



Sensitization to mouse and cockroach allergens and asthma morbidity in urban minority youth

Genes-environments and Admixture in Latino American (GALA-II) and Study of African-Americans, Asthma, Genes, and Environments (SAGE-II)

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ABSTRACT

Background: Pest allergen sensitization is associated with asthma morbidity in urban youth but minimally explored in Latino populations. Specifically, the effect of mouse sensitization on the risk of asthma exacerbation has been unexplored in Latino subgroups.

Objective: To evaluate whether pest allergen sensitization is a predictor of asthma exacerbations and poor asthma control in urban minority children with asthma.

Methods: Latino and African American children (8–21 years old) with asthma were recruited from 4 sites across the United States. Logistic regression models evaluated the association of mouse or cockroach sensitization with asthma-related acute care visits or hospitalizations.

Results: A total of 1,992 children with asthma in the Genes-environments and Admixture in Latino American (GALA-II) and Study of African-Americans, Asthma, Genes, and Environments (SAGE-II) cohorts were studied. Asthmatic children from New York had the highest rate of pest allergen sensitization (42% mouse, 56% cockroach), with the lowest rate in San Francisco (4% mouse, 8% cockroach). Mouse sensitization, more than cockroach, was associated with increased odds of acute care visits (adjusted odds ratio [aOR], 1.47; 95% CI, 1.07–2.03) or hospitalizations (aOR, 3.07; 95% CI, 1.81–5.18), even after controlling for self-reported race and site of recruitment. In stratified analyses, Mexican youth sensitized to mouse allergen did not have higher odds of asthma exacerbation. Other Latino and Puerto Rican youth sensitized to mouse had higher odds of hospitalization for asthma (aORs, 4.57 [95% CI, 1.86–11.22] and 10.01 [95% CI, 1.77–56.6], respectively) but not emergency department visits.

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Conclusion: Pest allergen sensitization is associated with a higher odds of asthma exacerbations in urban minority youth. Puerto Rican and Other Latino youth sensitized to mouse were more likely to have asthma-related hospitalizations than Mexican youth.

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Introduction

Approximately 9% of US children have asthma, with an increased prevalence and burden of disease in minority children,^{1,2} which is not accounted for by socioeconomic status or access to care.^{3–5} Pest allergen sensitization is associated with increased asthma morbidity in urban minority youth.⁶ Pest allergens, mouse and cockroach, in contrast to dust mite and other indoor allergens, are more significantly associated with asthma exacerbation.⁷ Furthermore, 8% to 30% of urban children are allergic to mouse or cockroach,^{8–10} with 50% to 95% of urban homes having detectable mouse or cockroach allergen levels.^{11,12} This is a major public health concern because asthma exacerbations represent approximately \$4 billion lost on an annual basis.¹³ However, most studies on mouse sensitization and asthma focus on populations that are more than 70% African American and limited to certain cities with high levels of exposure.^{9,14} Studies that adequately represent urban Latino subpopulations in the United States¹⁵ are lacking.

Allergen sensitization among inner-city children with asthma is more common in minority groups compared with white populations.¹⁶ In fact, there is evidence that certain Latino subgroups, such as Puerto Ricans, are more likely to develop indoor allergen sensitization compared with other Latino subgroups.^{17,18} A few studies have purported a significant burden of mouse in Latino households,¹⁹ with similar levels of sensitization compared with other minority populations.²⁰ However, these studies do not represent a national sample, and not all Latino subgroups are thought to have more poorly controlled asthma in the context of mouse exposure^{21,22}; adequate representation of Latino subgroups is necessary to evaluate factors associated with asthma morbidity.²³ The largest study to date, the Inner-City Asthma Study (ICAC), did not address the affect of mouse or cockroach sensitization on the risk of asthma exacerbation distinguishing different Latino subgroups. Our aim was to evaluate whether pest allergen (mouse or cockroach) sensitization is a predictor of asthma exacerbations and poor asthma control within a nationwide sample of urban minority asthmatic children, including Latino subgroups.

Methods

Study Design

The Genes-environments and Admixture in Latino American (GALA II)²⁴ study and the Study of African-Americans, Asthma, Genes, and Environments (SAGE II)²⁵ are 2 parallel case-control studies with asthmatic and control participants that used identical protocols and questionnaires, initiated in 2008, and funded by the National Institutes of Health. Urban minority youth aged 8 to 21 years were recruited as part of the 2 gene-environment studies with GALA II focused on Latino Americans and SAGE II focused on African Americans. Children and adolescents with and without asthma aged 8 to 21 years were recruited for SAGE II ($n = 908$ cases and 616 controls) and the GALA II studies ($n = 2,232$ cases and 2,228 controls). Children were recruited from 5 community- and clinic-based centers (Chicago, IL; New York, NY; Houston, TX; San Francisco Bay, CA; and San Juan, Puerto Rico) during July 2008 through November 2011 for GALA II and for 1 clinic (San Francisco Bay, CA) for SAGE II. Our cross-sectional analysis focused on children with asthma from the mainland United States. Each participating center's institutional review board reviewed and approved

the study. Written informed consent was provided by parent or legal guardian (if 18 years or older, by the study participant).

Patient Population

Asthmatic children were defined by a history of physician-diagnosed asthma and 2 or more symptoms (cough, wheezing, or shortness of breath) within 2 years before enrollment. For this cross-sectional analysis, we used the subset of children with asthma from the mainland United States with mouse and cockroach skin prick data ($n = 1,922$). We focus on pest allergen sensitization within the continental United States because allergen levels and other factors that affect control may be different within individuals living on the island of Puerto Rico. Furthermore, there were technique differences, which may limit comparability of skin tests in these sites to the other continental US sites. Other exclusion criteria included 10 or more pack-years of cigarette smoking, any smoking within 1 year of recruitment, history of other lung disease (other than asthma) or chronic illness, and third-trimester pregnancy.

Assessment of Pest Allergen Sensitization and Self-reported Exposure

Mouse epithelium (*Mus musculus*; Greer, Lenoir, North Carolina) and cockroach mix (*Blattella germanica* and *Periplaneta americana*; Hollister-Stier, Spokane, Washington) sensitization at the time of recruitment was determined by skin prick testing. Testing was performed on the volar aspect of the forearm with the Multi-Test II (Lincoln Diagnostics, Decatur, Illinois). Wheal diameter was measured using the mean length plus width and was considered positive if wheal size was 3 mm or more larger than saline, assuming adequate response to histamine (≥ 3 mm wheal larger than saline control). Trained interviewers administered comprehensive questionnaires and spirometry tests to gather baseline sociodemographic data, as well as information on general health and asthma-related health outcomes. As part of the recruitment questionnaire, participants were asked whether in the past 12 months they had problems with mice or cockroaches.

Outcomes

The coprimary outcomes (representing asthma exacerbation) were acute care visits for asthma or hospitalizations for asthma in the past 12 months. Secondary outcomes included asthma control via a composite index based on National Heart, Lung, and Blood Institute criteria and lung function measures of percentage predicted forced expiratory volume in 1 second (FEV₁) and ratio of FEV₁ to forced vital capacity (FVC).

With regard to the coprimary outcomes, individuals with asthma were categorized as having an acute care visit during the previous 12 months if they had 1 or more urgent care or emergency department (ED) visit(s) or hospitalized if they had 1 or more hospital admission(s). This was determined with the following questions: "How many times in the past 12 months has CHILD received asthma care that was not scheduled at least 24 hours ahead of time? (1, once; 2, 2–4 times; 3, ≥ 5)" and "How many times in the past 12 months has CHILD been hospitalized because of asthma? (1, once; 2, 2–4 times; 3, ≥ 5)."

The secondary outcome of asthma control was calculated via a composite index based on National Heart, Lung, and Blood Institute criteria as described in detail in previous articles,^{26,27}

with information collected using a modified version of the American Thoracic Society–Division of Lung Disease (ATS-DLD) questionnaire.²⁸ Briefly, control was defined based on the following: (1) daytime symptoms no more than twice per week, (2) no limitation of activities because of asthma, (3) no nocturnal symptoms within the previous month, (4) use of rescue medication no more than twice per week, and (5) FEV₁/FVC ratio of 85% or greater and/or FEV₁ of 80% or greater. Asthma was considered not well controlled if children did not meet at least 1 of these criteria.

Other secondary outcomes evaluated included lung function measures of percentage predicted FEV₁ and FEV₁/FVC ratio. Spirometry was performed using a KoKo spirometer (nSpire Health, Longmont, Colorado) according to the guidelines of the ATS/European Respiratory Society. References for spirometry values were determined using age, standing height (via calibrated stadiometer), sex, and ethnicity, using the National Health and Nutrition Examination Survey III reference standards. Of the spirometry values for lung function, we analyzed percentage predicted values (before bronchodilator use) of FEV₁, and FEV₁/FVC ratio. These values were classified as low based on ATS criteria²⁹ as follows: FEV₁ was classified as low if it was below 80% predicted, and FEV₁/FVC ratio was classified as low if below 85% predicted.

Covariates

Selection of covariates in the primary model was based on previous studies and presumed confounding factors that could influence asthma control, including sex, age, socioeconomic status (maternal highest educational level and household income), mother smoking during pregnancy, postnatal smoke exposure in home, prescribed asthma treatment, body mass index, self-reported race/ethnicity, other allergen sensitization (including cat, dog, mold, and dust mite), and site of recruitment. Of these, other allergen sensitizations were not included in the final model because it was not a confounder of the association. Reported problems with mice or cockroaches in the past 12 months were not included in the final model because they varied in a collinear manner with sensitization.

Analytical Strategy

Baseline characteristics of participants who were sensitized vs not sensitized to cockroach or mouse were compared using *t* tests and χ^2 tests. Our base logistic regression model was developed to determine the association of the primary determinate (pest allergen sensitization) with the coprimaries outcomes of asthma-related acute care visits or hospitalizations. All covariates identified as potential confounders were included in that model, except for self-identified race and site. These 2 variables were not included in the base model because we wanted to evaluate their effects on the observed association. Specifically, because sensitization and asthma severity varies by race/ethnicity and we sought to evaluate the association within Latino ethnic subgroups, we then added self-identified race to the model. Finally, given that self-reported exposure in our sample varied markedly by city, we then added site of recruitment into the regression model to determine the extent to which this covariate influenced the association between pest-allergen sensitization and asthma-related acute care visits or hospitalization. We also stratified our analysis by Latino subgroup to determine the relevance of pest allergen sensitization and risk of asthma exacerbation (acute care visit or hospitalization) by self-identified race/ethnicity. In secondary analysis, we explored the role of pest allergen sensitization and poor asthma control using logistic regression models similar to our primary analysis.

Results

Participant Characteristics

Table 1 presents the characteristics of the patients with asthma in the GALA II and SAGE II cohorts (*n* = 1,922), with regard to pest allergen sensitization. Overall, 13% of patients with asthma were mouse sensitized and 22% were cockroach sensitized. Our cohort was 47% male, with a mean (SD) age of 13.2 (3.5) years. Ethnic makeup is as follows: 33% Mexican, 7% Puerto Rican, 21% other Latino (South American, Central American, non–Puerto Rican Caribbean, or mixed Latino), and 40% African American. Asthma exacerbations that required acute care visits in the past 12 months occurred in 35% of participants and in 48% of mouse sensitized and 43% of cockroach sensitized children. Hospitalizations during the past 12 months were reported for 6% of participants and in 15% of mouse sensitized and 10% of cockroach sensitized children.

Children from New York had the highest rate of pest allergen sensitization (42% mouse, 56% cockroach), with the lowest rate in the San Francisco Bay (4% mouse, 8% cockroach) (Fig 1). In assessing mouse and cockroach exposure, there were wide variations in parent-reported exposure by site, with the greatest in New York (51% mouse, 63% cockroach) and the least in San Francisco (14% mouse, 12% cockroach) (eFig 1). Mouse sensitized children were more likely to be Puerto Rican or other Latino, come from homes with lower maternal educational level, have mothers who smoked during pregnancy, and have been prescribed asthma controller therapy (Table 1). Likewise, this was also true for cockroach sensitized children. In addition, cockroach sensitization alone was associated with obesity and lower household income.

Association Between Mouse and Cockroach Sensitization and Risk of Asthma Exacerbation

In assessing the risk of mouse and cockroach sensitization and asthma exacerbation, we analyzed coprimaries outcomes of acute care asthma visits and asthma hospitalizations during the past 12 months (Table 2). Mouse sensitization was associated with higher odds of acute care visits (adjusted odds ratio [aOR], 1.79; 95% CI, 1.34–2.39) or hospitalizations (aOR, 3.56; 95% CI, 2.25–5.63). Cockroach sensitization in this model was also associated with higher odds of acute care visits or hospitalizations (aORs, 1.54 [95% CI, 1.24–1.95] and 1.99 [95% CI, 1.29–3.09], respectively). Furthermore, when controlling for race, we found a continued association with mouse or cockroach sensitization and increased odds of acute health care visits and hospitalizations for asthma. When adding site into the model (controlling for site and race), there was a significant association between mouse sensitization and acute health care visits or hospitalizations during the past 12 months (aOR, 1.47 [95% CI, 1.07–2.03], and aOR, 3.07 [95% CI, 1.81–5.18], respectively). Cockroach sensitization was associated with increased odds of acute care visits in this model (aOR, 1.34; 95% CI, 1.03–1.76); however, the association with hospitalizations was diminished (aOR, 1.46; 95% CI, 0.89–2.39). We evaluated the subgroup of patients from San Francisco (*n* = 1,110) because they had the lowest levels of pest allergen sensitization. We found that even when controlling for covariates and race, mouse and cockroach sensitization was associated with increased odds of acute care visits (aORs, 2.34 [95% CI, 1.26–4.36] and 1.60 [95% CI, 1.01–2.53], respectively). The small number of asthma-related hospitalizations in San Francisco prevented us from evaluating the association between pest allergen sensitization and asthma-related hospitalization. We also considered dust mite sensitization in our models and found that in adjusted models (including controlling for site and race) there was no significant association between dust mite sensitization and asthma-related ED visits (aOR, 1.07; 95% CI, 0.85–1.34) or hospitalizations (aOR, 1.39; 95% CI, 0.90–2.15).

Table 1Characteristics of children with asthma selected for this analysis in the GALA II studies and SAGE II, 2008–2012^a

Characteristic	Overall (N = 1,922)	Mouse (n = 1,922)			Cockroach (n = 1,922)		
		Sensitized	Nonsensitized	P Value	Sensitized	Nonsensitized	P Value
Total		242 (12.6)	1680 (87.4)		424 (22.1)	1498 (77.9)	
Age in years, mean (SE)	13.2 (0.08)	12.9 (0.2)	13.3 (0.1)	.08	13.1 (0.2)	13.3 (0.1)	.46
Male, n (%)	898 (46.7)	113 (46.9)	785 (46.7)	.99	199 (46.9)	699 (46.7)	.92
Ethnicity				<.01			<.01
Mexican	631 (32.8)	78 (32.2)	553 (32.9)		170 (40.1)	461 (30.8)	
Puerto Rican	129 (6.7)	47 (19.4)	82 (4.9)		56 (13.2)	73 (4.9)	
Other	403 (21.0)	94 (38.8)	309 (18.4)		157 (37.0)	246 (16.4)	
African American	759 (39.5)	23 (9.5)	736 (33.8)		41 (9.7)	718 (47.9)	
Site of recruitment				<.01			<.01
San Francisco Bay, CA	1138 (59.2)	47 (19.4)	1091 (64.9)		95 (22.4)	1043 (69.6)	
Chicago, IL	287 (14.9)	50 (20.7)	237 (14.1)		83 (19.6)	204 (13.6)	
New York, NY	299 (15.6)	126 (52.1)	173 (10.3)		167 (39.4)	132 (8.8)	
Houston, TX	198 (10.3)	19 (7.9)	179 (10.7)		79 (18.6)	119 (7.9)	
BMI category				.06			<.01
Normal	811 (42.2)	97 (40.1)	714 (42.5)		144 (34.0)	667 (44.5)	
Overweight	359 (18.7)	35 (14.5)	324 (19.3)		76 (17.9)	283 (18.9)	
Obese	752 (39.1)	110 (45.5)	642 (38.2)		204 (48.1)	548 (36.6)	
Maternal educational level				<.01			<.01
Less than high school	690 (35.9)	115 (47.5)	575 (34.2)		202 (47.6)	488 (32.6)	
High school graduate	493 (25.7)	53 (21.9)	440 (26.2)		119 (28.1)	374 (25.0)	
Some college or higher	712 (37.0)	70 (28.9)	642 (38.2)		96 (22.6)	616 (41.1)	
Missing	27 (1.4)	4 (1.7)	23 (1.4)		7 (1.7)	20 (1.3)	
Household income in past 12 mo				.28			.04
<\$25,000	758 (39.4)	96 (49.7)	662 (39.4)		190 (44.8)	568 (37.9)	
\$25,000–\$74,999	515 (26.8)	62 (25.6)	453 (27.0)		105 (24.8)	410 (27.4)	
≥\$75,000	348 (18.1)	37 (15.3)	311 (18.5)		62 (14.6)	286 (19.1)	
Missing	301 (15.7)	47 (19.4)	254 (15.1)		67 (15.8)	234 (15.6)	
Prescribed medication in past 12 mo				<.01			<.01
None, SABA, or anticholinergic only	714 (37.2)	86 (35.5)	628 (37.4)		161 (38.0)	553 (36.9)	
ICS or LTRA monotherapy	738 (38.4)	74 (30.6)	664 (39.5)		123 (29.0)	615 (41.1)	
Combination therapy	470 (24.5)	82 (33.9)	388 (23.1)		140 (33.0)	330 (22.0)	
Smokers in household (n = 1,745)	423 (24.2)	52 (22.1)	371 (24.6)	.22	75 (18.5)	348 (25.9)	.03
Mother smoked during pregnancy	226 (11.8)	17 (7.0)	209 (12.4)	.01	34 (8.0)	192 (12.8)	<.01
Rodent problem (n = 1,776)	397 (22.4)	93 (38.8)	304 (19.7)	<.01			
Cockroach problem (n = 1,913)	473 (24.7)				204 (48.1)	269 (18.1)	<.01
Acute care visits in past 12 mo (n = 1,882) ^b	659 (35.0)	115 (48.1)	544 (33.1)	<.01	182 (43.4)	477 (32.6)	<.01
Hospitalizations in past 12 mo (n = 1,829) ^b	105 (5.7)	34 (14.5)	71 (4.5)	<.01	39 (9.6)	66 (4.6)	<.01
Asthma control				<.01			.06
Well controlled	678 (35.3)	64 (26.5)	614 (36.6)		133 (31.4)	545 (36.4)	
Uncontrolled	1244 (64.7)	178 (73.6)	1065 (63.5)		291 (68.6)	953 (63.6)	
Lung function (n = 1,915)							
FEV ₁ , mean (SE)	96.5 (0.3)	90.6 (1.0)	97.4 (0.3)	<.01	92.4 (0.7)	97.6 (0.3)	<.01
FEV ₁ /FVC ratio, mean (SE)	95.3 (0.2)	92.2 (0.6)	95.7 (0.2)	<.01	93.2 (0.4)	95.9 (0.2)	<.01
FEV ₁ <80, n (%)	204 (10.7)	53 (21.2)	151 (9.0)	<.01	78 (18.4)	126 (8.5)	<.01
FEV ₁ /FVC ratio <85, n (%)	210 (11.0)	40 (16.6)	170 (10.2)	<.01	61 (14.4)	149 (10.0)	.01

Abbreviations: BMI, body mass index; FEV₁, forced expiratory volume in 1 second; FVC, forced vital capacity; ICS, inhaled corticosteroid; LTRA, leukotriene receptor agonist; SABA, short-acting β -agonist.

^aData are presented as number (percentage) unless otherwise indicated. Denominator for percentages is 1,922 unless there are missing data; in these cases, category n is noted in the left-hand column and used as denominator.

^bPatients categorized as having acute care visits or hospitalizations during the past year if 1 or more visit(s).

Mouse and Cockroach Sensitization and Risk of Asthma Exacerbation in Latino Subgroups

We considered these findings by Latino subgroups (Table 3) and found that Mexicans sensitized to mouse or cockroach did not have increased odds of asthma exacerbation. However, Puerto Ricans and other Latinos sensitized to mouse had increased odds of hospitalization in the past 12 months from asthma (aORs, 10.01 [95% CI, 1.77–56.6] and 4.57 [95% CI, 1.86–11.22], respectively). Our analysis was limited by the small event number in subgroups, resulting in a decrease in precision of these estimates. Cockroach sensitization was only associated with higher odds of acute health care visits or hospitalizations in other Latinos (aORs, 1.73 [95% CI, 1.08–2.76] and 3.57 [95% CI, 1.47–8.66], respectively).

Association Between Sensitization and Lung Function or Asthma Control

We evaluated pest allergen sensitization and the secondary outcomes of decreased lung function and poor asthma control

(Table 4). Mouse and cockroach sensitization were associated with poorer lung function (FEV₁ <80; aORs, 2.49 [95% CI, 1.74–3.56] and 2.17 [95% CI, 1.58–2.98], respectively). Mouse sensitization, but not cockroach, was associated with poor asthma control. The inclusion of self-identified race/ethnicity as a covariate to the base model revealed a continued association between mouse sensitization and poor asthma control (aOR, 1.49; 95% CI, 1.07–2.07), which was no longer significant when adding site into the model. Despite the lack of significance, the magnitude of odds of poor asthma control via composite variable and lung function does not markedly change with the addition of site into the model.

Discussion

We sought to explore the relevance of mouse and cockroach allergen sensitization and asthma exacerbations (acute care visits or hospitalization) across minority groups, including Latino subgroups, not previously evaluated in inner city-asthma studies.

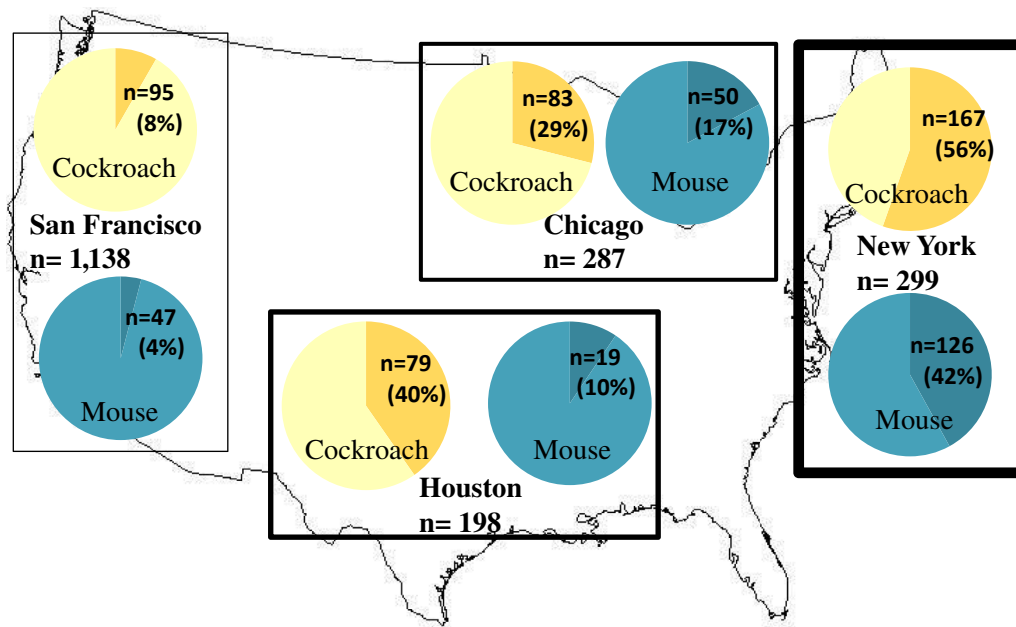


Figure 1. Percentage of children with asthma sensitized to mouse or cockroach by site.

Health care use (ED and hospitalization) remained significantly higher in mouse sensitized individuals in fully adjusted models, particularly in children identifying as Puerto Rican or other Latino. The effects of cockroach on acute care visits, but not hospitalization, were persistent in fully adjusted models. Mouse sensitization, as opposed to cockroach, was most significantly associated with poor asthma control and poor lung function even when ethnicity was added to our model. These findings are in keeping with recent assertions that mouse allergen sensitization is a greater driver of morbidity in inner-city populations.³⁰ Furthermore, our study suggests that mouse allergen is relevant across a range of exposures in this minority urban population. Mouse and cockroach sensitization and exposure were significantly higher in New York compared with San Francisco.

Prior national studies with predominantly African American or white participants have had similar findings that pest allergen exposure, most significantly mouse, increases risk of sensitization and asthma exacerbation.^{9,31} Specifically, Phipatanakul et al found exposure to mouse or cockroach resulted in increased sensitization to these allergens in inner-city African Americans, Latino, and other youth.⁸ In mouse sensitized youth compared with cockroach in the ICAC, there was increased risk of asthma exacerbation.¹⁰ Salo et al³¹ found mouse exposure and sensitization were associated with increased asthma morbidity in both urban and nonurban youth, including white and African American youth, with higher rates of sensitization in the inner city.³² Latino studies in the past, including the ICAC studies,¹⁰ included smaller numbers of participants and were inadequately powered to or did not evaluate Latino subgroups.²¹ Our study is the first, to our knowledge, to clarify this question in a nationwide sample adequately representing Latino youth from various ethnicities.

Although limited by small cell size, our secondary analyses of Latino subgroups raise the question of whether there are specific ethnic differences in the association of sensitization to mouse and cockroach and asthma outcomes. As Kumar et al¹⁸ previously published on this cohort, factors such as acculturation, migration pattern, or genetic ancestry were not as important as country of origin in risk of sensitization. Our findings within sensitized individuals, in combination with this prior study, underscore the importance of identifying specific Latino subgroups. By identifying

Latino subgroups, we are better able to risk stratify and personalize the approach to addressing pest allergen sensitization and thus risk of exacerbation. Indeed, sensitized Puerto Rican and other Latino youth had higher odds of hospitalization, in contrast to Mexican children.

We also found that pest allergen (mouse and cockroach) sensitization has large regional differences, as does self-reported exposure. Overall, 13% of asthmatic children were mouse sensitized (range, 4%–42%), and 22% were cockroach sensitized (range, 8%–56%). Previous studies confirm the finding that higher allergen exposure is associated with sensitization.³³ Although we did not have dust allergen levels by household, our sample included some US cities with 25-fold lower mean level of mouse allergen exposure^{11,14} than that reported in recent studies of high mouse allergen environments.³⁴ Lower levels of sensitization were noted in less densely populated cities with more arid climate. Our study included cities with a lower level of pest exposure than documented in the ICAC.³⁵ However, similar to cities with very high exposure, mouse sensitization was still a risk factor for asthma exacerbation. We verified this finding in our subanalysis of children from San Francisco, of whom those sensitized to mouse had increased odds of acute care visits. This finding suggests that the association of mouse sensitization and asthma exacerbation is present across different levels of exposure. Even in areas with a low prevalence of

Table 2

Odds of asthma exacerbation in mouse and cockroach sensitized children

Variable	aOR (95% CI) ^a		
	Base Model	Base Model and Race	Base Model, Race, and Site
Acute health care visits in 12 mo (n = 1,882)			
Mouse allergic	1.79 (1.34–2.39)	1.64 (1.21–2.22)	1.47 (1.07–2.03)
Cockroach allergic	1.54 (1.24–1.95)	1.48 (1.15–1.91)	1.34 (1.03–1.76)
Hospitalizations in 12 mo (n = 1,829)			
Mouse allergic	3.56 (2.25–5.63)	3.08 (1.89–5.00)	3.07 (1.81–5.18)
Cockroach allergic	1.99 (1.29–3.09)	1.69 (1.06–2.70)	1.46 (0.89–2.39)

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval.

^aOdds ratio adjusted for sex, age, body mass index, maternal smoking during pregnancy, smokers in household, maternal educational level, household income, and prescribed asthma treatment.

Table 3

Odds of asthma exacerbation in mouse and cockroach sensitized children by race/ethnicity

Variable	aOR (95% CI) ^a		
	Mexican	Puerto Rican	Other Latino
Acute health care visits in 12 mo			
No. of patients	620	128	397
Mouse allergic	1.33 (0.76–2.33)	1.32 (0.50–3.49)	1.37 (0.80–2.36)
Cockroach allergic	1.26 (0.81–1.96)	1.10 (0.44–2.79)	1.73 (1.08–2.76)
Hospitalizations in 12 mo			
No. of patients	605	125	394
Mouse allergic	2.09 (0.75–5.79)	10.01 (1.77–56.6)	4.57 (1.86–11.22)
Cockroach allergic	1.05 (0.45–2.49)	0.77 (0.18–3.40)	3.57 (1.47–8.66)

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval.

^aOdds ratios adjusted for sex, age, body mass index, maternal smoking during pregnancy, smokers in household, maternal educational level, household income, prescribed asthma treatment, and site of recruitment.

sensitization, both our study and the ICAC found that mouse allergen sensitization has a strong association with asthma exacerbation.¹⁰

Although the association between sensitization and exacerbation is clear, the association with asthma control is less clear and was diminished by site. However, the order of magnitude of odds is still in the same direction and does not markedly change when adding site into the model. In fact, risk of exacerbation remains significant. This finding suggests that we are underpowered for the mitigation in efficacy when looking at lower vs higher exposure sites. Previous studies also suggest that pest allergen sensitization presents a higher risk for exacerbation, as opposed to control. Residual confounding from factors that covary by site and are not accounted for in our model may also be involved in the association between mouse sensitization and poor asthma control. Examples of residual confounders that vary by site include pollution,³⁶ violence,³⁷ maternal stress,³⁸ and access to health care.³⁹ Additional studies are necessary to clarify the interaction between these factors and asthma control in pest allergic children.

Limitations to our study include that it was a case-control study, which means it cannot determine causation. In addition, our primary outcome was based on questions regarding exacerbation during the past 12 months, which might introduce recall bias. Sensitization was determined with mouse epithelium extract, which might underestimate the rate of sensitization.³⁵ As Matsui et al³⁵ previously reported, children with asthma are more

Table 4

Odds of outcomes of uncontrolled asthma composite score or lung function and mouse or cockroach sensitization

Variable	aOR (95% CI)		
	Base Model	Base Model and Race	Base Model, Race, and Site
Poor asthma control ^a (n = 1,922)			
Mouse allergic	1.68 (1.22–2.29)	1.49 (1.07–2.07)	1.24 (0.88–1.76)
Cockroach allergic	1.26 (0.99–1.61)	1.20 (0.92–1.55)	0.98 (0.75–1.29)
FEV ₁ <80 ^b (n = 1,915)			
Mouse allergic	2.49 (1.74–3.56)	1.76 (1.21–2.57)	1.36 (0.91–2.03)
Cockroach allergic	2.17 (1.58–2.98)	1.66 (1.18–2.33)	1.36 (0.95–1.95)
FEV ₁ /FVC ratio <85 ^b (n = 1,915)			
Mouse allergic	1.69 (1.15–2.49)	1.57 (1.04–2.37)	1.52 (0.99–2.35)
Cockroach allergic	1.48 (1.06–2.06)	1.49 (1.04–2.13)	1.45 (1.00–2.11)

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; FEV₁, forced expiratory volume in 1 second; FVC, forced vital capacity.^aOdds ratio adjusted for sex, age, body mass index, maternal smoking during pregnancy, smokers in home, maternal educational level, household income, and prescribed asthma treatment.^bOdds ratio adjusted for maternal smoking during pregnancy, smokers in home, maternal educational level, household income, and prescribed asthma treatment.

commonly sensitized to mouse urine as oppose to mouse epithelium. This finding would bias our findings to the null hypothesis, suggesting the effect of mouse sensitization on asthma exacerbation in Latino youth might be stronger than our findings suggest. Home allergen levels were not measured, but rates of sensitization correlate with levels of exposure.⁹ Other limitations include small event number when stratifying our analysis by Latino subgroup or in our subanalysis of San Francisco participants.

Mouse and cockroach allergy are large public health problems that are reported to contribute to asthma morbidity in urban minority youth. In our study, mouse allergen was more clearly associated with exacerbation across a range of exposures in urban minority youth, including African American and Latino children. Among Latino subgroups, this finding was most significant in Puerto Ricans and other Latinos but not in Mexicans. Given that sensitization to mouse or cockroach is associated with higher levels of exposure and asthma exacerbation, it is important to query patients regarding exposure to pest allergens. Further studies, with adequate representation of Latino subgroups, are needed to replicate and elucidate these differences.

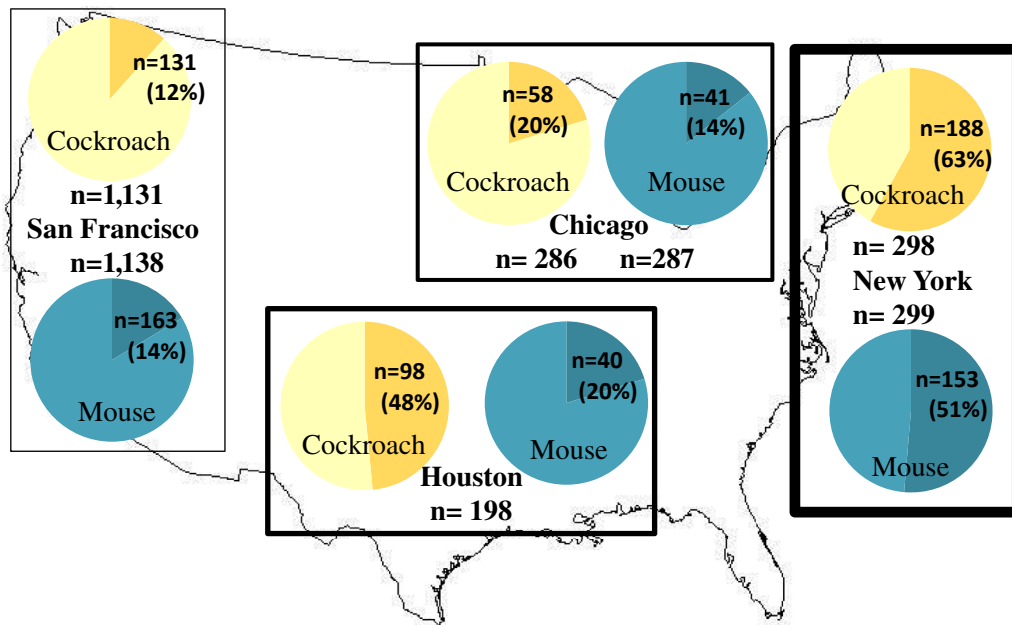
Supplementary Data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.anai.2016.05.004>.

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eFigure 1. Percentage of children with asthma reporting mouse or cockroach exposure by site.