

Educational intervention to control cockroach allergen exposure in the homes of hispanic children in Los Angeles: results of the La Casa study

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Summary

Background Cockroach allergy is common among inner city children with asthma, and exposure to cockroach allergen is associated with more severe disease. However, there has been little evaluation of educational approaches for controlling cockroach infestations and reducing allergen exposure.

Objective An educational intervention to reduce cockroach allergen exposure in the homes of Hispanic children in Los Angeles was implemented and evaluated.

Methods Caretakers of 150 children with asthma were randomly assigned to an in-home intervention or comparison group. In the intervention group, peer health educators trained the caretaker to control cockroaches by reducing harbourage and access to food and by applying boric acid, and to reduce allergen exposure by cleaning. Allergen impermeable covers were placed on the child's mattress and pillows. Knowledge, reported and observed behaviour, cockroach counts, and cockroach allergen (Bla g 1) in dust samples from the kitchen and the child's bedding were assessed at study entry and at follow-up 4 months later.

Results There was improvement in knowledge and in observed and reported behaviour hypothesized to be associated with cockroach control. The geometric mean cockroach number in the intervention homes at the follow-up visit was 60% lower than in the non-intervention homes (95% confidence interval (CI) 14%, 81%). Geometric mean total cockroach allergen collected from the child's bedding was 64% lower in the intervention group (95% CI 12%, 85%). In homes with heavier initial cockroach infestation, there was a larger reduction in total kitchen dust allergen and concentration associated with the intervention than in homes with fewer initial cockroaches.

Conclusions We conclude that reduction in number of cockroaches and in total allergen in bedding dust can be achieved by caretakers of asthmatic children following a single home educational intervention by peer educators.

Keywords allergens, asthma, cockroach, epidemiology, paediatric

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Introduction

The increased severity of asthma in inner city children may be explained in part by exposures to cockroach allergens [1]. Sensitivity to cockroach allergen is common among inner city children with asthma, and asthma has been found to be more severe among children both allergic and exposed to cockroaches [2]. As much as 60% of inner city residents with asthma has been found to be allergic to cockroaches [3]. Therefore, cockroach allergen exposure is an important public health problem in urban areas.

Reducing numbers of cockroaches and exposure to allergen in infested homes is challenging. Professionally applied insecticides have rapidly reduced the number of live cockroaches [4–6]. However, even with professional cleaning, cockroach allergen persisted at levels previously associated with in-

creased asthma severity [5, 7, 8]. There has been little evaluation of educational approaches to training low income, urban families to eliminate cockroaches, and the results have not been consistent [9, 10]. However, there is some evidence from studies of house dust mite (HDM) allergen, another important and more studied indoor allergen, that exposure can be reduced, resulting in improvements in clinical parameters of asthma, especially bronchial responsiveness, and perhaps in prevention of asthma onset [1, 11–15]. Therefore, reduction in exposure to cockroach allergen might also be expected to result in clinical benefit.

In this study, we evaluated an educational intervention for cockroach control and cockroach allergen reduction directed to the primary caretaker of inner city, primarily Hispanic children. We also hypothesized that there would be larger effects of intervention in homes with heavier initial cockroach infestation, based on the results of a previous study of cockroach control by a pest control company combined with professional cleaning [8]. In that study, the intervention resulted in reduced allergen concentrations only in homes

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with higher cockroach counts at study entry. In the current study, the caretakers were identified through treatment centers for asthmatic children in Los Angeles. Caretakers were largely recent immigrants from Mexico and Central America, spoke Spanish as a first language, and had limited formal education. The successful implementation of the intervention was facilitated by peer health educators, who conducted the educational training in the homes of participants.

Methods

Population

Families were recruited through the Breathmobile, a school-based mobile asthma clinic that visits inner-city public schools in Los Angeles, or through the allergy clinic at the Los Angeles County/University of Southern California Medical Center. Eligibility criteria included at least three visits to the Breathmobile or clinic, patient age 6–14 years old, and a positive skin test to mixed cockroach allergen (American and German) or to HDM *Dermatophagoides pteronyssinus* 1 or *Dermatophagoides farinae* 1. A positive skin test was defined as a weal with a maximum diameter 3 mm or greater than the weal from a saline control. On each visit to the clinic or Breathmobile, assessment of severity at that visit was evaluated using symptom criteria corresponding to the NHLBI categories of asthma severity [16]. Eligible children must have had symptoms corresponding to persistent asthma on at least one visit to the Breathmobile or clinic. Additional eligibility criteria established in a telephone recruitment interview included the child living in the same house, condominium, apartment, or trailer for at least 4 months and a primary caretaker speaking Spanish or English. Exclusion criteria included participation in any other study related to the child's asthma during the previous year, someone smoking inside the house on a daily basis, and any other serious respiratory or cardiac illness. Of children contacted and eligible, 38% agreed to participate. After enrollment, study staff opened a sealed envelope with a random assignment immediately prior to departing for the first visit to the participant's home. We report on the results from 150 families randomly assigned either to an intervention ($N = 77$) or comparison group ($N = 73$). The study was approved by the Institutional Review Board at the University of Southern California, and informed consent was obtained from all participants.

Intervention

An educational intervention was delivered by a peer health educator to the caretaker in the child's home. The health educators were selected from among graduates of a training program in urban health education for immigrants from Latin America, which is conducted by community partners to the study, Esperanza Community Housing Corporation, Hathaway Family Services, and Planned Parenthood of Los Angeles. Further training was provided by the Allergy and Asthma Foundation of America, Southern California Chapter, and by other study investigators. Information was presented to the caretakers using a flip chart in English or

Spanish. The intervention was focused on conditions in the home, 'LA CASA' in Spanish, which is also an acronym for Los Angeles Controlling Asthma by Stopping Allergens, and which is appropriate to a loose translation into Spanish (*Los Angeles Hacia una Comunidad Activa en la Salud Ambiental*). The effect of cockroach allergen on asthmatic lungs was explained, and the life cycle described. The role of cracks and old newspapers as hiding places and of food and dampness in promoting cockroach infestations was explained. The caretaker was encouraged to become involved in helping to identify problems and solutions during a tailored home assessment. Steps that could be taken to restrict cockroach access to food and water, sealing cracks and crevices with caulking or duct tape, and the use and correct application of boric acid were discussed. The importance of cleaning to reduce allergen exposure was explained, and instructions were provided for the preparation of a dilute bleach solution, which has been shown to denature allergen [17]. The intervention was focused on areas where cockroaches were reported or observed, usually the kitchen or bathroom, but caretakers were encouraged to monitor cockroach locations with sticky traps to target their control efforts. Other recommendations included using enclosed insecticide bait traps, which limit the possibility for human exposure to insecticides, and not using aerosol insecticides that could exacerbate asthma. The health educator put an allergen impermeable casing on the pillows, mattress and (if present) box springs of the bed where the child slept. At the end of the training, the health educator and the caretaker agreed on commitments to a selected list of activities for cockroach control within the next 4 months before the second visit was to take place, e.g. house cleaning to restrict cockroach access to food, caulking, or applying boric acid.

The health educator left a bottle of boric acid, caulking materials for cracks and crevices, a booklet copy of the flip chart used in the educational session, a list of cockroach control products and prices and store locations in Los Angeles where they could be purchased, and a colouring book for the child which contained the same information the caretaker received during the educational intervention. At the conclusion of their participation in this ongoing study, all participants in the comparison group will be provided with a condensed version of the educational intervention, designed over a series of five follow-up visits also to reduce exposure to HDM, pet and mold allergen, home dampness, and second-hand smoking in the intervention group. Additional details of the educational program can be viewed at: <http://www.usc.edu/schools/medicine/lacasa>.

Assessment

Parents reported demographic information and socioeconomic characteristics (school grade completed, family income, type of health insurance) by questionnaire. Knowledge and reported behaviour was evaluated at the initial visit and during a follow-up assessment 4 months later. The caretaker was asked to agree or disagree with four statements: Cockroaches can make asthma worse (true); bait traps to kill cockroaches last longer and are cheaper than boric acid (false); cockroaches live best in dry conditions (false); and cockroaches are impossible to get rid of (false). The number

of correct responses was summed on a scale of 0–4. Caretakers were asked whether they had applied boric acid, caulking to cracks where cockroaches might hide, or used sticky monitoring traps to identify where cockroaches live in the home. An indicator of house cleaning practices was whether caretakers reported mopping the kitchen floor and emptying the garbage daily (or more frequently) in the previous week. In addition, the caretakers were asked if they had applied a spray insecticide (not recommended) or another pesticide, such as a cockroach bait trap or insecticidal gel bait, for cockroach control. The number of reported activities that had been strongly recommended to the intervention group (boric acid application, caulking, sticky traps, and cleaning) was summed on a scale of 0–4.

Observations of indicators of practices to control cockroaches were recorded by the health educator during a home assessment conducted with the caretaker. In the bedroom, the presence of an allergen cover on the child's mattress and pillow(s) was noted, as were any tears or damaged or open zippers that might compromise the allergen impermeability of the covers. In the kitchen the presence of boric acid or of sticky monitoring traps was noted. The presence of food (any crumbs or food on counters or floor, clutter or unwashed dishes, food stored in containers accessible to cockroaches, or an overflowing trash receptacle) was recorded. The number of these four indicators of exposed food was summed (for a scale of 0–4).

Caretakers were asked if they had had any problems with cockroaches in the home during the previous 8 weeks. They also were asked if they had any professional cockroach control treatments during this period. The presence of droppings, stains, or observed cockroaches were noted during the home assessment. In the kitchen one sticky monitoring trap was placed under the sink (JTE 822 Stick-A-Roach, Vernon Sanitation Supply, Vernon, CA, USA); one was placed near the trash receptacle; and one was placed in the space between the refrigerator or stove and the wall. In the bathroom one sticky trap was placed under the sink and another behind the toilet or close to the trash receptacle. The monitoring traps were placed in the same locations at each visit, and caretakers were supplied with a pre-addressed envelope to return them 1 week from the date of the visit. The total number of cockroaches on the five traps was counted and recorded.

Two dust samples were collected during each home visit, using a 9.5 A Mighty Mite Boss Plus™ vacuum cleaner, model 3674 (The Eureka Company, Bloomington, IL, USA). One composite sample was collected from the child's bedding, using a dust collection sleeve with a 1 µm exclusion limit placed over the end of the vacuum tubing and anchored with a crevice tool to filter incoming dust (Johns Hopkins University DACI Reference Laboratory, Baltimore, MD, USA). Dust was collected from the pillow (30 s), from covers, sheets, mattress pad (2.5 min), and mattress (2 min) along a surface 36 in wide down the length of the bed, or from the entire surface for a single bed, sofa, cot, or pile of blankets. (If the mattress or pillow had an allergen impermeable cover, the sample was taken from the outside of the cover.) In the kitchen, a 5 min composite sample was collected to reflect recently deposited dust from areas that are routinely cleaned, along the base of all cabinets, walls and counters, and from

the floor. Between each sample the attachments were cleaned with a wet alcohol wipe. Vacuum crevice tool attachments were cleaned between homes with soap and water. The season of sample collection was recorded as winter (November–February) or summer (the rest of the year).

Dust was stored at -20°C until shipping to the laboratory (on dry ice), and then stored at -20°C until analyzed. Samples were sieved through a 45-mesh size and weighed. Fifty milligrams of the resulting sample of dust was extracted for 1 h in 1 mL phosphate-buffered saline (pH = 7.4) containing 0.05% Tween-20 (PBS-T) while on an orbital shaker. Samples were then centrifuged (600 g, 20 min) after which an aliquot was withdrawn for analysis of allergens by monoclonal ELISA [18]. Briefly, microplates were coated overnight at 4°C with anti-Bla g 1 capture monoclonal antibody (#10A6, Indoor Biotechnology, Charlottesville, VA, USA) in 50 mM carbonate-bicarbonate buffer (pH 9.6) and then blocked with 1% bovine serum albumin in PBS-T (30 min, 22°C). The dust extract was diluted twofold from 1 : 5 to 1 : 40 in blocking buffer. A Bla g 1 standard curve was established using *B. germanica* (cockroach) extract in serial twofold dilutions from 1 to 0.002 U/mL. One hundred microliter aliquots of dilutions of samples and standards were added and incubated (60 min, 22°C). Next, 100 µL of 1 : 1000 dilution of rabbit anti-rBla g 1 antibody (Indoor Biotechnology) in blocking buffer was added and incubated (60 min, 22°C). Peroxidase-conjugated goat anti-rabbit IgG (#AL14404, Biosource, Camarillo, CA, USA) at 1 : 10 dilution in blocking buffer was added and incubated (60 min, 22°C). 100 µL of 1 mM ABTS (#A1888, Sigma, St. Louis, MO, USA) dissolved in citrate-phosphate buffer (pH 4.2) containing 1 µL/mL of 30% H_2O_2 was added. Absorbance was determined (405 nm) using a microplate reader (Molecular Devices, Sunnyvale, CA, USA). Samples with allergen below the limit of detection (LOD) were assigned a value of the $\text{LOD}/\sqrt{2}$. The effect of the intervention was evaluated both for total allergen in each sample and for the allergen concentration.

Statistical analysis

Differences between the intervention and comparison group in reported and observed outcomes at the second home visit were tested using multiple linear regression for continuous outcomes (cockroach counts and total allergen and allergen concentration) and logistic regression for categorical variables. All models were adjusted for cockroach allergy in the child, because there were differences between the intervention and comparison groups in the prevalence of cockroach allergy at study entry, as noted below. All models were adjusted for baseline levels of the outcome variable to control for any pre-existing differences on these measures. Cockroach counts and allergen levels, the continuous outcomes of interest, had a highly skewed distribution. These were log (ln) transformed to achieve approximately normal distributions appropriate for parametric analysis. (Cockroach counts were transformed after adding 0.1 to each value, because some participants had cockroach counts of zero.) Results for categorical outcomes are expressed as the odds ratio (OR) associated with the intervention. For continuous (log transformed) outcomes the intervention effect is expressed as a

percent difference from the geometric mean for the group without intervention, ie. $(e^{\beta} - 1) \times 100$, where β is the estimate from the model. Negative differences indicate proportionally fewer cockroaches (or total allergen or allergen concentration) in the intervention group at the follow-up visit than in the non-intervention group. Results were considered statistically significant if $P < 0.05$. We tested the hypothesis that having heavier initial cockroach infestations, as defined by cockroach counts greater than or equal to the median of three, would modify the effect of intervention by including interaction terms for intervention and initial cockroach counts (high or low) in the models. All analyses were conducted using the SAS software version 8.02 [19].

Results

There was minimal loss to follow-up between the first and second visits, and the attrition rates did not differ substantially between the intervention group ($n = 7$, 9%) and comparison group ($n = 4$, 5%). The average time between the first visit and the follow-up evaluation was 4.3 months ($SD = 0.81$) and this also was similar in both groups.

The caretakers and children in the intervention and comparison group had similar demographic and other characteristics at study entry (Table 1). The caretakers were Spanish speaking and poor. Half of all children had a history of being hospitalized for asthma, indicating relatively severe disease. Of note is the higher prevalence of cockroach allergy in the intervention group (61%), compared with the comparison group (40%; $P = 0.01$), in spite of the random assignment of participants. Approximately half of children in both groups lived in single family homes.

At the follow-up evaluation caretakers in the intervention group were significantly more likely than those in the comparison group correctly to disagree that bait traps are cheaper and last longer than boric acid (the recommended pesticide for cockroach control in this intervention), after controlling for the response at the first visit (Table 2). The sum of correct responses to four questions assessing knowledge was greater by 0.25 (95% confidence interval (CI) -0.05 , 0.55 ; $P = 0.10$), on average, for the intervention group (not tabulated). Caretakers in the intervention group were significantly more likely to report applying boric acid, caulking and sticky trap monitors in the previous 4 months. The intervention group also was significantly more likely to report activities comprising the composite sum of the first four reported practices in Table 2, which were the primary recommendations to this group (average increase 0.67 ; 95% CI 0.35 , 0.99 ; $P = 0.01$; not tabulated). This group was less likely to have used sprays for cockroaches (which we advised against; $P = 0.39$). Allergen encasement of the child's mattress and pillow(s) and boric acid in areas frequented by cockroaches were more likely to be observed in the intervention homes. The sum of the four observed exposed food items was less in the intervention group by -0.33 , on average (95% CI -0.73 , 0.08 ; $P = 0.11$), than in the comparison group (not tabulated). Most homes (75%) had some evidence of cockroaches, either reported, observed, or present on traps. Baseline cockroach counts, which required the participants to

Table 1. Distribution of demographic and other baseline characteristics by intervention group

	Intervention		
	Yes, N (%)	No, N (%)	Total, N (%)
<i>Caretaker</i>			
Sex ($\chi^2 = 0.15$; $P = 0.70^*$)			
Male	5 (7)	6 (8)	11 (7)
Female	70 (93)	66 (92)	136 (93)
Ethnicity ($\chi^2 = 0.16$; $P = 0.69^*$)			
Hispanic	72 (94)	67 (92)	139 (93)
Other	5 (6)	6 (8)	11 (7)
Preferred language ($\chi^2 = 1.37$; $P = 0.51^*$)			
English	6 (8)	8 (11)	14 (9)
Spanish	70 (91)	65 (89)	135 (90)
Other	1 (1)	0 (0)	1 (1)
School grade completed ($\chi^2 = 0.88$; $P = 0.64^*$)			
≤ 6th	29 (39)	25 (35)	54 (37)
7th–11th	27 (36)	23 (32)	50 (34)
≥ 12th	19 (25)	23 (32)	42 (29)
Family income ($\chi^2 = 0.06$; $P = 0.97^*$)			
< \$15 000	19 (40)	18 (38)	37 (39)
\$15 000–\$24 999	15 (31)	16 (33)	31 (32)
≥ \$25 000	14 (29)	14 (29)	28 (29)
<i>Child</i>			
Sex ($\chi^2 = 0.01$; $P = 0.91^*$)			
Male	51 (66)	49 (67)	100 (67)
Female	26 (34)	24 (33)	50 (33)
Insurance ($\chi^2 = 2.1$; $P = 0.36^*$)			
Public	48 (63)	54 (74)	102 (68)
Private	5 (7)	3 (4)	8 (5)
Other	23 (30)	16 (22)	39 (26)
Cockroach allergic ($\chi^2 = 6.34$; $P = 0.01^*$)			
No	29 (39)	39 (60)	65 (46)
Yes	46 (61)	26 (40)	75 (54)
Hospitalized ($\chi^2 = 1.31$; $P = 0.25^*$)			
No	35 (45)	40 (55)	75 (50)
Yes	42 (55)	33 (45)	75 (50)
<i>Home</i>			
Home type ($\chi^2 = 2.22$; $P = 0.53^*$)			
Single family detached	37 (48)	39 (53)	76 (51)
Attached to other home	11 (14)	9 (12)	20 (13)
Multi-family unit	27 (35)	25 (34)	52 (35)
Trailer	2 (2.6)	0 (0)	2 (1)

* P value for χ^2 .

return the sticky monitoring traps left by the peer educators, were returned by all but one of the participants still in the study at the second visit, and second visit cockroach counts were returned by all but nine of these participants. There was little difference at the follow-up visit in the proportion of homes with any cockroaches trapped, although there was a modest (but not significant) decrease (from 72% to 57%) in the proportion of homes with cockroaches in the intervention group. However, in the intervention group the geometric mean cockroach count at the follow-up visit was 60% less than in the non-intervention group, a difference that was statistically significant. In the intervention group, the cockroach count in the homes in the upper quartile of the

Table 2. Effect of intervention on cockroach knowledge correct responses at follow-up, reported and observed practice, and cockroaches

	Visit 1		Visit 2		OR† (95% CI)
	Intervention		Intervention		
	No, <i>N</i> * (%)	Yes, <i>N</i> * (%)	No, <i>N</i> * (%)	Yes, <i>N</i> * (%)	
Knowledge					
Bait traps last longer	11 (15)	9 (12)	11 (16)	25 (36)	2.8 (1.2, 6.8)§
Make asthma worse	59 (81)	61 (79)	61 (88)	67 (96)	3.2 (0.77,13)
Live best in dry	12 (16)	16 (21)	16 (23)	20 (29)	1.5 (0.64, 3.5)
Impossible to get rid	40 (55)	40 (52)	46 (67)	40 (57)	0.56 (0.24, 1.3)
Reported practice					
Boric acid	7 (9.6)	8 (10)	8 (12)	36 (51)	13 (4.3, 41)¶
Applied caulking	12 (16)	15 (19)	10 (14)	25 (36)	2.9 (1.2, 6.9)§
Sticky traps	13 (18)	10 (13)	9 (13)	18 (26)	3.1 (1.1, 9.2)§
House cleaning	44 (65)	57 (75)	46 (67)	48 (70)	0.96 (0.38, 2.4)
Other spraying	18 (25)	25 (32)	16 (23)	13 (19)	0.64 (0.23, 1.8)
Other pesticide	25 (34)	40 (52)	24 (35)	34 (49)	1.3 (0.57, 3.0)
Observed practice					
Mattress/pillow cover	3 (4.1)	3 (3.9)	3 (4.4)	49 (71)	67 (15, 302)¶
Boric acid	8 (11)	7 (9.0)	8 (12)	28 (40)	8.3 (2.7, 26)¶
Bait traps	15 (21)	27 (36)	9 (13)	23 (33)	2.5 (0.99, 6.1)‡
Sticky traps	6 (8.2)	4 (5.2)	7 (10)	11 (16)	1.7 (0.58, 4.9)
Unsealed food	58 (79)	66 (86)	57 (84)	57 (83)	0.80 (0.29, 2.2)
Food on counters	44 (60)	48 (62)	46 (68)	40 (58)	0.65 (0.30, 1.4)
Unwashed dishes	56 (76)	48 (62)	52 (75)	43 (61)	0.54 (0.24, 1.2)
Trash overflow	17 (23)	27 (35)	27 (39)	21 (30)	0.66 (0.31, 1.4)
Cockroaches					
Present on traps	42 (60)	55 (72)	38 (59)	37 (57)	0.46 (0.18, 1.2)
Problem reported	29 (40)	31 (40)	36 (52)	29 (42)	0.50 (0.21, 1.2)
Evidence observed	35 (48)	43 (56)	36 (52)	36 (51)	0.91 (0.40, 2.0)
	GM (SE)	GM (SE)	GM (SE)	GM (SE)	Diff** (%) (95% CI)
Number trapped	2.0 (1.4)	3.2 (1.4)	1.9 (1.4)	1.3 (1.4)	− 60 (− 14, − 81)§

*Number (percent) answering correctly. †OR, odds ratio (95% confidence interval (CI)), adjusted for outcome at first visit and for cockroach allergy.

‡0.05 < *P* < 0.10; §*P* < 0.05; ¶*P* < 0.01 ||GM, geometric mean; SE, geometric standard error, based on unadjusted results. **Diff, Second visit intervention group geometric mean cockroach count percent difference from the mean in the non-intervention group (95% confidence interval), adjusted for outcome at first visit and for cockroach allergy.

distribution decreased from 33 to 8, compared with an increase from 23 to 29 in the non-intervention group (results not tabulated). Thus, the decrease in the average count in the intervention group was accounted for by those homes with heavier initial cockroach infestations. Of note was that at study entry the intervention group was more likely to report the use of pesticides not sprayed (52% compared with 34% in the non-intervention group; *P* = 0.04) and to have more bait traps observed (36% compared with 21%; *P* = 0.04). However, adjusting for a baseline report of other pesticide use did not substantially change the overall pattern of estimated effects of the intervention, although the intervention effect on the reported use of sticky traps became slightly weaker (OR 2.6, 95% CI 0.87, 7.7; *P* = 0.09).

In bedding, the concentration of cockroach allergen was below 2 U/g in most samples. Nevertheless, the follow-up visit total geometric mean allergen collected from bedding was 64% lower in the intervention group (Table 3). There was little overall intervention effect on other indices of allergen exposure. However, the effect of the intervention on kitchen total allergen and concentration was greater in homes with higher initial cockroach counts than in homes with fewer cockroaches (*P*-value for interaction 0.04 for allergen concentration and 0.01 for total allergen; Table 4). In

stratified analyses, among those with higher initial cockroach counts, there was a 65% lower geometric mean total kitchen allergen and 60% lower kitchen allergen concentration (both marginally significant; *P* = 0.05) in the intervention group.

We adjusted for the child's cockroach allergy in all analyses, because it was associated with the intervention, as noted above. In addition, there were more cockroaches counted at study entry in the homes of children who were allergic (geometric mean 4.5; geometric SE 1.4) than in the homes of children who were not allergic (geometric mean 1.5; geometric SE 1.4), and these differences were significant (*t* = 2.52; *P* = 0.01). In additional sensitivity analyses, we examined the potential confounding effect of season on the intervention. More evaluations were conducted in the summer (60% of first home visits, 77% of second visits), but these were approximately equally distributed between intervention and control groups (60% and 61% of first visits, and 74% and 80% of second visits). The pattern of effects of the intervention (in Tables 3, 4, and on the number of cockroaches trapped) was not changed by adjustment for season of measurement. We also adjusted for the effect of a report of professional cockroach control in the home at study entry, which was rare (10 (13%) in the intervention group and seven (10%) in the comparison group), and there was

Table 3. Effect of intervention on cockroach allergen Bla g 1 load and concentration

Allergen	Visit 1		Visit 2		Diff†(%) (95% CI)
	Intervention		Intervention		
	No	Yes	No	Yes	
	GM* (SE)	GM* (SE)	GM* (SE)	GM* (SE)	
Kitchen (U)	1.7 (1.5)	2.6 (1.4)	1.0 (1.5)	1.1 (1.5)	16 (– 53, 184)
Kitchen (U/g)	19 (1.5)	28 (1.4)	14 (1.3)	13 (1.4)	– 1 (– 58, 64)
Bedding (U)	0.22 (1.3)	0.25 (1.3)	0.21 (1.3)	0.10 (1.4)	– 64 (– 85, – 12)§
Bedding (U/g)	0.63 (1.3)	0.53 (1.3)	0.41 (1.3)	0.43 (1.3)	1 (– 49, 97)

*GM, geometric mean; SE, geometric standard error (based on unadjusted results). †Diff is second visit intervention group geometric mean allergen concentration as a percent difference from the mean in the non-intervention group (95% confidence interval), adjusted for outcome at first visit and roach allergy. § $P < 0.05$.

Table 4. Effect of intervention on cockroach allergen Bla g 1 load and concentration in homes with high and low initial cockroach counts

Allergen	Visit 1		Visit 2		Intervention Effect Diff† (%) (95% CI)
	Intervention		Intervention		
	No	Yes	No	Yes	
	GM* (SE)	GM* (SE)	GM* (SE)	GM* (SE)	
High initial cockroach count					
Kitchen (U)	7.3 (1.6)	17 (1.5)	5.8 (1.5)	3.4 (1.6)	− 65 (− 88, 0)‡
Kitchen (U/g)	89 (1.6)	134 (1.4)	71 (1.5)	40 (1.5)	− 60 (− 84, 0)‡
Bedding (U)	0.47 (1.6)	0.45 (1.5)	0.51 (1.5)	0.17 (1.5)	− 69 (− 89, 11)§
Bedding (U/g)	1.3 (1.5)	0.98 (1.5)	0.96 (1.5)	0.83 (1.4)	− 1 (− 62, 154)
Low initial cockroach count					
Kitchen (U)	0.57 (1.6)	0.35 (1.6)	0.16 (1.8)	0.36 (1.7)	303 (− 1, 1541)‡
Kitchen (U/g)	5.7 (1.6)	5.3 (1.7)	2.8 (1.6)	4.5 (1.7)	112 (− 36, 607)
Bedding (U)	0.10 (1.3)	0.13 (1.3)	0.09 (1.4)	0.06 (1.6)	− 55 (− 87, 51)
Bedding (U/g)	0.31 (1.3)	0.27 (1.3)	0.19 (1.3)	0.23 (1.4)	3 (− 60, 164)

*GM, geometric mean; SE, geometric standard error (based on unadjusted results). †Diff is second visit intervention group geometric mean allergen concentration as a percent difference from the geometric mean for non-intervention group (95% confidence interval), adjusted for outcome at first visit and cockroach allergy. ‡ $0.05 \leq P < 0.10$; § $P < 0.05$.

minimal or no change in the effect of the intervention on these outcomes, and the pattern of statistical significance was identical.

Discussion

In this study an educational approach using peer health educators resulted in the implementation of measures to control cockroaches and reduced cockroach counts. The low total allergen collected from bedding at study entry was further reduced in the intervention group. This reduction in allergen likely occurred because the use of impermeable mattress covers and pillow cases, which increased from 4% to 71% in the intervention group (Table 2), reduced the amount of dust available for sampling. However, this reduction in allergen in bedding is of plausible biological and clinical relevance, because allergen in bedroom dust has been shown to be a better indicator of sensitization to cockroach allergen than allergen concentration in the kitchen [20]. In addition, based on a previous study [8], we hypothesized that

intervention effects would be larger in homes with higher initial cockroach counts. The larger observed effect of the intervention on total kitchen allergen and allergen concentration in homes with heavier initial infestations is consistent with this hypothesis. In addition, in stratified analyses there were reductions both in total kitchen allergen and allergen concentration in these homes that were similar in magnitude to the observed effect in bedding.

The educational approach might make this intervention more sustainable over a prolonged period than professional cockroach extermination and cleaning. Nevertheless, allergen concentration in kitchen dust in our study remained high in the intervention group, in which the median exceeded 8 U/g, a level above which more severe asthma has been observed among children allergic to cockroaches [2]. Large and sustained reductions in kitchen allergen exposure are likely to occur only if caretakers can change behaviour sufficiently to be able to eradicate cockroaches (an outcome for which there were no significant differences between groups). Although there were clear benefits of the intervention on behaviour, there was considerable opportunity for continued improvement in almost all recommended measures for

cockroach control. As the intervention is ongoing, it remains to be seen whether additional reductions in cockroach counts and allergen will occur or whether it will be reflected in improved health outcomes to be assessed in later home visits.

A recent study of 937 inner city children demonstrated reductions in bedding and bedroom floor cockroach allergen in a group receiving a comprehensive 1-year educational intervention designed to control exposure to multiple allergens [9]. When cockroach allergen was measured in the homes of children allergic to cockroach, the intervention was supplemented with commercial cockroach eradication. The effects on allergen were sustained throughout a second year, and reduced morbidity was associated with reductions in allergen. However, the results of other studies of educational approaches to cockroach control in inner city homes have been relatively disappointing. A study in Seattle found changes in behaviour and reductions in numbers of cockroaches and in dust mite allergen, but not in cockroach allergen, in a group receiving a comprehensive educational intervention [21]. In this study statistical power was limited because allergen was measured in only a sample of homes. In another well-designed study in the homes of children with asthma in Atlanta, an educational intervention providing instruction in cockroach control, insecticide bait containers, and allergen impermeable mattresses found no change in cockroach allergen concentration after a 12 month follow-up [10]. Total allergen was not evaluated, and the primary outcome of interest was the proportion of homes in which the highest allergen concentration measured was reduced by 70%. Therefore, differences in sampling and analytic strategy (and a smaller sample size) may explain the difference in results. It is possible that because of language and cultural barriers, many LA CASA study participants had limited understanding of the relationship between allergen exposure and asthma at study entry or of methods for allergen control. Some had little prior positive experience with social service agencies. Thus, we speculate that the participant population and a favourable experience with the peer health educators may have enhanced the effect of the intervention relative to the comparison group. Although these questions cannot be addressed with the available data, the different conclusions from different studies suggest that caution is warranted in generalizing the results to populations unlike those under study.

Another approach to cockroach allergen reduction is professional treatment and/or cleaning. A recent study employing an educational approach in combination with professional cockroach extermination using low toxicity pesticides demonstrated a large reduction in the proportion of inner city apartments with cockroaches at modest cost [22]. Unfortunately, allergen was not measured in this study. Another recent study demonstrated large decreases both in cockroach counts and in allergen concentration in inner city apartment units treated and aggressively cleaned professionally [5], an effect which was sustained with intermittent treatment alone [23]. Cockroaches were eradicated in a majority of homes. However, this approach was expensive. We observed only modest reductions in allergen concentration in another study with professional insecticide application and cleaning, but the short follow-up period may have been insufficient to observe reductions [8]. Most other previous

studies have had small sample sizes or have not had appropriate comparison groups [4, 7, 24].

Because group assignment occurred after enrollment, at the time of the initial home visit, there was no possibility for bias in the assignment. It was not possible to blind the participants to their intervention status, a generic limitation to educational interventions of this type. The assessment of knowledge, reported and observed practice was conducted by the health educators, because it would have been burdensome to the participants to have had a separate evaluation team making a separate home visit. However, the assessment was conducted using standard questionnaires and observational checklists with little opportunity for discretionary characterization of participant responses or the home observation by the evaluation team, and the health educators were trained to follow the instructions for these evaluations exactly. In addition, effects were observed on cockroach count, total allergen collected, and allergen concentration, objective measurements of outcome unlikely to be influenced by bias either by subjects or observers. Therefore, neither over-reporting by participants in the intervention group, nor observer bias by the evaluation team, is likely to have accounted for the observed effects. Because there was minimal loss to follow-up, this also was an unlikely explanation for the observed results.

Our results suggest that reduction in the number of cockroaches and in overall total allergen collected from the bedding of asthmatic children of immigrant Latinos can be achieved through a single educational intervention in the home by peer health educators. Although it is likely that there is a dose-response relationship between cockroach allergen exposure and asthma exacerbation [25], it is not yet known whether these modest reductions in allergen have health benefits.

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