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Rodent Allergen in Los Angeles Inner City Homes of Children with Asthma

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ABSTRACT *Recent studies have examined the presence of mouse allergen in inner city children with asthma. Researchers have found high levels of rodent allergen in homes sampled in the northeast and midwest United States, but there has been considerable variation between cities, and there have been few studies conducted in western states. We evaluated the frequency of rodent sightings and detectable mouse allergen and the housing conditions associated with these outcomes in inner city homes in Los Angeles. Two hundred and two families of school children, ages 6–16 living in inner city neighborhoods, participated in the study. Families were predominantly Latino (94%), and Spanish speaking (92%). At study entry, parents completed a home assessment questionnaire, and staff conducted a home evaluation and collected kitchen dust, which was analyzed for the presence of mouse allergen. Fifty-one percent of homes had detectable allergen in kitchen dust. All 33 families who reported the presence of rodents had detectable allergen in the home and were also more likely to have increased levels of allergen compared to those who did not report rodents. Unwashed dishes or food crumbs, lack of a working vacuum, and a caretaker report of a smoker in the home were all significantly associated with a greater risk of rodent sightings or detectable allergen ($P<0.05$). Detached homes were significantly more likely to have detectable allergen. The prevalence of allergen is common enough that it may have public health implications for asthmatic children, and detectable allergen was not routinely identified based on rodent sightings. Many of the predictors of rodent allergen are amenable to low-cost interventions that can be integrated with other measures to reduce exposure to indoor allergens.*

KEYWORDS *Asthma, Mouse allergen, House dust, Rodent, Environment*

Abbreviations: FEV1 – Forced expiratory volume in 1 second; Mus m1 – Mouse allergen; NCICAS – National Inner City Asthma Study; Rat N1 – Rat allergen

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INTRODUCTION

The role of allergy in the development and exacerbation of asthma in children has been the topic of much research during the past four decades.[1] Approximately 51% of children with asthma are allergic to one or more allergens.[2] Allergens may come from a variety of sources, both indoor and outdoor. Animal dander, cockroaches, house dust mites, and molds have all been identified as indoor allergen sources that have been linked to asthma exacerbations in children with sensitivity to the particular agent or to the development of asthma.[3] It has been suggested that indoor allergens are an increasingly important public health problem because of the increased time children spend indoors.[1]

Studies of laboratory technicians working with experimental animals have established that exposure to rodent allergens may cause respiratory symptoms in susceptible individuals.[4–9] Eggleston et al.[10] demonstrated that in rodent sensitive laboratory workers, decreases in forced expiratory volume in 1 second (FEV1) of up to 10% occurred after a 1-hour exposure to airborne rodent allergens. Phipatanakul et al.[11] examined the prevalence of rodent allergen in the homes of participants in the National Inner City Asthma Study (NCICAS). Ninety-five percent of NCICAS inner city homes had detectable levels of mouse allergen in analyzed dust particles. Homes in the inner cities are more likely to have residents who are of lower socioeconomic status and belong to ethnic minorities (African American and Latino) that may be challenged by lack of resources (such as financial resources to purchase cleaning products, remove carpeting, and make other changes in substandard housing units). Since the findings of the NCICAS study, other researchers have identified characteristics associated with higher levels of mouse allergen including high-rise apartments, older homes (>50 years old), food left out, and cracks and crevices in the wall. Rodent allergen has been identified as a trigger for asthma exacerbations and the onset of asthma in children.[12–15] Research efforts in the United States, such as the NCICAS, have focused more on the east coast and midwest sections of the country, and not enough is known about residential exposure to rodent allergen on the west coast (California). We examined the prevalence of rodent allergen and its association with self-reported rodents and characteristics of the home environment of Latino children with asthma living in inner city Los Angeles.

METHODS

This study utilized baseline data from an evaluation of an intervention to reduce dust mite and cockroach allergen from Los Angeles inner city homes (the LA CASA Study).[16] Two hundred and two families were recruited for the study from a mobile asthma clinic serving school children in Los Angeles and from allergy clinics at Los Angeles County/University of Southern California Medical Center and Children's Hospital of Los Angeles. The mobile asthma clinic (Breathmobile™) serves a predominantly Latino population (90%). Eligibility criteria for the LA CASA study included having a child 6–16 years old with persistent asthma who had a positive skin test reaction to house dust mite and/or cockroach. Children were not eligible if they were participants in other asthma studies or had any other chronic respiratory or cardiac illness.

We included all LA CASA study participants for baseline analyses of rodent allergen in their homes. The study protocol included a home screening interview and

a walk-through inspection of the home and dust sample collection described below. As part of the baseline questionnaire, participants were asked if they had observed rodents in the home. Dust samples collected from the kitchen of each home at study entry were analyzed for the presence of mouse (Mus m1) allergen. Rat n1 allergen also was measured in 33 homes where rodents were self-reported, but only two homes had rat allergen over the level of detection, so only Mus m1 was measured on all samples.

Self-Report Questionnaire

A questionnaire was administered by a health educator to the primary caretaker of the child with asthma. The questionnaire included self-reported information about the caretaker, including education, ethnicity, preferred language (Spanish, English), child's gender, and health insurance. Caretakers were also asked to report information about their home, if anyone living in the home smoked, if they had pets, and if they had seen rats or mice in the house in the past 8 weeks. They were also asked whether they had and used a working vacuum cleaner within the last 2 weeks. General questions about the home focused on type of dwelling (detached, multilevel dwelling, trailer), number of people sharing bedrooms (density), and age of the home.

Observer Home Screening

Trained staff members visited every home and completed a checklist. The checklist included information about observed environmental risk factors, such as overflowing trash containers, unsealed food in the kitchen, mold on the kitchen wall/ceiling, unwashed dishes and crumbs in the kitchen, and cracks in the kitchen walls. In addition to the checklist, staff members completed moisture readings on each wall in the kitchen. This was accomplished with a noninvasive moisture meter that detected wall moisture.

Dust Sampling and Analysis

At the time of the home visit, staff members collected dust samples from the kitchen. A 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. A square meter was marked out and vacuumed for 5 minutes, using the 9.5 A Mighty Mite Boss Plus vacuum cleaner, model 3674 (The Eureka Company, Bloomington, IL, USA) fitted with a filter to trap dust. The filter was removed and sealed in a labeled plastic bag. Vacuumed samples were stored at –20°C within 24 hours of collection. Between samples, the nozzle of each vacuum cleaner was washed with detergent, rinsed, and dried, and a new filter was replaced.

Dust was stored at –20°C until shipping to the laboratory (on dry ice), and then stored at –20°C until analyzed. All samples were extracted and analyzed at the University of Iowa using a protocol described previously.[13,17]

Statistical Analysis

We computed the frequency distributions for each of the demographic and housing variables measured. The two main outcome variables, having rodents in the home and Mus m1 levels in dust, were both analyzed as binary variables. Mus m1 concentrations in dust were dichotomized into those above and below the limit of detection (which was either 0.0007 or 0.0008 ng/mg dust for all but two samples for which the limit was 0.00138). Association of each household characteristic with

these outcomes was assessed. Those household characteristics that showed significant associations with detectable mouse allergen at a 5% significance level were then adjusted for each other using logistic regression. All analyses were performed using SAS Version 9.2.

RESULTS

Participants/Housing Characteristics

Almost all of the 202 primary caretakers who participated in the study were Latino and Spanish speaking, and 69% had less than a high school education (Table 1). Forty-eight percent lived in a detached house and 29% had more than three people sleeping in each bedroom. Study staff observed that more than half of the homes had unsealed food in the kitchen and unwashed dishes.

Thirty-three families (16%) reported that they had seen rodents in the home (Table 2). Almost all of these homes had detectable allergen ($\chi^2=28.5$, $p<0.0001$) and allergen levels were significantly higher in homes with rodents reported than in homes without rodents reported ($p<0.0001$). However, 51% of the families in the study had detectable mouse allergen, and almost half of families not reporting rodents had detectable mouse allergen. Weak associations were seen with

TABLE 1 Demographic and housing characteristics of participants

Characteristic	*N** (%)
Caretaker reported	
Caretaker education ≤ high school	140 (69%)
Hispanic ethnicity	185 (92%)
Spanish preferred caretaker language	182 (90%)
Child, a boy	133 (66%)
Insurance coverage for child	140 (73%)
Pets in home	85 (46%)
Cats only	6 (3%)
Dogs only	44 (22%)
Cats and dogs	5 (3%)
Lack of a working vacuum	41 (20%)
Smoker in home	43 (23%)
Density >3 people/bedroom	58 (29%)
Staff observation	
Unsealed food	151 (81%)
Kitchen mold	25 (14%)
Unwashed dishes/food crumbs	122 (66%)
Overflowing trash	68 (37%)
Kitchen moisture	110 (55%)
Cracks in kitchen wall	82 (44%)
Home type—detached	96 (48%)
Dwelling materials	
Wood	198 (98%)
Brick	3 (1.5%)

*Denominator varies because of missing values

TABLE 2 Rodent self-report and mouse allergen distribution in kitchen dust for all families

Self-reported rodents	Detectable allergen *N* (%)	Allergen concentration (ng/mg) median, IQR (range)[b]
No (155)[a]	73 (47%)	LOD, 0.054 (LOD—7.59)
Yes (33)	30 (91%)[a]	LOD, 3.241 (LOD—46.4)

[a]No dust for analysis ($N=16$)
[b]LOD = limit of detection

socioeconomic or demographic characteristics, and none were statistically significant.

A caretaker report of a smoker living in the house was associated with an almost fivefold risk of seeing a rodent in the house (odds ratio [OR] 4.74, $p=.0002$) (Table 3). Having pets in the home (OR = 2.02, $p=0.08$) and kitchen mold (OR 2.45, p = 0.07) showed a trend toward significance.

Household characteristics that were significantly associated with increased mouse allergen levels include lack of a working vacuum (OR = 2.15, $p=0.05$) having a smoker in the house (OR = 2.15, $p=0.04$) unwashed dishes/food or crumbs (OR = 1.93, $p=0.04$), and a detached house (OR = 2.49, $p=0.003$). Other characteristics that showed a trend toward significance were unsealed food (OR = 1.91, $p=0.09$), kitchen mold (OR = 2.21, $p=0.09$), and cracks in the kitchen wall (OR = 1.73, $p=0.07$).

Characteristics significantly associated with mouse allergen in the univariate analysis included smoker in the house, unwashed dishes, detached house, and lack of a working vacuum, and these effects were then examined in a model comprised of all four variables (Table 4). The effect of unwashed dishes/food and crumbs observed by study staff and of a detached house were modestly stronger in the adjusted model and remained significant. The associations with lack of a working vacuum and with a smoker were not significant in this final model.

DISCUSSION

Risk factors for rodent sightings and mouse allergen in homes of immigrant Latino families in Los Angeles included having a detached house, unwashed dishes/food or crumbs, as well as having a smoker living in the house and lack of a working vacuum. The associations that we observed in this study are generally consistent with results from previous studies.[13,18,19] Using a vacuum to clean has been associated with reduced mouse allergen compared with mopping the floor.[13] Conditions that may indicate underlying housing disrepair, such as mold (which was strongly but not significantly associated with detectable allergen and rodent sighting), have previously been associated with increased allergen and with greater asthma morbidity[18,20] as well as with pest infestation. Having unwashed dishes, and having crumbs on the floors because of lack of a working vacuum cleaner may provide access to food and water that could attract rodents, but which are potentially amenable to intervention at modest cost. Repairing substandard housing conditions is likely to be beyond the resources available to inner city families like our study participants.[21]

TABLE 3 Association of household characteristics with reported sightings and detectable mouse allergen: bivariate models

Characteristic	*N* (%) self-reporting rodents	OR (95% CI)[a]	*N* (%) with allergen levels > than LOD	OR (95% CI)[a]
Pets in the house		2.02 (0.91, 4.49)*		1.49 (0.83, 2.67)
Yes	21 (23%)		52 (61%)	
No	12 (11%)		52 (52%)	
Lack of a working Vacuum		1.40 (0.57, 3.43)		2.15 (1.02, 4.55)**
Yes	8 (20%)		28 (70%)	
No	25(16%)		76 (52%)	
Smoker in the house		4.74 (2.07,10.84)***		2.15 (1.04,4.46) **
Yes	16 (33%)		30 (70%)	
No	17 (11%)		74 (52%)	
Unsealed Food		2.34 (0.67, 8.21)		1.91 (0.91, 4.03)*
Yes	30 (18 %)		89 (59%)	
No	3 (7.9%)		15 (43%)	
Kitchen Mold		2.45 (0.92,6.57)*		2.21 (0.88,5.59)*
Yes	9 (33%)		18 (72%)	
No	24 (15%)		86 (54%)	
Unwashed dishes/food		1.56 (0.65, 3.72)		1.93 (1.04,3.55) **
Yes	25 (19%)		75 (62%)	
No	8 (11%)		29 (45%)	
Overflowing Trash		0.84 (0.37,1.91)		0.91 (0.50, 1.66)
Yes	10 (14%)		37 (54%)	
No	23 (18%)		67 (57%)	
Detached House		0.96 (0.44, 2.10)		2.49 (1.37, 4.53)***
Yes	16 (16%)		60 (67%)	
No	17 (17%)		44 (45%)	
Moisture in wall		0.96 (0.43, 2.13)		1.33 (0.74, 2.39)
Yes	18 (16%)		60 (59%)	
No	14 (16%)		42 (52%)	
Cracks in kitchen wall		1.54 (0.70, 3.38)		1.73 (0.96, 3.13)*
Yes	18 (21%)		52 (63%)	
No	15 (13%)		52 (50%)	
Built before 1950		0.75 (0.23, 2.42)		0.83 (0.32, 2.13)
Yes	27 (15%)		92 (89%)	
No	6 (25%)		12 (60%)	

*=$p<0.1$, **=$p<0.05$, ***=$p<0.01$
[a]Odds ratio (95% confidence interval)

TABLE 4 Association of detectable allergen with housing characteristics: multiple logistic regression model

Characteristic	OR	95% CI
Lack of a working vacuum	2.18	0.99, 4.80
Smoker in the house	2.09	0.96, 4.53
Unwashed dishes/food crumbs	2.16*	1.13, 4.13
Detached house	2.64**	1.41, 4.92

*=$p<0.05$, **=$p<0.01$

Several other aspects of this study merit comment, including the high frequency of detectable mouse allergen, even in homes without rodent sightings, and the unexpected association of detectable allergen with smoking and detached housing. Over half (51%) of our participants' homes had detectable mouse allergen in kitchen dust. These results have clinical and public health relevance to our study population. Although we did not assess sensitization to mouse allergen, all of the participating children were atopic, and other investigators have found strong associations between rodents, rodent allergen, and sensitization among atopic asthmatic children.[16] Almost all of the 33 families reporting rodent sightings had detectable allergen. However, observing rodents is not a sensitive screening question for mouse allergen exposure, as almost half of the families who had not observed rodents had detectable allergen in their homes. As routine measurement of allergen in house dust is not feasible in the context of clinical or public health interventions outside of the research setting, other means of identifying rodent infestations and their correspondence to detectable allergen would be useful to guide intervention.

Although detectable mouse allergen was frequent in our study (51%), the proportion of homes with detectable levels, and the levels of allergen, were generally lower than reported in other inner city dwellings selected based on the presence of a child with asthma (see Table 5) and in other urban dwellings from a national sample of U.S. housing.[13] Environmental assessment and training to reduce exposure to indoor allergens such as house dust mites and cockroaches have been shown in some studies to be both clinically and cost effective.[22] An intervention designed specifically to reduce rodent allergen in Boston homes by filling holes with copper mesh, vacuuming and cleaning, and using low-toxicity pesticides and traps resulted in marked reductions in allergen in kitchen and bedroom dust.[23] Because many of the risk factors for cockroach infestation, another allergenic pest, are also risk factors for rodent infestation (for example, availability of food and water sources), rodent control could be integrated into comprehensive and practical multifaceted interventions that train family members to target a variety of allergens. It would be beneficial to increase education/awareness of potential rodent allergens being in the house despite no obvious signs.

The association of detached homes with an increased rate of detectable mouse allergen is in contrast to the national sample of residences that found an increased concentration of allergen in high-rise and multilevel dwellings.[13] However, detached housing was more likely to be associated with rodent infestation in another study of homes of immigrant Latinas in Northern California.[18] The investigators in that study speculated that detached houses may offer many points of entry to rodents on the ground level and therefore it may be easier for mice to enter detached homes than to gain access to multilevel dwellings in California. Another possible explanation for our results is that because of the mild climate, detached houses may be less well sealed than multilevel units in Los Angeles, making it easier for mice to enter. Seasonal changes in Southern California are less dramatic than in other parts of the country and may have less of an impact on the rodent population in Los Angeles.

Having a smoker living in the house was strongly associated with rodent sightings and detectable rodent allergen (but was not significant in the model adjusted for other risk factors). This observation warrants further investigation.

This study has some limitations. Airborne mouse allergen is likely to be relevant to allergy and asthma exacerbations and it is not known how well airborne levels are correlated with concentrations in settled dust. Further research is needed to determine how well allergen in settled dust predicts airborne allergen. Because the

TABLE 5 Selected published descriptive rodent studies

Author/yr	Geographic location (% with detectable allergen)	Population	Allergen Measurement Range/LOD	Room where dust collected	Predictors of high allergen levels
Phip et al., 2000[11,19]	NCICAS-cities included: Baltimore (100%), Bronx (94%), Chicago (82%), Cleveland (74%), Detroit (87%), St. Louis (91%), Washington, DC (84%)	n=608, 75% black, 19% Hispanic, Inner city families	0–618 μg/gm (median 1.60) 0–294 μg/gm (median .52) 0–203 μg/gm (median .57)	Kitchen Bedroom TV room	Kitchen-cockroaches House >50 years disrepair
Stelmach et al., 2002[24]	Lodz, Poland inner city homes (46%)	n=39 mostly low-income children with asthma	0.1–2.34 μg/gm,(median 0.2) 0.09–1.62 μg/gm (median 0.23)	Kitchen bedroom	Visible evidence of mice
Chew et al., 2003[12]	NYC apartments (95%)	n=221 mothers in birth cohort study, 42% Black, 58% Dominican	GM 4.6 μg/gm GM 0.9 μg/gm	Kitchen Bedroom (bed)	Mouse sightings, presence of holes in walls, living in building with fewer than 8 floors, no cat
Matsui et al., 2004[14]	Baltimore middle class homes (75%)	n=335 children with asthma 49.3% white 38.4% black 12.3% other	Median 17 ng/gm Median 22 ng/gm Median 28 ng/gm	Kitchen Bedroom TV room	Lower maternal ed, city residence, higher cockroach levels in bdrm predictive of high bedrm mouse allergen levels
Cohn et al., 2004[13]	US homes, NSLAH 1 study, 75 locations across US. (82%)	831 homes, 80% white, 8% Hispanic	Median .36 μg/gm Median .28 μg/gm LOD=>1.6 μg/gm	Kitchen Bedroom	High rise apartments, mobile homes, older and low-income homes,
Phip et al., 2004[23]	Urban and suburban homes in Boston (42%)	n=498 infants, 74.7% white, 12.7% black, 5.6% Hispanic, 6.9% Asian and others	LOD=0.25 μg/gm Detectable vs. non-detectable in 31.65%33.25% (overall 42% of homes)	Kitchens Living rooms	Race, household income <$30,000, signs of mice or cockroaches in homes, maternal ed. less than college, living in city.
Berg, 2007	Inner city LA (51%)	N=202, 92% Latino	LOD>0.01 0.0014–46.4 ng/mg 51% had detectable MuP (mouse urinary protein) levels	Kitchen	Unwashed dishes or food crumbs, lack of a working vacuum and a caretaker report of a smoker in the home

study was cross-sectional and the sample included only homes where children with asthma resided, it is possible that the homes were not representative of inner city Los Angeles. However, the participants were recruited from several clinical sites serving a broad spectrum of inner city children, so it is likely that the homes were similar to those of other children with asthma.

In conclusion, rodent sightings and detectable mouse allergen in kitchen dust were found in more than 50% of homes of children with asthma in Los Angeles. This is common enough that it may have public health implications for children with asthma, as it has been shown to be a risk factor for sensitization and for clinical morbidity. Although detectable allergen was not routinely identified based on rodent sightings, many of the predictors of rodent allergen (such as unwashed dishes, food, and crumbs) are amenable to low-cost interventions that could be integrated with other measures to reduce exposure to indoor allergens.

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