, as many of our outcomes are correlated, and the correlation varies by outcome, common correction methods such as Bonferroni are likely to be overly conservative, leading to inaccurate inference (Pocock, Geller, & Tsiatis, 1987). We have therefore opted not to perform statistical adjustment for multiple comparisons. Two-tailed tests of significance using alpha = .05 were used to allow for assessment of either beneficial or negative effects.

RESULTS

Participants

Of the original 9,627 questionnaires distributed, 3,342 questionnaires were returned (response rate of 34%), 3,067 screening questionnaires were analyzed (an additional 295 were not analyzed for the following reasons: they were blank [*n* = 117], they were duplicates [*n* = 56], the child was ineligible for the study [lived outside of the study area or was too young or too old (*n* = 65)]), and 708 children met eligibility criteria to be invited into the study (Lewis et al., 2004). Of these 708 children/caregivers, 510 were successfully contacted and invited to participate, and 328 of these 510 children/ caregivers agreed to participate and were enrolled and subsequently randomized to either the intervention group (*n* = 162) or the control group (*n* = 166). The 182 eligible children/caregivers who were contacted but chose not to participate showed no significant differences in the child's age, gender, ethnicity, residential location (southwest versus eastside), or asthma severity from the screening questionnaire when compared with the 328 who did enroll. Among the 328 enrollees, 30 were lost to follow-up between initial time of enrollment in the study and a preintervention baseline caregiver interview. Thus, among the intent-to-treat population of 328, only the 298 who completed a baseline caregiver interview received any intervention or provided any data upon which assessments could be based. These 298 constitute the sample size for analysis of intervention effects. The 30 randomized children who did not begin the intervention showed no significant differences from the 298 who did on the screening questionnaire variables listed above. The intervention and control groups showed no significant differences with respect to baseline characteristics (see Table 1).

Among the 298 participating families, 77% (*n* = 116) of the intervention arm and 75% (*n* = 111) of the control arm completed a postintervention caregiver interview. Reasons for loss to follow-up were the following: moving out of the intervention area (19 intervention, 16 control), request to withdraw (9 intervention, 9 control), and inability to locate (6 intervention, 12 control). Those participants completing a follow-up differed significantly from those who did not for gender and home ownership: respectively, 39% (*n* = 90) versus 52% (*n* = 39) female (*p* = .05), and 36% (*n* = 82) versus 18% (*n* = 12) homeowners (*p* = .02).

Lung Function

Valid lung function measures were collected from 157 children preintervention (82 intervention, 75 control) and 54 children postintervention (23 intervention, 31 control). (Although, as noted previously, we restricted participation in the postintervention measurement to 86 children, only 54 children were included in the postintervention analysis because of invalid or missing data). Preintervention, participating children showed, on average, mild to moderate airflow obstruction (Table 2). There was a significant intervention-associated beneficial effect on lung function in daily nadir FEV_1 (*p* value = .03) and in daily nadir PF (*p* value = .02). The magnitude of the change in lung function should be interpreted with caution, as the protocol for assessing lung function changed slightly from the pre- to postintervention assessment. Nevertheless, because these protocol changes were applied uniformly to both intervention and control groups, we can assess the relative change over time in the intervention group compared with that of the control group.

Child's Average Asthma Symptom Frequency

At follow-up, the intervention group reported symptoms occurring less frequently than they had at baseline for all eight symptoms assessed and the control group for six of eight symptoms. There was a statistically significant beneficial intervention effect for the symptoms of persistent cough and cough with exercise. In the intervention group, the mean for persistent cough was 3.81 at baseline and 3.36 at postintervention, whereas the control group had a mean of 3.48 at baseline and 3.44 at follow-up ($p = .034$). For coughing with exercise, the intervention group had a baseline mean of 4.27 and a postintervention mean of 3.69, whereas the control group had a baseline mean of 3.80 and a postintervention mean of 3.66 ($p = .017$).

Health Care Utilization and Inadequate Asthma Medication Use

There was a highly significant intervention effect in reducing unscheduled health care utilization for asthma both in the last 3 months and the last 12 months (Table 3). Additional analyses (results not shown) suggested that most of the intervention effect was due to a reduction in unscheduled doctor visits, and restricting analysis to emergency room visits and hospitalization alone did not result in statistical significance because of small sample size.

Preintervention, a large proportion of children appeared to be undertreated for active symptoms, with a somewhat higher proportion among the intervention group than the controls (Table 3). There were highly significant intervention effects in reducing undertreatment for active symptoms in the category of children who should be on a controller but are not.

Allergens in Dust Samples

There was a statistically significant intervention effect in the reduction of concentration of dog allergen per gram of bedroom dust, but not for cockroach, dust mite, or cat allergen concentration. For dog allergen concentration, the median for the intervention group was at 130.9 ng/g at baseline and 9.6 ng/g at follow-up, whereas the control group was at 37.2 ng/g at baseline and 10.3 at follow-up ($p < .001$).

Behavior to Reduce Environmental Triggers

The CAAA intervention was effective at increasing the proportion of families reporting behaviors and household factors related to reduced exposure to house dust mites, but not effective at changing the proportion of families reporting behaviors related to reducing mold or ETS exposure (see Table 4).

Caregiver Depressive Symptoms and Social Support

The intervention had a statistically significant effect with a reduced report of caregiver depressive symptoms from a mean 1.62 to 1.54 in the intervention group, whereas the control group rose from 1.58 to 1.64 ($p = .0218$). The improvement in both instrumental and emotional social support combined and instrumental support alone were not statistically significant (results not shown).

Intervention Visits

For the intervention group, although the minimum number of planned visits was 9, the range of delivered visits was 1 to 17, with a mean of 9.24 and a mode of 8 to 9 visits. To assess possible implications of the variation of visits on the health outcomes of the study, we performed regression analysis of health outcomes by CES visit number (categorized as < 8, 8–10, 11–17). The distribution of families across these three categories was as follows: < 8 visits, n = 26, group mean = 7.06 visits; 8–10 visits, n = 57, group mean = 9.43 visits; 11–17 visits, n = 24, group mean = 13.22 visits. For most of the outcomes, there is no consistent pattern of differences across these three categories. An exception was unscheduled medical visits for which the protective effect of intervention increased monotonically as the number of visits increased.

DISCUSSION

The CAAA randomized controlled intervention trial found a number of significant positive impacts on the health of children with asthma (including improvements in lung function and decreases in symptoms of cough, unscheduled medical visits, and inadequate medication use) and on the health of the caregiver, with a reduction in the caregiver's report of depressive symptoms. The intervention had mixed results in measures related to reducing environmental triggers, showing positive intervention effects on some behaviors related to reduction of environmental triggers, and on reducing dust allergen concentrations of dog, but showing no effect in reducing child exposure to ETS, measured dust allergen concentrations of cockroach and dust mite, and in surface dust loading of these allergens.

Home-based environmental intervention is increasingly being recognized as a viable strategy for improving the health of children with asthma living in urban environments (McConnell et al., 2003; Morgan et al. 2004), and interventions using community health workers are increasing in number (Krieger et al., 2005; Persky et al., 1999).

Although promising, the effects of the intervention described here were not as strong as some recently reported interventions using similar strategies (Krieger et al., 2005; Morgan et al., 2004) but were similar to other evaluations of home interventions directed at multiple triggers that have demonstrated improvement in some, but not all, health outcomes (Evans et al., 1999) and in some, but not all, targeted environmental outcomes (Krieger et al., 2005). These mixed results are perhaps due to the widely acknowledged challenges associated with this approach (Custovic et al., 2002; Morgan et al., 2004; Platts-Mills et al., 2000), including difficulty in eliminating the cockroach allergen source and subsequently the allergens (Eggleston, 2003), and difficulty in reducing ETS exposure through behavioral-based intervention strategies (Wakefield et al., 2002). For example, although Krieger and colleagues demonstrated significant health and environmental outcomes, they did not see a reduction in dust allergen concentration (Takaro, Krieger, & Song, 2004) or ETS exposure (Krieger et al., 2005). McConnell and colleagues (2003) reported significant results in reducing cockroach allergen in the kitchens of homes of children with asthma through a combination of integrated pest management and professional cleaning, but they reported modest and nonsignificant reduction in allergen concentration in the child's bedroom.

Despite our inability to demonstrate consistent environmental effects, we were able to show positive health outcomes. For example, the reduction in unscheduled medical visits combined with reduction in the proportion of children at an inadequate level of asthma medication strongly suggests that the children's asthma is better controlled. Some of the intervention effects may be due to increased coping mechanisms achieved by caregivers through the information, assistance, and referrals given to them by the CESs. For example, although CAAA's emphasis on medical control of asthma was minimal, it is notable that the intervention helped reduce the proportion of children with active symptoms who were undertreated. We hypothesize that intervention families were better able to access and use the health care system as an ancillary benefit of the knowledge gained from, and their supportive interactions with, the CESs.

Several characteristics of the CAAA intervention are likely to have contributed to the observed successes. First, CAAA used a CBPR approach, which actively involved community partners in the design and conduct of the intervention to adapt methods from the literature to the specific context of Detroit (Edgren et al., 2005; Parker et al., 2003). The use of a CBPR approach enhanced the recruitment and retention of participants, the appropriateness of the intervention strategies, and the quality and validity of the data (Parker et al., 2003). For example, our community partners helped design community-based recruitment strategies and appropriate incentives for the participants, participated in the hiring of all project staff, contributed to the content and wording of all questionnaires, and reviewed and suggested revisions for all intervention and research-related protocols (Edgren et al., 2005). Second, the CAAA outreach workers (CESs), who were from the involved communities and culturally similar to participants, expended significant effort early in the intervention developing rapport with the families and helping with referrals to social service agencies. This helped develop trust between the family and their CES that may have been instrumental in facilitating behavior change related to allergen exposure. Third, CAAA adopted a comprehensive approach to reduce exposure to multiple triggers in the indoor environment responsive to the "real-life" situation faced by many urban children. The CESs intervened at several levels, providing not only education and supplies but coaching, encouragement, reinforcement, and, as needed, direct integrated pest management services to the families. Although some of these strategies have been employed in other studies, CAAA offered a unique combination of intervention strategies as part of this comprehensive approach.

Possible reasons for our lack of some results include the preintervention health status of our children and factors related to our measures that may have affected our findings. Our population of children did not appear to be as sick at baseline as those children in the studies described by Morgan and colleagues (2004) and Krieger and colleagues (2005), as a sizable proportion of the intervention population had intermittent asthma and a smaller proportion had moderate to severe asthma than in these two studies. With a population with more severe asthma, the effect of our intervention would possibly have been stronger.

There were also factors related to our measures that may have affected our results. Although the intervention effect estimate for all eight asthma symptoms suggested a decrease in symptom frequency, only the two cough-related symptoms reached statistical significance. The lack of more significant symptom differences between the groups in part may be due to the annual measurement, with the caregiver asked to consider a long reference period of the last 12 months. This time period may have blunted our ability to detect changes that occurred during the latter months of the 12-month intervention, when any intervention effects are likely to be the strongest. Alternatively, the control group may have experienced a Hawthorne effect of being enrolled in a study, with the attendant periodic interviews and health assessments (Greineder, Loane, & Parks, 1998), or the external attention to issues around asthma may have prompted the control families to change some of their asthma-related health behaviors, reducing the detectable difference between groups. Similarly, our measurement of dust only on an annual basis may have masked some initial reduction in cockroach allergens that may have taken place. In addition, unlike other studies (McConnell et al., 2003), we only measured changes in dust in the bedroom and not the kitchen, thereby precluding assessment of possible changes in other areas of the home.

Two other possible factors that may have had an impact on our findings include the change in our lung function protocol and potential seasonal influences on our measures. Although the change in instrumentation and protocol for the lung function measurement means that pre- and postintervention measurements within an individual are not directly comparable, the protocol change was applied consistently across all individuals, and any increase in misclassification of pulmonary function outcomes introduced by the inclusion of the preintervention period should be nondifferential. This preserves the ability to make valid comparisons between the intervention and control groups. However, the reduction in the number of children participating in postintervention measures may have limited the ability for smaller differences between groups (such as that seen with PF intraday variability) to reach statistical significance at the alpha = .05 level. Although asthma is a condition subject to seasonal fluctuations (Gergen, Mitchell, & Lynn, 2002), and thus, our time of measurement may have affected the absolute level of the health outcomes, there was comparability of season in pre- and postintervention measurements, and seasonal influences should have affected the intervention and control groups equally.

In summary, the CAAA home environmental intervention was associated with improvement in several, but not all, indicators of asthma health status. The overall magnitude of these effects was in a modest to moderate range of clinical significance. Our home visit intervention was effective in improving some aspects of children’s pulmonary function, health care utilization, and medication use and in changing some behaviors related to reduction of environmental triggers, but it was less effective in reducing measured dust allergen concentrations. The intervention was successful in decreasing depressive symptoms for caregivers, suggesting that some of the intervention effects may be due to increased coping mechanisms achieved by caregivers through the information and assistance given to them by the CESs. We believe that the participation of local community representatives in designing and implementing the CAAA intervention was an important factor contributing to its acceptance by families and its ability to make an impact.

Implications for Practice

Building on the work of previous studies, this study reinforces the value of CHW interventions using a CBPR approach and the need for continued efforts to adapt, implement, and evaluate comprehensive approaches to reducing environmental triggers of childhood asthma. Although increasing attention has been paid to the importance of reducing household environmental triggers for childhood asthma, fewer studies have employed randomized controlled designs to evaluate the efficacy of CHW interventions in reducing these triggers. Our study, combined with others (Krieger et al., 2005), suggests a valuable and useful role for CHWs in reduction of childhood asthma exacerbation, particularly in urban areas. Impacts on health outcomes, such as improved lung function and reduced unscheduled medical visits, have the potential to improve the well-being of asthmatic children and their families as well as decease expenditures associated with avoidable, urgent medical care utilization. Our study also suggests that CBPR approaches can be combined with more traditional research approaches, such as a randomized controlled design, to investigate health concerns of communities. In addition, as exhibited by the non-asthma-related referrals that our CHWs provided, a very practical implication of our research is the need to focus more broadly on the other issues and needs facing caregivers of children with asthma to allow these caregivers to then focus on controlling their children's asthma. Given these results, there is a need to work for systems and policy-level change to facilitate the adoption and sustainability of such CHW interventions to have a major impact on reducing environmental triggers of childhood asthma in urban areas.

Acknowledgments

Community Action Against Asthma is a community-based participatory research project of the Michigan Center for the Environment & Children's Health (MCECH) aimed at investigating the influence of environmental factors on childhood asthma. We acknowledge the contributions of all of the partners who have been involved in this collaborative effort: University of Michigan Schools of Public Health and Medicine, the Detroit Department of Health and Wellness Promotion, the Michigan Department of Agriculture, Plant and Pest Management Division, and nine community-based organizations in Detroit (Butzel Family Center, Community Health and Social Services Center [CHASS], Detroiters Working for Environmental Justice, Detroit Hispanic Development Corporation, Friends of Parkside, Kettering/Butzel Health Initiative, Latino Family Services, United Community Housing Coalition, and Warren/Conner Development Coalition), and Henry Ford Health System. MCECH, established in 1998, is funded by the National Institute of Environmental Health Sciences (R01 ES010688 and P01 ES09589) and the U.S. Environmental Protection Agency (R826710-01). MCECH is affiliated with the Detroit Community-Academic Urban Research Center (URC), a collaboration of partners from academia, the local health department, community-based organizations, and an integrated health system (see www.sph.umich.edu/urc for more information).

References

American Lung Association Epidemiology and Statistics Unit. , editor. Trends in asthma morbidity and mortality. New York: Author; 2003.

Anderson, RM.; Funnell, M. The art of empowerment: Stories and strategies for diabetes educators. Alexandria, VA: American Diabetes Association; 2000.

Baranowski, J.; Perry, CL.; Parcel, GS. How individuals, environments, and health behavior interact: Social cognitive theory. In: Glanz, K.; Rimer, BK.; Lewis, FM., editors. Health behavior and health education: Theory, research and practice. 3rd ed.. San Francisco: Jossey-Bass; 2002. p. 165-184.

Carter MC, Perzanowski MS, Raymond A, Platts-Mills TAE. Home intervention in the treatment of asthma among inner-city children. Journal of Allergy & Clinical Immunology. 2001; 108(5):732–737. [PubMed: 11692097]

Clark NM, Brown RW, Joseph CL, Anderson EW, Liu M, Valerio M, et al. Issues in identifying asthma and estimating prevalence in an urban school population. Journal of Clinical Epidemiology. 2002; 55(9):870–881. [PubMed: 12393074]

Clark NM, Brown RW, Joseph CLM, Anderson EW, Liu M, Valerio M. Effects of a comprehensive school-based asthma program on symptoms, parent management, grades, and absenteeism. Chest. 2004; 125:1674–1679. [PubMed: 15136375]

Custovic A, Murray CS, Gore RB, Woodcock A. Controlling indoor allergens. Annals of Allergy Asthma & Immunology. 2002; 88(5):432–441.

Custovic A, Simpson A, Woodcock A. Importance of indoor allergens in the induction of allergy and elicitation of allergic disease. Allergy. 1998; 53 suppl(48):115–120. [PubMed: 10096822]

Edgren KK, Parker EA, Israel BA, Lewis TC, Salinas M, Robins TG, et al. Conducting a health education intervention and an epidemiological research project involving community members and community partner organizations: The Community Action Against Asthma Project. Health Promotion Practice. 2005; 6(3):263–269. [PubMed: 16020621]

Eggleston P. Cockroach allergen abatement: The good, the bad, and the ugly. Journal of Allergy & Clinical Immunology. 2003; 112(2):265–267. [PubMed: 12897730]

Eggleston PA, Bush RK. Environmental allergen avoidance: An overview. Journal of Allergy & Clinical Immunology. 2001; 107 suppl(3):S403–S405. [PubMed: 11242600]

Eng E, Parker E, Harlan C. Lay health advisor intervention strategies: A continuum from natural helping to paraprofessional helping. Health Education & Behavior. 1997; 24(4):413–417. [PubMed: 9247821]

Evans R, Gergen PJ, Mitchell H, Kattan M, Keresmar C, Crain E, et al. A randomized clinical trial to reduce asthma morbidity among inner-city children: Results of the National Cooperative Inner-City Asthma Study. Journal of Pediatrics. 1999; 135(3):332–338. [PubMed: 10484799]

Gergen PJ, Mitchell H, Lynn H. Understanding the seasonal pattern of childhood asthma: Results from the National Cooperative Inner-City Asthma Study (NCICAS). Journal of Pediatrics. 2002; 141(5):631–636. [PubMed: 12410190]

Global Initiative for Asthma. What you and your family can do about asthma. Bethesda, MD: National Institutes of Health; 1995. (NIH Publication No. 96-3659C).

Gold DR. Environmental tobacco smoke, indoor allergens, and childhood asthma. Environmental Health Perspectives. 2000; 108(Suppl. 4):643–651. [PubMed: 10931782]

Greineder DK, Loane KC, Parks P. Outcomes for control patients referred to a pediatric asthma outreach program: An example of the Hawthorne effect. American Journal of Managed Care. 1998; 4(2):196–202. [PubMed: 10178491]

Hankinson JL, Odencrantz JR, Fedan KB. Spirometric reference values from a sample of the general U.S. population. American Journal of Respiratory and Critical Care Medicine. 1999; 159(1):179–187. [PubMed: 9872837]

Hopp RJ, Townley RG, Biven RE, Bewtra AK, Nair NM. The presence of airway reactivity before the development of asthma. American Review of Respiratory Disease. 1990; 141(1):2–8. [PubMed: 2404438]

Israel BA, Lichtenstein R, Lantz P, McGranaghan R, Allen A, Guzman JR, et al. The Detroit Community-Academic Urban Research Center: Development, implementation and evaluation. Journal of Public Health Management and Practice. 2001; 7(5):1–19. [PubMed: 11680026]

Israel BA, Schulz AJ, Parker EA, Becker AB. Review of community-based research: Assessing partnership approaches to improve public health. Annual Review of Public Health. 1998; 19:173–202.

Krieger JW, Song L, Takaro TK, Weaver M. The Seattle-King County Healthy Homes Project: A randomized, controlled trial of a community health worker intervention to decrease exposure to indoor asthma triggers among low-income children. American Journal of Public Health. 2005; 95(4):652–659. [PubMed: 15798126]

Krieger JW, Takaro TK, Allen C, Song L, Weaver M, Chai S, et al. The Seattle-King County Healthy Homes Project: Implementation of a comprehensive approach to improving indoor environmental quality for low-income children with asthma. Environmental Health Perspectives. 2002; 110(Suppl. 2):311–322. [PubMed: 11929743]

Lewis TC, Robins TG, Joseph CLM, Parker EA, Israel BA, Rowe Z, et al. Identification of gaps in the diagnosis and treatment of childhood asthma using a community-based participatory research approach. Journal of Urban Health. 2004; 81(3):472–488. [PubMed: 15273269]

Mannino DM, Homa DM, Akinbami LJ, Moorman JE, Gwynn C, Redd SC. Surveillance for asthma—United States, 1980–1999. MMWR Surveillance Summary. 2002; 51(1):1–13.

McConnell R, Jones C, Milam J, Gonzalez P, Berhane K, Clement L, et al. Cockroach counts and house dust allergen concentrations after professional cockroach control and cleaning. Annals of Allergy Asthma & Immunology. 2003; 91(6):546–552.

Morgan WJ, Crain EF, Gruchalla RS, O'Connor GT, Kattan M, Evans R III, et al. Results of a home-based environmental intervention among urban children with asthma. New England Journal of Medicine. 2004; 351(11):1068–1080. [PubMed: 15356304]

National Asthma Education Program (NAEPP). Guidelines for the diagnosis and management of asthma. Bethesda, MD: National Asthma Education Program, Office of Prevention, Education and Control, National Heart, Lung and Blood Institute; 1997. (NIH Publication No. 97–4051).

Parker EA, Israel BA, Brakefield-Caldwell W, Keeler GJ, Lewis TC, Ramirez E, et al. Community Action Against Asthma: Examining the partnership process of a community-based participatory research project. Journal of General Internal Medicine. 2003; 18(7):558–567. [PubMed: 12848839]

Parker, EA.; Robins, TG.; Israel, BA.; Brakefield-Caldwell, W.; Edgren, KK.; Wilkins, D. Developing and implementing guidelines for dissemination: The experience of the Community Action Against Asthma project. In: Israel, BA.; Eng, E.; Schulz, AJ.; Parker, E., editors. Methods in community-based participatory research for health. San Francisco: Jossey-Bass; 2005. p. 285-306.

Persky V, Coover L, Hernandez E, Contreras A, Slezak J, Piorkowski J, et al. Chicago community-based asthma intervention trial: Feasibility of delivering peer education in an inner-city population. Chest. 1999; 116 Suppl. 1(4):216S–223S. [PubMed: 10532497]

Platts-Mills TAE, Vaughan JW, Carter MC, Woodfolk JA. The role of intervention in established allergy: Avoidance of indoor allergens in the treatment of chronic allergic disease. Journal of Allergy & Clinical Immunology. 2000; 106(5):787–804. [PubMed: 11080699]

Pocock SJ, Geller NL, Tsiatis AA. The analysis of multiple endpoints in clinical trials. Biometrics. 1987; 43:487–498. [PubMed: 3663814]

Radloff LS. The CES-D: A self-report depression scale for research on the general population. Applied Psychological Measurement. 1977; 1:385–401.

Rothman KJ. No adjustments are needed for multiple comparisons. Epidemiology. 1987; 1(1):43–46. [PubMed: 2081237]

Strogatz DS, Croft JB, James SA, Keenan NL, Browning SR, Garrett JM, et al. Social support, stress, and blood pressure in Black adults. Epidemiology. 1997; 8(5):482–487. [PubMed: 9270947]

Takaro TK, Krieger JW, Song L. Effect of environmental interventions to reduce exposure to asthma triggers in homes of low-income children in Seattle. Journal of Exposure Analysis & Environmental Epidemiology. 2004; 14(Suppl. 1):133–143.

Wakefield M, Banham D, McCaul K, Martin J, Ruffin R, Badcock N, et al. Effect of feedback regarding urinary cotinine and brief tailored advice on home smoking restrictions among low-income parents of children with asthma: A controlled trial. Preventive Medicine. 2002; 34(1):58–65. [PubMed: 11749097]

Wayne State University Center for Urban Studies. 2000 census demographic profile of city of Detroit. Detroit: Wayne State University; 2000.

Yang L, Tsiatis AA. Efficiency study of estimators for a treatment effect in a pretest-posttest trial. American Statistician. 2001; 55(4):314–321.

Zeger SL, Liang KY. Longitudinal data analysis for discrete and continuous outcomes. Biometrics. 1986; 42(1):121–130. [PubMed: 3719049]

Table 1

Characteristics of the CAAA Cohort at Baseline[a]

	Intervention *N* = 150	Control *N* = 148
Child age, *M* (*SD*)	9.01 (1.50)	8.8 (1.41)
Female, *n* (%)	65 (43)	60 (41)
Child ethnicity, *n* (%)[b]		
African American	124 (83)	117 (79)
Hispanic	16 (11)	15 (10)
Caucasian	6 (4)	7 (5)
Other	4 (3)	9 (6)
Child location of residence, *n* (%)		
Eastside	112 (75)	111 (75)
Household income		
< $10,000/year (%)	56 (37)	69 (46)
Caregiver female, *n* (%)	142 (95)	138 (93)
Caregiver smokes, *n* (%)	60 (40)	52 (35)
Previously diagnosed with asthma, *n* (%)	103 (69)	110 (74)
Child's asthma severity, *n* (%)		
Moderate-severe persistent	77 (51)	65 (44)
Mild persistent	42 (28)	42 (28)
Mild intermittent	28 (19)	33 (22)
None	3 (2)	8 (5)
Child skin test positive, *n* (%)[c]		
Dust mite	41 (41)	32 (35)
Grasses	29 (29)	28 (30)
Ragweed	24 (24)	21 (23)
Cat	21 (21)	23 (25)
Cockroach	25 (25)	15 (16)
Alternaria	22 (22)	17 (18)
Mouse	12 (12)	12 (13)
Rat	10 (10)	9 (10)
Dog	11 (11)	5 (5)
Histamine control only	32 (32)	25 (27)

NOTE: CAAA = Community Action Against Asthma.

[a]There is no significant difference between groups ($p > .05$).

[b]Percentages may not add up to 100 because of rounding.

[c]One hundred ninety-one children successfully underwent skin testing (99 in intervention group, 92 in control group). Percentages do not add to 100, as each child can have more than one positive skin test.

Table 2

Generalized Estimating Equation Models of the Intervention Effect on Mean Change in Lung Function Comparing Preintervention (Spring/Summer 2000) to Postintervention (Spring/Summer 2001)

	Intervention Unadjusted Mean (*SD*)		Control Unadjusted Mean (*SD*)			
	Pre	Post	Pre	Post		
Variable	**80–82 Children 458–490 Person-Days[b]**	**23[a] Children 141–175 Person-Days[b]**	**73–75[a] Children 502–526 Person-Days[b]**	**30–31[a] Children 170–177 Person-Days[b]**	**Intervention Effect[c] (95% CI)**	***p* Value**
FEV_1 intraday variability (%)	15.1 (12.2)	14.4 (12.1)	14.2 (12.0)	17.1 (13.7)	–1.3 (–5.8, 3.1)	.559
PF intraday variability (%)	15.1 (12.6)	8.7 (8.5)	14.4 (12.3)	11.6 (9.7)	–2.1 (–5.0, 0.8)	.153
Daily nadir FEV_1 (% predicted)	76.7 (22.3)	83.1 (15.7)	79.5 (19.9)	75.6 (18.5)	10.0 (0.9, 19.1)	.032
Daily nadir PF (% predicted)	79.6 (19.9)	94.1 (15.0)	82.7 (18.0)	85.1 (19.2)	8.2 (1.1, 15.2)	.023

NOTE: CI = confidence interval; FEV_1 = forced expiratory volume at one second; PF = peak expiratory flow.

[a]Number of children varies in each regression based on available valid data.

[b]Number of person-days varies in each regression based on available valid data.

[c]The intervention effect is adjusted for age, gender, ethnicity, location of residence, and household income.

Table 3

Generalized Estimating Equation Models of the Intervention Effect on the Proportion of Children Needing Unscheduled Medical Care for Asthma, and the Proportion of Children With Active Symptoms Who Are Not on a Controller Medication

		Intervention Proportion %		Control Proportion %			
Variable		**Pre** *n* **= 150**	**Post** *n* **= 115**	**Pre** *n* **= 148**	**Post** *n* **= 112**	**Intervention Effect[c] (95% CI)**	***p* Value**
Needed unscheduled	in last 12 months	65	59	58	73	0.40 (0.22, 0.74)	.004
medical care	in last 3 months[a]	50	45	42	56	0.43 (0.23, 0.80)	.007
Has any symptom more than	not on a corticosteroid	60	42	51	46	0.56 (0.29, 1.06)	.073
2 days per week, and not on controller medication	not on any controller[b]	53	32	38	37	0.39 (0.20, 0.73)	.004

NOTE: CI = confidence interval.

[a]Those patients needing unscheduled medical care (doctor visit, emergency room visit, or hospitalization) in the last 3 months are a subset of those needing medical care in the last 12 months.

[b]Those patients not on any controller therapy (corticosteroids, leukotriene modifiers, long-acting beta-agonsists, cromolyns, or theophylline) are a subset of those not on corticosteroids.

[c]Intervention Effect = OR postintervention-year vs. baseline for intervention group/OR postintervention-year vs. baseline for control group. The intervention effect is adjusted for age, gender, ethnicity, location of residence, and household income.

Table 4

Percentage of Caregivers Reporting “Yes” to Having Undertaken Certain Behavior

Behavior	Intervention (%)		Control (%)		Intervention Effect[a] (OR_{int}/OR_{con})	*p* Value
	Pre *n* = 150	Post *n* = 115	Pre *n* = 148	Post *n* = 112		
Vacuum cleaner used for cleaning	61	97	59	59	29.5 (6.90, 126)	< .0001
Dusted room where child sleeps during the last 2 weeks?	78	89	79	80	2.35 (0.94, 5.86)	.07
Sheets changed at least once/week	69	88	74	70	3.88 (1.53, 9.83)	.004
Bedcovers washed at least once per month	90	96	86	93	1.18 (0.29, 4.81)	.82
Allergen cover on child’s pillow	3	47	5	7	19.7 (4.12, 94.2)	.0006
Allergen cover on child’s mattress	19	65	20	17	9.70 (4.33, 21.7)	< .0001
Visible mold growth removed?	21	22	22	27	0.74 (0.33, 1.66)	.47
Caregiver smokes cigarettes	40	33	36	34	0.75 (0.43, 1.31)	.32
Any household member smokes cigarettes	57	56	54	59	0.73 (0.42, 1.27)	.27
Child is around people who smoke	76	61	75	69	0.60 (0.28, 1.32)	.20

[a] OR_{int} is the odds ratio for change in the intervention group from pre to post Year 1 of the intervention. OR_{con} is the same for the control group. The measure of the effectiveness of the intervention, controlling for the changes seen in the control group over time, is the ratio of these odds ratios (OR_{int}/OR_{con}). An example of interpretation for the symptom “vacuum cleaner use” is that the odds ratio for improvement in the intervention group is 29.5 times that for the control group, and this is statistically significantly different from 1.0 at the alpha =.05 level ($p < .05$).