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Predictors of Indoor Exposure to Mouse Allergen in Inner-City Elementary Schools

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Mouse allergen exposure is prevalent in homes and schools [1–3]. While home mouse allergen and predictors of home exposure have been well-characterized, little is known about school environments where children spend the majority of their day [4–6]. The ongoing School Inner-City Asthma Study (SICAS; NIH/NIAID) seeks to evaluate the role of school-specific exposures and asthma morbidity in urban students with asthma. In this report, we examined predictors of school-specific mouse exposure for children with asthma.

The SICAS study design has previously been reported [7]. Briefly, students with asthma were recruited from validated school screening surveys [8]. Students who fulfilled established inclusion/exclusion criteria modeled from other urban asthma studies were enrolled [7,9].

Classrooms/cafeterias were sampled (settled and airborne) twice during the academic year, approximately 6 months apart (designated as fall and spring, respectively) to assess seasonal differences. Home settled samples were also collected. School and home samples were linked to enrolled students and analyzed for indoor allergens using multiplex array technology (Indoor Biotechnologies, Charlottesville, Virginia). School/classroom and home environment assessments were made by trained research assistants using surveys, inspection forms and questionnaires. The study was approved by the Boston Children's Hospital Institutional Review Board.

School/classroom environment predictor variables analyzed included presence of school basement and signs of mice in the classroom/cafeteria. Home environment predictor variables included signs of mice in the home in the past 12 months and housing type (detached vs. attached).

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Wilcoxon rank sum test was used to analyze the relation between predictor variables and detectable levels of mouse allergen. When indicated, generalized estimating equation (GEE) models of log-transformed variables accounted for correlation from repeated observations. Analyses were generated using STATA 12 (StataCorp. 2011. *Stata Statistical Software: Release 12.* College Station, TX:StataCorp LP).

Twenty-nine schools participated in the study. Schools were built between 1904–2002, mean age 64.9 years. Mus m 1 settled levels were detectable in 96.8% and 92.3% of school and home samples, respectively, with much higher levels in students' schools/classrooms than their homes. Bla g 2 settled levels were detectable in only 1.2% of school and 2.9% of home samples, with similar findings seen for Der p 1. In addition, there were virtually no reports of cockroach signs in school classrooms and cafeterias.

Table I shows predictors of mouse allergen levels in classrooms, cafeterias and homes. Visible classroom mouse droppings was significantly associated with higher levels of classroom Mus m 1 settled dust in the spring (6.11 vs. 1.21 μg/g, p=0.002) and airborne levels in both the spring and fall (5.25 vs. 2.68 ng/m^3, p=0.007; 3.51 vs. 1.20 ng/m^3, p=0.04, respectively) (see eFigure 1a/b). Visible cafeteria mouse droppings was significantly associated with higher levels of cafeteria settled levels in the spring (6.50 vs. 0.21 μg/g, p=0.005). The presence of a school basement was predictive of higher cafeteria Mus m 1 airborne levels (1.83 vs. 0.97 ng/m^3, p=0.03).

Homes of enrolled students with evidence of mice in the past 12 months significantly predicted higher levels of Mus m 1 settled levels (0.30 vs. 0.03 μg/g, p<0.001). Detached one-family homes had a non-significant trend toward lower Mus m 1 settled levels.

The goal of this study was to determine whether a relationship exists between inner-city elementary school characteristics obtained by inspection and measured mouse allergen. Identifying predictors of school mouse allergen levels may help tailor intervention strategies towards schools/classrooms likely to have more exposure. To our knowledge, this is the first study looking at predictors of indoor mouse allergen exposure in urban schools of children with asthma.

In this study, we found a relationship between signs of mice and higher levels of mouse allergen, mainly in the spring. Mouse allergen levels were higher during the spring season in both classrooms and cafeterias. A plausible explanation is that during the summer months when students are on break, the schools are thoroughly cleaned, thereby, lessening allergen present in the fall season. Moreover, during the colder fall/winter months the mice are likely breeding covertly, resulting in lower allergen levels. During the warmer spring/summer months the mice emerge leading to higher allergen levels but interestingly, the same or less visible droppings. Based on these findings of seasonal variability, the spring season may be a time when more intense integrated pest management (IPM) is necessary to control levels.

There may have been less statistical significance for cafeterias than classrooms with respect to visible mouse droppings predicting higher allergen levels given that fewer cafeterias were sampled, resulting in less power. The only statistically significant finding for cafeteria was that signs of mice were predictive of higher settled allergen levels in the spring, consistent with findings seen in the classroom. Interestingly, the presence of a basement did not predict higher classroom allergen levels as would be expected and was only associated with higher cafeteria airborne levels.

Similar to previous studies, the reported presence of mice in homes was predictive of higher mouse allergen levels [5,6]. However, home allergen levels were much lower than school

levels. Housing type did not predict allergen levels although detached one-family homes seemed to have lower levels, consistent with other published findings [4,10].

Although we found a significant association between visible classroom mouse droppings and higher mouse allergen levels, it is important to note that there was still a substantial amount of allergen present even when droppings were not seen. Matsui et al. reported more days of asthma symptoms, rescue medication use and a greater risk of asthma-related healthcare use in inner-city Baltimore preschool children exposed to >0.5 μg/g of Mus m 1 in bedroom settled dust [3]. Our settled mouse allergen levels exceeded this cut-off even in the groups that did not see mouse droppings. If a Mus m 1 level of >0.5 μg/g is indeed associated with an increase in asthma symptoms and healthcare utilization, then actual measurement of allergen levels may be more informative for assessing asthma morbidity outcomes than relying on reported school characteristics as a surrogate for allergen exposure.

This study demonstrated that children with asthma are exposed to significant levels of mouse allergen in inner-city schools. We found that when mouse droppings are seen in the classroom there are much higher levels of settled mouse allergen than if there are no signs of mice. However, even if droppings are not seen there are still significant levels of mouse allergen, >0.5 μg/g of Mus m 1, a level linked to an increase in asthma symptoms and healthcare utilization. Based on our findings, objective sampling in schools may still be necessary to determine the extent of mouse exposure. IPM strategies may need to be more intensely applied in the spring, although year long strategies are likely necessary to tackle this potential public health problem in the school environment.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. Phipatanakul W, Eggleston PA, Wright EC, Wood RA. Mouse allergen. I. The prevalence of mouse allergen in inner-city homes. The National Cooperative Inner-City Asthma Study. J Allergy Clin Immunol. 2000; 106:1070–4. [PubMed: 11112888]
2. Permaul P, Hoffman E, Fu C, et al. Allergens in urban schools and homes of children with asthma. Pediatr Allergy Immunol. 2012; 23:543–9. [PubMed: 22672325]
3. Matsui EC, Eggleston PA, Buckley TJ, et al. Household mouse allergen exposure and asthma morbidity in inner-city preschool children. Ann Allergy Asthma Immunol. 2006; 97:514–20. [PubMed: 17069107]
4. Phipatanakul W, Gold DR, Muilenberg M, Sredl DL, Weiss ST, Celedón JC. Predictors of indoor exposure to mouse allergen in urban and suburban homes in Boston. Allergy. 2005; 60:697–701. [PubMed: 15813819]

5. Salo PM, Arbes SJ, Crockett PW, Thorne PS, Cohn RD, Zeldin DC. Exposure to multiple indoor allergens in US homes and its relationship to asthma. J Allergy Clin Immunol. 2008; 121:678–84. e2. [PubMed: 18255132]

6. Berg J, McConnell R, Milam J, et al. Rodent allergen in Los Angeles inner city homes of children with asthma. J Urban Health. 2008; 85:52–61. [PubMed: 18004665]

7. Phipatanakul W, Bailey A, Hoffman EB, et al. The school inner-city asthma study: design, methods, and lessons learned. J Asthma. 2011; 48:1007–14. [PubMed: 22010992]

8. Redline S, Gruchalla RS, Wolf RL, et al. Development and validation of school-based asthma and allergy screening questionnaires in a 4-city study. Ann Allergy Asthma Immunol. 2004; 93:36–48. [PubMed: 15281470]

9. Mitchell H, Senturia Y, Gergen P, et al. Design and methods of the National Cooperative Inner-City Asthma Study. Pediatr Pulmonol. 1997; 24:237–52. [PubMed: 9368258]

10. Chew GL, Perzanowski MS, Miller RL, et al. Distribution and determinants of mouse allergen exposure in low-income New York City apartments. Environ Health Perspect. 2003; 111:1348–51. [PubMed: 12896857]

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Table I

Predictors of Mouse (Mus m 1) Allergen Levels in Classrooms, Cafeterias, and Homes

		Mus m 1 - Settled Dust (μg/g)				Mus m 1 – Airborne Dust (ng/m^3)			
		Number	Median	25th to 75th percentile	*P*-value	Number	Median	25th to 75th percentile	*P*-value
CLASSROOM									
	[*]**Signs of mice**								
Fall	**No**	166	0.45	(0.15 – 1.95)	0.12	162	1.20	(0.54 – 2.83)	0.04
	Yes	21	2.22	(0.10 – 5.28)		20	3.51	(0.87 – 6.34)	
Spring	**No**	162	1.21	(0.31 – 4.53)	0.002	153	2.68	(1.04 – 4.86)	0.007
	Yes	20	6.11	(2.14 – 9.15)		18	5.25	(3.00 – 11.75)	
	[†]**Basement present**								
	No	119[a]	1.38	(0.33 – 4.53)	0.67	116[a]	2.21	(0.77 – 4.16)	0.72
	Yes	253[b]	0.62	(0.16 – 3.81)		240[b]	1.78	(0.70 – 4.50)	
SCHOOL CAFETERIA									
	[£]**Signs of mice**								
Fall	**No**	20	0.15	(0.01 – 5.67)	0.91	20	1.20	(0.51 – 5.59)	0.61
	Yes	7	0.05	(0.03 – 2.44)		8	1.35	(0.59 – 2.21)	
Spring	**No**	17	0.21	(0.03 – 1.72)	0.005	14	1.21	(0.69 – 3.71)	0.50
	Yes	11	6.50	(1.07 – 15.15)		7	1.67	(0.97 – 20.54)	
	[†]**Basement present**								
	No	16[a]	0.31	(0.06 – 4.03)	0.92	14[a]	0.97	(0.47 – 1.68)	0.03
	Yes	39[b]	1.01	(0.02 – 5.35)		35[b]	1.83	(0.69 – 5.68)	
HOME									
	[‡]**Signs of mice**								
	No	142	0.03	(0.01 – 0.23)	<0.001				
	Yes	129	0.30	(0.07 – 1.28)					
	[‡€]**Detached home**								
	No	238	0.12	(0.02 – 0.48)	0.61				

	Mus m 1 - Settled Dust (μg/g)				Mus m 1 – Airborne Dust (ng/m^3)			
	Number	**Median**	**25th to 75th percentile**	***P*-value**	**Number**	**Median**	**25th to 75th percentile**	***P*-value**
Yes	33	0.06	(0.02 – 0.47)					

[*] Classroom inspection form filled out at the time of each seasonal sampling of classrooms

[†] One school environment survey filled out per school;

[a] 9 schools,

[b] 20 schools

[£] Cafeteria inspection form filled out at the time of each seasonal sampling of cafeterias

[‡] One baseline questionnaire filled out per home; one settled dust sample collected during the year; no home airborne dust samples collected

[€] Detached home (one-family house detached from any other house); Attached home (one-family home attached to one or more houses and buildings with ≥ 2 apartments).