

Cockroach allergen exposure and sensitization in suburban middle-class children with asthma

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Background: Exposure to cockroach allergen is prevalent in inner-city homes and is associated with an increased risk of cockroach sensitization.

Objective: We sought to determine the prevalence of cockroach allergen exposure in suburban middle-class homes and to study its relationship to cockroach sensitization.

Methods: Children with asthma, 6 to 17 years of age, were recruited from 3 pediatric practices located in counties surrounding Baltimore city and from 1 practice located within Baltimore city limits. Participants underwent skin prick testing and completed baseline questionnaires. In addition, their homes were inspected, and settled dust samples were collected for allergen analysis.

Results: Forty-one percent of the total study population (n = 339) had kitchen Bla g 1 levels of greater than 1 U/g. Forty-nine percent were white, 53% had annual incomes of greater than \$50,000, and 48% of mothers had college degrees. Seventy-seven percent of the study population resided in a suburban or rural location, and 30% of kitchens in these homes had Bla g 1 levels of greater than 1 U/g. Among the suburban-rural subgroup, 21% were sensitized to cockroach compared with 35% of the city group. In multivariate analysis, exposure to kitchen Bla g 1 levels of greater than 1 U/g was associated with cockroach sensitization for both the total study population (odds ratio, 2.29; 95% CI, 1.28-4.11) and the suburban-rural subgroup (odds ratio, 2.37; 95% CI, 1.23-4.57).

Conclusions: Cockroach allergen exposure might be more common in suburban middle-class homes of asthmatic children than previously thought. Moreover, the data suggest that low-level cockroach exposure is a risk factor for cockroach sensitization. (*J Allergy Clin Immunol* 2003;112:87-92.)

Key words: *Cockroach allergen, childhood asthma, cockroach sensitization, allergen exposure*

Cockroach allergen is prevalent in the inner city, and allergic sensitization to cockroach has been shown to be related to exposure in this setting. Among participants in the National Cooperative Inner-City Asthma Study (NCI-

Abbreviations used

NCICAS: National Cooperative Inner-City Asthma Study

OR: Odds ratio

SES: Socioeconomic status

CAS), 35.8% were sensitized to cockroach. For those with dust samples available for allergen analysis, 94% had detectable Bla g 1 levels in the kitchen, and the median level in the kitchen was 80 U/g.¹ In other studies risk factors for the presence of cockroach allergen in the home have included low income, less education, African American and Hispanic race, and type of dwelling.² There is also evidence to suggest that cockroach sensitization is related to exposure in a dose-dependent manner. Among children in the NCICAS, increasing exposure to Bla g 1 was associated with an increasing prevalence of cockroach sensitization.¹

There are only a few studies examining the prevalence of cockroach allergen outside of the inner city. In one study of homes in Wilmington, Delaware, only 16% of homes with measurable Bla g 2 levels were in suburban areas.³ These findings suggest that cockroach allergen might be present in a small number of suburban homes, but it is unclear whether these were primarily middle-class homes or whether the presence of cockroach allergen could be accounted for by low socioeconomic status (SES). In the Boston metropolitan area only 3% of homes outside of low-poverty areas had greater than 2 U/g cockroach allergen.² The Childhood Asthma Management Program study, which included children from 8 North American cities, found an overall prevalence of cockroach allergen exposure of 9.4%, with an overall sensitization prevalence of 34%, although no details about the domestic setting and SES of the study participants were reported.⁴ None of these studies reported the relationship between cockroach allergen exposure and sensitization for those exposed to cockroach allergen in suburban homes.

There are similarly few studies reporting the prevalence of cockroach sensitization among suburban middle-class children. One study of middle-school children in Charlottesville, Virginia, reported that 33% of atopic children in the city were cockroach sensitized, whereas only 14% of atopic children in the county were cockroach sensitized. No information about the SES of these children was reported.⁵ A survey in Kentucky found that 43% of patients from small rural towns were sensitized,

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but criteria for sensitization included responses to intradermal skin testing.⁶

Although poverty and inner-city residence are established risk factors for home cockroach allergen exposure, the prevalence of cockroach allergen exposure and its relationship to sensitization in middle-class suburban settings remain largely unknown. We therefore studied home cockroach allergen exposure and its relationship to sensitization in a cross-sectional study of suburban school-age children with asthma.

METHODS

Study population

Participants were recruited for a randomized controlled trial of environmental allergen control from 3 pediatric practices in the counties surrounding Baltimore and 1 practice located within Baltimore city limits. Children between the ages of 6 and 17 years who had physician-diagnosed asthma were contacted, and if the family was interested in participating, a screening questionnaire was administered to determine eligibility. Participants were eligible if they had currently active asthma, defined as at least one symptomatic day in the previous week, and families were willing to have home visits for dust collection. Those children who completed the baseline evaluation and had skin prick testing and home dust samples adequate for allergen analysis were included in this study. The Johns Hopkins University Joint Commission on Clinical Investigation approved the study, and all parents and children provided informed consent.

Skin testing

Skin tests to cat, dog, *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae*, mouse, German cockroach, ragweed, grass, oak, maple, *Alternaria* species, *Penicillium* species, *Aspergillus* species, and *Helminthosporium* species were performed by using full-strength glycerinated extracts with the MultiTest device (Decatur, Ill). The skin test panel was considered valid if the difference between the positive control and negative control was greater than 1 mm, and a particular skin test's result was considered positive if the orthogonal wheal diameter was at least 3 mm greater than that produced by the negative control and at least one half of that produced by the histamine control.

Questionnaire

As part of the baseline evaluation, parents completed a questionnaire that included sociodemographic information, such as maternal education, family income and race, and details about the home environment. The questionnaire was adapted from one used in the Childhood Asthma Management Program study.⁷

Environmental assessment

An environmental technician conducted a home inspection as a part of the baseline evaluation, using a home evaluation checklist to collect data regarding structural aspects of the home and the location of the home (city, suburban, or rural). The home evaluation checklist was originally developed and tested in the NCICAS.⁸ A dust sample was also collected during this visit.

Dust sample collection, extraction, and ELISAs

Baseline dust samples were collected by trained research technicians using a handheld vacuum (Oreck, New Orleans, La) and collection sleeve according to published methods.⁹ Samples were collected from the bed and adjacent floor, television room furniture and

the adjacent floor, and the kitchen floor. After sieving, samples were extracted in borate-buffered saline with 5% BSA, and extracts were analyzed for Bla g 1, Fel d 1, Der p 1, Der f 1, and Can f 1 by using 2-site monoclonal-based ELISAs.^{9,10}

Statistical analysis

All analyses were performed with SPSS 11.0 software (Chicago, Ill). This study population included 339 of the participants who completed the baseline evaluation, had valid skin test results, and had adequate settled dust samples for allergen analysis. Analyses were performed on the total study population and on subgroups of home location. Because 71% of participants resided in the suburbs and only 6% resided in rural areas and because the characteristics of these 2 groups were similar, the suburban and rural participants were combined into one group. The sociodemographic profiles of the city and suburban-rural subgroups were compared by using χ^2 analysis or the Fisher exact test. Mean age was compared between groups by using the Student *t* test. Associations between Bla g 1 exposure and cockroach sensitization were analyzed by using the χ^2 test, and the analysis was stratified by home location to determine whether there were any differences in the relationship between city and suburban-urban homes. A test for trend was used to determine whether cockroach sensitization was dose dependent. The association between kitchen Bla g 1 exposure and cockroach sensitization was modeled by using multivariate logistic regression to control for the potential confounders of age, sex, race, maternal education, and type of home. Income was excluded from the model because it was closely associated with maternal education.

RESULTS

Three hundred thirty-nine study participants had valid skin test results and completed the baseline questionnaire and home evaluation (Table I). Forty-nine percent of the study population was white, and 53% had an annual income of greater than \$50,000. Income data were missing for 49 of the participants, who declined to provide that information. Forty-eight percent of mothers had college degrees. The mean patient age was 10.4 years, and 44% were male. Seventy-one percent of participants resided in a suburban location, and 6% resided in a rural location. Because the rural subgroup comprised a small minority of homes and their characteristics did not differ markedly from those of the suburban subgroup, the 2 groups were combined for the analysis. An analysis of zip codes of the suburban-rural group confirmed that 93% of this group lived in Anne Arundel, Carroll, Howard, Montgomery, Prince George's, or Baltimore counties. The remainder of the group resided in zip codes that straddled the Baltimore city line.

Indoor allergen exposure was prevalent for all indoor allergens assessed (Table II). Levels of Can f 1, Fel d 1, and mite allergen (Der f 1 plus Der p 1) of greater than 2000 ng/g were detected in 44%, 38%, and 40% of homes, respectively. Forty-one percent of kitchens had Bla g 1 levels of greater than 1 U/g. Although Bla g 1 was commonly found in the kitchens of these homes, only 18% had evidence of cockroach infestation on home inspection. Among city homes with kitchen cockroach allergen levels of greater than 1 U/g, 27 (34%) had evidence of infestation, whereas only 13 (5%) of suburban-rural homes with kitchen cockroach allergen had evidence of infestation.

TABLE I. Sociodemographic characteristics

Race (336)	African American, n (%)	128 (38)
	White	165 (49)
	Other	43 (13)
Annual income (339)	<15,000, n (%)	32 (9)
	15-29,999	33 (10)
	30-49,999	41 (12)
	50-74,999	57 (17)
	≥75,000	123 (36)
Maternal education (334)	Refused-missing	53 (16)
	Some high school, n (%)	19 (6)
	High school degree	58 (17)
	Some college	98 (29)
	College graduate	99 (30)
Sex (339)	Postgraduate	60 (18)
	Male, n (%)	150 (44)
Age (339)	Age, y (mean ± SD)	10.4 ± 3.1
Home characteristics (339)	City, n (%)	79 (23)
	Suburban-rural	260 (77)
	Detached home	177 (52)

Allergic sensitization to environmental allergens was also very common (Table III). Seventy percent of the study population was sensitized to dust mite, 76% to at least one outdoor allergen, 29% to cat, and 24% to cockroach. Sensitization to dog was less common, with a prevalence of 10%. The city and suburban-rural subgroups had similar rates of sensitization for all allergens except cockroach, with 35% of city dwellers and 21% of suburban-rural dwellers being sensitized to cockroach ($P < .05$).

Sociodemographic factors in city homes that conferred a decreased risk of exposure to a kitchen Bla g 1 level of greater than 1 U/g were an income of greater than \$50,000 per year and having a mother with a college degree (odds ratios [ORs] of 0.26 and 0.19, respectively; Table IV). African American race was only marginally associated with kitchen cockroach allergen exposure ($P = .05$) in this bivariate analysis. Those with kitchen Bla g 1 levels of greater than 1 U/g were older than those with kitchen Bla g 1 levels of less than 1 U/g (mean age, 11.2 vs 9.6 years; $P < .05$). Detached home and male sex were not significantly associated with the presence of cockroach allergen in city kitchens. Factors that conferred a decreased risk of exposure to a kitchen Bla g 1 level of greater than 1 U/g for the suburban-rural group were having a mother with a college degree and living in a detached home (ORs of 0.53 and 0.45, respectively). There was no significant difference in the mean age of those with kitchen Bla g 1 levels of greater than 1 U/g and those with levels of less than 1 U/g in the suburban-rural group (10.3 vs 10.3 years).

A kitchen Bla g 1 level of greater than 1 U/g was associated with cockroach sensitization for the total study population and the suburban-rural subgroup (Table V). In the total study population, 36% of those with kitchen cockroach allergen of greater than 1 U/g were cockroach sensitized, whereas only 17% of those with a level of less than 1 U/g were sensitized ($P < .0001$). This association was also found in the suburban-rural subgroup, with 32% in the exposed group being sensitized compared with 16% in the unexposed group ($P = .004$). A kitchen Bla g 1 level of greater than 2 U/g was also significantly asso-

TABLE II. Indoor allergen distributions

Allergen	Room	Median	5%, 95%
Bla g 1 (U/g)	Bedroom	BD	BD, 11.1
	Kitchen	BD	BD, 245
	Television room	BD	BD, 13.6
Can f 1 (μg/g)	Bedroom	0.89	BD, 200
	Kitchen	0.22	BD, 114
	Television room	1.55	BD, 418
Fel d 1 (μg/g)	Bedroom	0.51	0.03, 363
	Kitchen	0.11	BD, 68.0
	Television room	0.81	BD, 374
Dust mite (mg/g)	Bedroom	379	BD, 20.6
	Kitchen	BD	BD, 1.84
	Television room	1.00	BD, 30.6

BD, Below detection; dust mite, Der f 1 plus Der p 1.

ciated with sensitization for the total study population and suburban-rural subgroups. The association for the city group did not meet statistical significance ($P = .08$). A Bla g 1 level of greater than 8 U/g was also significantly associated with sensitization for the total study population ($P = .001$), as well as for the city and suburban-rural subgroups ($P = .05$ for both).

To determine whether sensitization was dose dependent, we examined rates of sensitization among 5 exposure groups for the total population and the suburban-rural subgroup (Fig 1). For the total population, 17% of those with undetectable Bla g 1 levels were cockroach sensitized. Those exposed to 1 to 1.99, 2.0 to 3.99, 4.0 to 7.99, and 8 U/g or greater had increasing sensitization rates of 23%, 31%, 37%, and 39%, respectively ($P < .001$). The pattern of sensitization was similar among the suburban-rural subgroup. Sixteen percent of those with undetectable kitchen Bla g 1 levels were cockroach sensitized, and those exposed to 1 to 1.99, 2.0 to 3.99, 4.0 to 7.99, and 8 U/g or greater had sensitization rates of 27%, 29%, 31%, and 34%, respectively ($P < .001$).

After adjusting for race, sex, age, maternal education, and type of home, a kitchen Bla g 1 level of greater than 1 U/g was still significantly associated with cockroach sensitization (OR, 2.29; 95% CI, 1.28-4.11; Table VI). Age was also significantly associated with cockroach sensitization (OR, 1.19; 95% CI, 1.09-1.30). When the multivariate model was applied to the suburban-rural subgroup, kitchen cockroach allergen remained a significant predictor of sensitization (OR, 2.37; 95% CI, 1.23-4.57). Age was also significantly associated with sensitization in this subgroup (OR, 1.16; 95% CI, 1.04-1.28), whereas living in a detached home was protective (OR, 0.45; 95% CI, 0.22-0.92). In the city subgroup the only risk factors that were significantly associated with sensitization in the multivariate model were male sex (OR, 8.12; 95% CI, 2.06-32.08) and age (OR, 1.46; 95% CI, 1.16-1.84). Kitchen Bla g 1 levels were not significantly associated with cockroach sensitization in the city subgroup.

DISCUSSION

We have found a surprisingly high prevalence of cockroach allergen exposure and sensitization in a predomi-

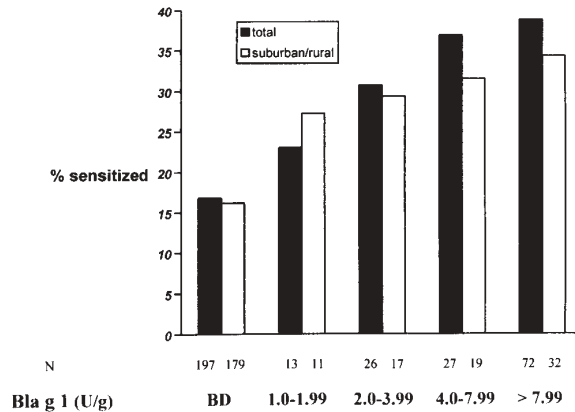


FIG 1. Dose-response relationship between kitchen Bla g 1 levels and cockroach sensitization. Bars represent the percentage with cockroach sensitization within each exposure category. The total number of subjects in each exposure group is listed under the corresponding column. $P < .001$ for trend for both the total and suburban-rural groups.

nantly suburban middle-class population. Previously published studies suggested that the prevalence of cockroach allergen in suburban middle-class homes was well below the 41% that we found in our population.²⁻⁴ Further analysis of our data revealed that almost half of the mothers of our participants held college degrees and that over 50% of families had annual incomes of greater than \$50,000. Because 23% of the study population resided in the city, we analyzed both the total study population and the subgroups that resided in a city or suburban-rural location. The suburban-rural subgroup was wealthier and better educated than the total study population as a whole, and yet 30% of the homes had detectable cockroach allergen. The distribution of other indoor allergens was consistent with previously published reports.^{4,11} Dust mite, cat, and dog allergens were found in approximately 40% of homes. Although cockroach allergen was more prevalent in city homes, the fact that it was found in almost a third of the suburban-rural homes suggests that cockroach allergen exposure is not limited to poor inner-city residents and might be a significant problem for some middle-class suburban families.

Although Bla g 1 was common in the suburban-rural homes, only 5% of these homes had evidence of cockroach infestation. It is unclear why cockroach allergen was found in so many homes that did not have evidence of infestation. Cockroach infestation could be occult. Although this is not likely in homes with high levels of allergen, where live or dead cockroaches or cockroach stains are usually easily detected on home inspection, it might well occur with lower levels of exposure. Other possible explanations include previous cockroach infestation or tracking of the allergen into homes from other sites. Cockroach allergen is difficult to remove, and thus previous infestation might result in residual allergen that could persist for years.^{12,13} Tracking of cockroach allergen might also occur, and this phenomenon has been shown to occur with cat and dog allergens.^{14,15} Although cat and

dog allergens are typically airborne, it is still plausible that an allergen carried on heavier particles could be tracked from place to place on shoes, clothing, or both. Additional study will be needed to determine whether the source of cockroach allergen in these homes is due to occult infestation, prior infestation, allergen tracking, or some combination of all 3 possibilities. Because of the significant public health implications, it will be an important next step to determine the source or sources of the cockroach allergen.

Because cockroaches spread from home to home through common walls and housing type has been associated with the presence of cockroach allergen,^{11,16} we also examined the association of housing type with the presence of cockroach allergen. Although detached homes were underrepresented among the suburban-rural homes with cockroach allergen, they still comprised over half of the homes with detectable allergen. Further support that cockroach allergen is common in detached homes came from the city subgroup, in which homes with cockroach allergen were actually more likely to be detached than nondetached. The explanation for this latter finding remains unclear because the number of city homes with cockroach allergen was too small to draw any conclusions about possible confounding variables.

Cockroach sensitization was also surprisingly common, with positive skin test responses in 35% of the total study population and 21% of the suburban-rural subgroup. One previous study found a cockroach sensitization rate of 14% for middle-school atopic children living in Albemarle County, Virginia.⁵ This study, however, did not provide other indicators of SES, such as income and education. On the other hand, Wilson et al¹⁷ evaluated a rural population of children and found that 26% were sensitized to cockroach, and only 55% of those sensitized to cockroach had Medicaid or no medical insurance.

Because there have been several reports of cross-reactivity of cockroach and dust mite,¹⁸⁻²⁰ we explored this as a possible explanation for the significant percentage of cockroach-sensitized participants in this study. In fact, cockroach sensitization was not associated with dust mite exposure. In addition, cockroach sensitization was not associated with dust mite sensitization to any greater degree than was sensitization to other indoor allergens. Although sensitization was more common among city residents in our study, the finding that 21% of the suburban-rural subgroup was sensitized to cockroach underscores the potential importance of this allergen in middle-class suburban children.

We also found significant relationships between cockroach allergen exposure and sensitization. For the total study population and the suburban-rural subgroup, a kitchen Bla g 1 level of greater than 1 U/g was significantly associated with cockroach sensitization. The same association was not found for the city group and is most likely a result of the small sample size within that group, diminishing the power to detect a significant difference. When the dose-response relationship between exposure and sensitization was examined, we found statistically significant trends for both the total

TABLE III. Prevalence of specific sensitizations

Allergen	Total population, n (%), n = 339	City, n (%), n = 79	Suburban-rural, n (%), n = 260
Cockroach	83 (24)	28 (35)*	55 (21)*
Dust mite	235 (70)	54 (68)	181 (70)
Cat	166 (29)	35 (44)	131 (50)
Dog	34 (10)	5 (6)	29 (11)
Outdoor	256 (76)	65 (82)	191 (74)

**P* = .01.

TABLE IV. ORs for kitchen cockroach allergen by home location

	City, OR (95% CI)	Suburban-rural, OR (95% CI)
African American	4.08 (1.03-16.13)*	1.82 (0.99-3.33)
≥50,000/y income†	0.26 (0.08-0.84)*	0.59 (0.29-1.18)
Mother with college degree	0.19 (0.05-0.74)*	0.53 (0.31-0.91)*
Male	0.71 (0.24-2.07)	1.14 (0.67-1.95)
Detached home	0.67 (0.16-2.93)	0.45 (0.26-0.78)*

*Statistically significant at *P* < .05.

†Data missing for 49 participants.

population and the suburban-rural subgroup, with an increase in the sensitization rate beginning in the groups exposed to 1 to 1.99 U/g. Although the response slope appears less steep in the suburban-rural subgroup, the underlying distributions of cockroach exposure of the suburban-rural subgroup and the total population likely account for the apparent difference. After adjusting for potential confounders, a kitchen Bla g 1 level of greater than 1 U/g remained a significant risk factor for cockroach sensitization for the total study population and the suburban-rural subgroup.

Because of the cross-sectional design of this study, results should be interpreted cautiously until prospective studies can be conducted that corroborate these findings. Nevertheless, other cross-sectional studies have found similar associations. For example, results from the NCI-CAS indicated that exposure to greater than 1 U/g Bla g 1 was associated with a significantly increased risk of sensitization and that this risk continued to increase until exposure reached greater than 4 U/g. After constructing a dose-response curve, the authors concluded that the cockroach allergen sensitization threshold was 2.3 U/g or less.¹ Our findings in this primarily suburban study population are consistent with those in the NCICAS population and add strength to the hypothesis that the cockroach sensitization threshold might be as low as 1 U/g. Should sensitization occur at such a low level of exposure, primary prevention of allergic sensitization by allergen removal might not be feasible.

In the multivariate analyses age was also significantly associated with cockroach sensitization, and this finding might reflect the added risk of increasing duration of exposure to a specific allergen. Increasing risk with increasing age might also simply be a reflection of the natural history of allergic sensitization because atopic children tend to add to the number of sensitizations as they age.^{21,22} Living in a detached home protected

TABLE V. Kitchen Bla g 1 exposure and prevalence of cockroach sensitization

	≤1 U/g	>1 U/g	<i>P</i> value
City, n (%)	4/18 (22)	24/59 (41)	.15
Suburban-rural, n (%)	29/180 (16)	25/78 (32)	.004
Total population, n (%)	33/198 (17)	49/137 (36)	<.0001
≤2 U/g			
City, n (%)	4/20 (20)	24/57 (42)	.08
Suburban-rural, n (%)	32/192 (17)	22/66 (33)	.004
Total, n (%)	36/212 (17)	46/123 (37)	<.0001
≤8 U/g			
City, n (%)	19/63 (30)	9/16 (56)	.05
Suburban-rural, n (%)	43/226 (19)	11/32 (34)	.05
Total, n (%)	54/263 (21)	28/72 (39)	.001

against sensitization among suburban dwellers, but the effect was lost in the total population because of the fact that living in a detached home was associated with a trend toward increased cockroach sensitization among city dwellers. In the multivariate analysis of city dwellers, the only risk factors that remained significant were male sex and age. Although boys are known to be at greater risk for atopy in general,²³ the small numbers among this subgroup and the fact that this was not seen in the other analyses make it difficult to draw any firm conclusions about the risk associated with male sex.

Unlike previously published studies,^{2,11} we found no association between African American race and cockroach allergen exposure after adjusting for potential confounders. It might therefore be the case that the risk associated with race is only applicable to poor inner-city populations. On the other hand, our findings might be different because the racial composition of our study population was heterogeneous and the SES of our study participants was fairly homogeneous. In other words, if previously reported racial differences were actually the result of residual confounding by low SES, then we would expect that the racial differences would be attenuated in a study population such as ours.

Although risk factors for cockroach allergen exposure included living in the city and having a lower income and less education, we found that a significant proportion of middle-class suburban children were exposed to cockroach allergen. In addition, exposure to low levels of cockroach allergen among this population was associated with cockroach sensitization. These results suggest that home cockroach allergen exposure plays an important role in the development of cockroach sensitization in middle-class suburban children with asthma. Whether

Environmental and occupational disorders

TABLE VI. Risk factors for cockroach sensitization

	Crude OR	95% CI	Adjusted OR*	95% CI
Total study population (n = 327)				
Bla g 1 >1 U/g	2.78†	1.67-4.64	2.29†	1.28-4.11
African American race	0.56†	0.34-0.92	0.90	0.48-1.70
Male	1.28	0.77-2.11	1.74	0.99-3.05
Age	1.17†	1.08-1.27	1.19†	1.09-1.30
Maternal education (college degree)	0.63	0.38-1.05	1.08	0.56-2.07
Detached home	0.48†	0.29-0.80	0.57	0.29-1.10
Suburban-rural (n = 253)				
Bla g 1 >1 U/g	2.46†	1.32-4.56	2.37†	1.23-4.57
African American race	0.83	0.42-1.66	1.03	0.48-2.22
Male	0.94	0.52-1.71	1.11	0.57-2.13
Age	1.13†	1.02-1.24	1.16†	1.04-1.28
Maternal education	0.85	0.47-1.56	1.26	0.62-2.55
Detached home	0.45†	0.25-0.82	0.45†	0.22-0.92
City (n = 74)				
Bla g 1 >1 U/g	2.40	0.70-8.18	1.99	0.44-8.97
African American race	0.40	0.08-2.05	1.71	0.21-13.93
Male	2.81†	1.05-7.55	8.12†	2.06-32.08
Age	1.27†	1.07-1.49	1.46†	1.16-1.84
Maternal education	0.36	0.07-1.83	0.13	0.01-2.85
Detached home	2.00	0.53-7.61	10.39	0.67-161.86

*Adjusted for all covariates listed in the table.

†Statistically significant at $P < .05$.

exposure to cockroach allergen contributes to asthma morbidity in this population remains to be seen.

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