

Limitations of a Home Characteristics Questionnaire as a Predictor of Indoor Allergen Levels

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We examined associations between reported home characteristics and levels of indoor allergens in 499 homes of a birth cohort of children of allergic/asthmatic families from the Boston area. The risk of having dust mite allergen (*Der f 1* or *Der p 1*) $\geq 2 \mu\text{g/g}$ on the bedroom floor was highest in houses, but 16% of apartments had levels this high. Compared with that from smooth floors, dust from carpeted bedroom floors had 2.1 times the risk of dust mite allergen $\geq 10 \mu\text{g/g}$, but levels exceeded $2 \mu\text{g/g}$ in 32% of uncarpeted floors. The risk of dust mite allergen $\geq 10 \mu\text{g/g}$ of dust from plastic-encased mattresses was 0.5 times that for cloth mattresses, but levels in 21% of plastic-encased mattresses were $\geq 2 \mu\text{g/g}$. In 93% of homes with and 3% of homes without cats, *Fel d 1* was $\geq 8 \mu\text{g/g}$, but 34% of homes without cats had *Fel d 1* $\geq 1 \mu\text{g/g}$. Cockroach allergen (*Bla g 1* or *Bla g 2*) was $\geq 2 \text{ U/g}$ of kitchen dust in 26% of apartments and only 6% of houses, and it was detected in 48% of homes with no reported signs of cockroaches in the previous 12 mo. Home characteristics reporting is a relatively weak predictor of the absence of allergen, and exposure can occur even when no cats are present, beds are encased in plastic, no carpets are present, and no signs of cockroaches have been reported. Chew GL, Burge HA, Dockery DW, Muilenberg ML, Weiss ST, Gold DR. Limitations of a home characteristics questionnaire as a predictor of indoor allergen levels.

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Questionnaires are commonly used in epidemiologic studies to obtain information about housing characteristics that might be associated with health outcomes (1-4). In addition, clinicians commonly question patients about environmental conditions that might lead to allergen exposures. Although it is generally accepted that certain home characteristics are associated with the presence of certain allergens (4), the strengths of the associations between home characteristics and allergen levels are not completely understood (5). When clinicians ask whether dust mite sensitized asthmatics have carpeting in their bedroom, they do not know the likelihood that the presence of carpeting will predict exposure to dust mite allergens at levels that may exacerbate the patient's asthmatic symptoms. Nor do they know the likelihood that the absence of a carpet will predict the absence of exposure to dust mite allergens at levels that may exacerbate symptoms. We investigated the positive and negative predictive power of home characteristics to predict allergen exposures at high levels associated with sensitization or exacerbation of asthma in sensitized asthmatics and at lower levels believed to be associated with sensitization or exacerbation

of asthma in particularly sensitive individuals or populations. We did so through a cross-sectional study of associations between home characteristics and dust mite (*Der f 1* and *Der p 1*), cat (*Fel d 1*), and cockroach (*Bla g 1* and *Bla g 2*) allergens in Boston area homes from a birth cohort of children whose parents had a history of doctor-diagnosed inhalant allergy and/or asthma.

METHODS

Study Cohort

Participants were part of a metropolitan Boston prospective birth cohort study designed to examine relationships between exposure to indoor allergens and the development of allergic sensitization and asthma. The 505 infants from 499 families were enrolled on the basis of parental history of doctor-diagnosed asthma, hay fever, or allergy and no plan to change residence during the first year of follow-up. All primary care-givers of the selected children gave informed consent to be included in this study.

Questionnaires

During a home visit when the index child was 2 to 3 mo of age (November 1994 through October 1996), a trained field technician administered a home characteristics to the primary care-giver. Questions inquired about building structure, type of heating, home dampness and the presence of fungi, as well as other factors such as presence of pets and frequency of cleaning. The care-giver was asked to indicate the type of floor covering that occupied most of the child's bedroom; the field technician reported the type of surfaced that was vacuumed, which could include a rug that did not occupy most of the bedroom.

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Temperature and Relative Humidity Measurements

A psychrometer was placed on the infant's bedroom floor. Wet-bulb and dry-bulb temperatures were recorded after a 3-min equilibration period, and relative humidity was calculated from these two temperatures (6). Indoor absolute humidity of each home was calculated using a psychrometric chart.

Dust Collection

Dust samples were collected with a Eureka Mighty-Mite II canister vacuum cleaner (Model 3621; The Eureka Co., Bloomington, IN) modified to collect dust in a 19 × 90-mm cellulose extraction thimble (Whatman International, Maidstone, Kent, UK). All surfaces that could contact the thimble, causing cross-sample contamination, were cleaned with isopropanol between each sample collection. Four separate dust samples were collected by vacuuming the following areas for the following lengths of time: (1) 2 m² of the floor surrounding the baby's bed for 5 min; (2) all layers of bedding, including mattress and pillows, for 5 min; (3) the family room chair or sofa most commonly used by the care-giver when holding or feeding the infant for 2.5 min; 2 m² of the floor around the chair or sofa and in high-traffic areas for 2.5 min; (4) the kitchen floor for 5 min, concentrating on edges by cabinets, inside cabinets under the sink, and around the refrigerator. If a rug was present in any of the rooms, half of the time was devoted to sampling the rug. After sampling, each thimble was sealed in a plastic bag and returned to the laboratory the same day for sifting and weighing.

Dust Extraction and Allergen Analysis

Each dust sample was sieved through 425-μm mesh, and the fine dust was weighed. ELISAs for *Der p* 1, *Der f* 1, *Fel d* 1, *Bla g* 1, and *Bla g* 2 were performed (7–9). Instead of stopping the reactions with sodium azide, optical density was measured kinetically for a total of 5 min using a CERES900C microtiter plate reader (Bio-Tek Instruments, Winooski, VT). Allergen concentrations were reported as micrograms per gram of dust except for *Bla g* 1 and *Bla g* 2, which were reported in units per gram (U/g) of dust. Bedroom and living room dust samples were analyzed for all allergens except for *Bla g* 2. Kitchen dust samples were analyzed for all allergens. When limited dust was available from the bed, bedroom floor, or family room, *Der f* 1 was analyzed first, followed by *Der p* 1, *Fel d* 1, and finally *Bla g* 1. For kitchen sam-

ples, *Bla g* 1 was analyzed first, followed by *Bla g* 2, *Fel d* 1, *Der f* 1, and finally *Der p* 1.

Definitions of Categorical Variables

The questionnaire outcomes were treated as categorical variables. For example, the type of home was grouped into: (1) buildings with three or more apartments and (2) houses and duplexes. Seasons were categorized as winter (November–February), spring (March–May), summer (June–August), and fall (September–October). Allergen levels were grouped to provide categories that might be relevant to sensitization and development of asthma. Dichotomous categories with two different cut points were created for *Der f* 1 or *Der p* 1 (cut points = 2 and 10 μg/g) (10, 11); *Fel d* 1 (cut points = 1 and 8 μg/g) (11, 12) and *Bla g* 1 or *Bla g* 2 (cut points = detectable 0.025 U/g and 2 U/g) (11, 12). Categories for dust mite allergen (*Der f* 1 or *Der p* 1) were slightly different from the international workshop recommendation of *Der f* 1 and *Der p* 1 (10).

Bed and bedroom floor samples containing too little dust (< 25 mg) to assay for *Der f* 1 or *Der p* 1 were grouped with “below limit of detection” samples for data analysis. When a kitchen had too little dust (< 25 mg) to assay *Bla g* 1 or *Bla g* 2, the sample was coded as “below limit of detection.” Samples that did not have enough dust for *Fel d* 1 analysis were coded as “missing” because the missingness could have been due to the fact that all available dust had been used for dust mite or cockroach allergen assays. The choice to group “no-dust samples” with the lower of the two allergen categories (i.e., greater than or less than a given cut point) was based upon the strong correlations between our 484 living room dust samples with detectable allergen concentration per unit mass and per unit area (e.g., *Der f* 1 μg/g versus *Der f* 1 μg/m²; $r = 0.98$, $p = 0.0001$). Custovic and colleagues (13) also found strong correlations between allergen concentration expressed in amounts per unit mass and per unit area, suggesting that locations that have little dust tend to have a low allergen concentrations per gram of dust.

Statistical Analysis

Associations between home characteristics and allergen levels were examined with 2 × 2 contingency tables, univariate and multiple logistic regression using SAS statistical software (SAS Institute, Inc., Cary, NC) (14). The negative predictive value of a question was reported as the probability of a dust sample having a low allergen concentration (i.e., below a given cut point), given the absence of a certain home characteristic. The positive predictive value of a question was reported as the probability or risk of a dust sample having a high allergen concentration (i.e., above a given cut point), given the presence of a certain home characteristic. Risk ratios from univariate analyses and odds

TABLE 1
LEVELS AND DISTRIBUTION OF ALLERGEN EXPOSURE

	Level Category					
	Living Room		Child's Floor		Child's Bed	
	(n)	(%)	(n)	(%)	(n)	(%)
<i>Der f</i> 1						
No dust	12	2.4	23	4.6	194	40.2
< 0.025 μg/g	23	4.6	30	6.0	11	2.3
0.025 to < 0.5 μg/g	125	25.2	110	22.1	89	18.5
0.5 to < 2 μg/g	107	21.6	109	21.9	80	16.6
2 to < 10 μg/g	105	21.2	102	20.5	69	14.3
≥ 10 μg/g	124	25.0	124	24.9	39	8.1
<i>Der p</i> 1						
No dust	20	4.0	37	7.4	260	52.1
< 0.025 μg/g	141	28.3	162	32.5	77	15.4
0.025 to < 0.5 μg/g	203	40.7	194	38.9	100	20.0
0.5 to < 2 μg/g	63	12.6	57	11.4	29	5.8
2 to < 10 μg/g	49	9.9	26	5.2	20	4.0
≥ 10 μg/g	23	4.6	23	4.6	13	2.6
<i>Fel d</i> 1						
No dust	25	5.05	61	12.2	312	62.5
< 1 μg/g	183	36.7	228	45.7	102	20.4
1 to < 8 μg/g	179	35.9	117	23.4	45	9.0
≥ 8 μg/g	112	22.4	93	18.6	40	8.0
<i>Bla g</i> 1						
No dust	31	6.2	62	12.4	13	2.6
< 0.025 U/g	342	68.7	310	62.1	266	53.3
0.025 to < 2 U/g	106	21.3	108	21.6	172	34.5
≥ 2 U/g	19	3.8	19	3.8	48	9.6

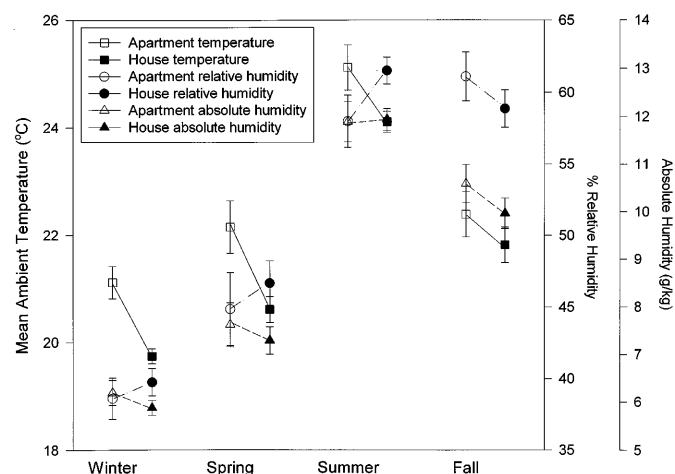


Figure 1. Mean ambient temperature, relative humidity, and absolute humidity of apartment and houses/duplexes by season. House and apartment temperatures were significantly different during winter, spring, and summer (Wilcoxon's rank sum $p < 0.05$).

TABLE 2
UNIVARIATE PREDICTORS OF MEDIUM TO HIGH AND HIGH LEVELS OF CAT ALLERGEN ON THE BEDROOM FLOOR

Variable	Number	≥ 1 µg/g			≥ 8 µg/g		
		(%)	(RR)	(95% CI)	(%)	(RR)	(95% CI)
Cat ever present in home							
No	183	32			2		
Yes	153	74	2.3	1.8–2.8	55	33.5	18.0–62.3
Cats in home, n							
None	347	34			3		
1 or more	90	100	2.9	2.4–3.5	93	36.0	24.7–52.4
Cats allowed in home, n							
None	351	35			3		
1 or more	86	100	2.9	2.4–3.6	94	27.5	19.4–39.2
Cats allowed in bedroom, n							
None	371	39			8		
1 or more	66	100	2.6	2.1–3.2	94	11.2	8.3–15.2

Definition of abbreviation: RR = risk ratio.

ratios from multiple regression were reported as measures of association. Seasonal differences between temperature and humidity measurements were assessed by Wilcoxon's rank sum and Student's *t* test procedures using an α level of 0.05.

RESULTS

Allergen Measurements

The most prevalent dust mite allergen was *Der f 1* (Table 1). In greater than 65% of homes, dust mite allergen concentrations were ≥ 2 µg/g, and *Fel d 1* concentrations were ≥ 1 µg/g in at least one of the sample locations. *Bla g 1* and *Bla g 2* at concentrations ≥ 2 U/g were recovered in kitchens with approximately the same frequency, 9% (46/498) and 8% (39/491), respectively.

Temperature and Humidity

Temperatures in apartments were higher than those in houses/duplexes during the winter, spring, and summer months ($p = 0.0001$, Wilcoxon's rank sum test) (Figure 1). Differences in

fall were not significant. There were no significant differences between humidity measurements in houses/duplexes and apartments.

Cat Allergen

It can be seen in Table 2 that every home with at least one cat had a bedroom floor dust sample with *Fel d 1* ≥ 1 µg/g and most had *Fel d 1* ≥ 8 µg/g. Conversely, 34% of homes without cats had a bedroom floor dust sample with *Fel d 1* ≥ 1 µg/g; only 3% of homes without cats had *Fel d 1* ≥ 8 µg/g. The frequency of *Fel d 1* ≥ 8 µg/g, in the bedroom floor was 36 times higher if a cat had ever been present in the home than if one had never been present. Other home characteristics, seasons, and temperature and humidity measurements were not significant predictors of *Fel d 1* concentrations.

Dust Mite Allergen

Thirty-six percent of dust samples from smooth-floored bedrooms (according to field technician reports) contained *Der f 1* or *Der p 1* ≥ 2 µg/g compared with 50% of samples from bedroom floors with any carpeting (Table 3). Using a higher cut point of 10 µg/g, the difference between smooth-floored and carpeted rooms was more pronounced. Of the carpeted floors that were vacuumed, the risk of having *Der f 1* or *Der p 1* ≥ 2 µg/g was significantly higher in carpets with thicker pile (> 1 cm) than in those with lower pile. Parental report of the main floor covering was not predictive for any category of dust mite allergen level for any location.

More than 70% of the houses/duplexes had either *Der p 1* or *Der f 1* in their beds, bedroom floors, or living rooms in concentrations ≥ 2 µg/g compared with only 41% of samples from apartments. In each sample location, the percentage of houses/duplexes with dust mite allergen levels ≥ 2 µg/g and ≥ 10 µg/g was higher than that of apartments (Table 3). For example, 42 of the 47 bed samples with *Der f 1* or *Der p 1* ≥ 10 µg/g came from house/duplexes.

Insufficient amounts of dust for analysis were recovered for 42% of plastic-encased mattresses and 33% of the mattresses without plastic encasing. The infant's bed was less likely to have *Der f 1* or *Der p 1* ≥ 10 µg/g if the mattress was encased in

TABLE 3
UNIVARIATE PREDICTORS OF MEDIUM TO HIGH AND HIGH LEVELS OF DUST MITE ALLERGEN (*Der f 1* OR *Der p 1*) ON THE BEDROOM FLOOR AND IN THE BED

Variable	Number	Floor Dust						Bed Dust					
		≥ 2 µg/g			≥ 10 µg/g			≥ 2 µg/g			≥ 10 µg/g		
		(%)	(RR)	(95% CI)	(%)	(RR)	(95% CI)	(%)	(RR)	(95% CI)	(%)	(RR)	(95% CI)
Type of building													
Apartment	118	27			16			10			4		
House/duplex	380	53	2.0	1.5–2.6	29	1.8	1.2–2.7	27	2.7	1.6–4.4	11	2.6	1.1–6.1
Main type of floor covering													
Smooth	163	44			19			25			10		
Carpeted	257	51	1.2	0.9–1.4	32	1.7	1.2–2.4	23	0.9	0.6–1.3	10	1.0	0.5–1.8
Surface vacuumed by field technician													
Smooth	135	32			14			24			10		
Carpeted	364	52	1.6	1.3–2.1	30	2.1	1.4–3.2	23	1.0	0.7–1.4	9	0.9	0.5–1.6
Plastic-encased mattress													
No	102	44			26			29			15		
Yes	383	47	1.1	0.8–1.4	25	1.0	0.7–1.4	21	0.7	0.5–1.0	8	0.5	0.3–0.9
Carpet thickness													
< 1 cm	73	36			16								
≥ 1 cm	246	57	1.6	1.2–2.1	37	2.2	1.4–3.6						

Definition of abbreviation: RR = risk ratio.

TABLE 4
MULTIPLE LOGISTIC REGRESSION MODELS

Allergen	Location	Variable	Odds Ratio	95% CI
<i>Der p 1</i> or <i>Der f 1</i> (Cut point = 2 µg/g)	Child's bed	Single-family home	3.6	1.8–7.0
		Plastic-encased mattress	0.6	0.4–0.97
	Bedroom floor	Single-family home	2.9	1.9–4.7
		Presence of any carpeting*	2.3	1.5–3.5
	Family Room	Single-family home	3.4	2.1–5.3
		Summer sampling period	2.0	1.1–3.6
		Fall sampling period	3.4	1.7–6.8
<i>Bla g 1</i> or <i>Bla g 2</i> (Cut point = 0.025 U/g)	Kitchen	Winter sampling period	2.3	1.3–4.0
		Single-family home	0.5	0.3–0.8
		Use of boric acid in previous 12 mo	3.7	1.0–13.8
		Summer sampling period	1.6	1.1–2.6
		Fall sampling period	1.7	0.9–3.0
		Spring sampling period	0.9	0.6–1.6
<i>Bla g 1</i> or <i>Bla g 2</i> (Cut point = 2 U/g)	Kitchen	Single-family home	0.3	0.2–0.6
		Signs of cockroaches in previous 12 mo	10.6	5.2–21.2

* As reported by the field technician.

plastic than if it were not encased (Table 3). Encasement did not significantly predict dust mite allergen level using a lower cut point of 2 µg/g. Of the mattresses without plastic encasing, the proportion with low levels of allergen (negative predictive value) was 71% for a cut point of 2 µg/g and 85% for a cut point of 10 µg/g (Table 3).

Adjusting for the type of building, the following variables: plastic-encasement of mattresses, floor covering (as reported by field technician), and season, remained significant in the multiple regression models for bed, bedroom floor, and family room samples, respectively (Table 4). With spring as the baseline group, family room levels of dust mite allergen were highest in fall, followed by winter and then by summer. Although increased indoor temperature was a univariate predictor of dust mite allergen < 2 µg/g in each sample location, it did not remain a significant predictor in the multivariable models after adjusting for the type of building. Season and relative and absolute humidity were not significant predictors in the univariate or multivariable models for dust mite allergen in bed or bedroom floor. Interaction terms between home characteristics, seasons, and temperature and humidity measurements were not significant predictors in any of the models.

Cockroach Allergen

The number of dust samples from apartment kitchens containing *Bla g 1* or *Bla g 2* ≥ 2 U/g was 4.3 times higher than that of samples from house/duplex kitchens (Table 5). Signs of cockroaches in the previous month and in the previous 12 mo, and use of boric acid increased the frequency of recovering cockroach allergen ≥ 2 U/g in the kitchen. The risk of cockroach allergen ≥ 0.025 U/g was 40% higher in kitchens with reported cockroaches in the previous 12 mo, than in those without such report. However, 48% of homes without reported signs of cockroaches still had levels of cockroach allergen ≥ 0.025 U/g in their dust, and 6% had ≥ 2 U/g.

Adjusting for signs of cockroaches in the previous 12 mo, apartment buildings were more likely than houses/duplexes to have kitchen *Bla g 1* or *Bla g 2* ≥ 2 U/g (Table 4). Adjusting for use of boric acid and season, the odds of recovering detectable levels of cockroach allergen (i.e., kitchen *Bla g 1* or *Bla g 2* ≥ 0.025 U/g) were also lower for houses/duplexes than for apartments (OR = 0.5, 95% CI = 0.4 to 0.9). Dust samples from summer had a higher odds of detectable cockroach allergen than did those from winter, OR = 1.6, 95% CI = 1.1 to 2.6 (Table 4).

Interaction terms were not significant in any of the multiple regression models.

DISCUSSION

This study has demonstrated that although certain home characteristics are significant predictors of dust mite, cat, and cockroach allergen exposure, they may not be sufficiently predictive for many clinical and epidemiologic purposes. Our results indicate that positive responses to some questions do not necessarily mean that allergen levels will be high (except in the case of *Fel d 1* and owning a cat) or that negative responses mean that allergen levels will be low. Epidemiologic studies have begun to suggest associations between sensitization and measured allergen levels in house dust that are lower than the lowest cut points used in our study (15, 16). Our data suggest that home characteristics are particularly poor at predicting whether or not low levels of allergen are present in the home.

We did not assess the reproducibility of our questionnaire responses, and for many of the time-varying covariates, such testing would be difficult. Other investigators have tested reproducibility for a limited number of our questions (17–19). Dales and colleagues (18) found 87% to 95% agreement be-

TABLE 5
UNIVARIATE PREDICTORS OF DETECTABLE AND HIGH LEVELS OF COCKROACH ALLERGEN (*Bla g 1* OR *Bla g 2*) IN THE KITCHEN

Variable	Number	≥ 0.025 U/g			≥ 2 U/g		
		(%)	(RR)	(95% CI)	(%)	(RR)	(95% CI)
Type of building							
House/duplex	379	46			6		
Apartment	116	61	1.4	1.1–1.6	26	4.3	2.7–6.8
Signs of cockroaches in previous 12 mo							
No	442	48			6		
Yes	53	66	1.4	1.1–1.8	49	7.7	5.1–11.9
Signs of cockroaches in previous month							
No	452	48			7		
Yes	43	67	1.4	1.1–1.8	53	7.8	5.1–12.0
Use of boric acid in previous 12 mo							
No	462	49			9		
Yes	14	79	1.6	1.0–2.4	50	5.4	2.7–10.5

Definition of abbreviation: RR = risk ratio.

tween answers to home dampness questions distributed 1 mo apart. Andrae and colleagues (14) also found good agreement between questions regarding dampness and visible mold growth, although questions regarding construction materials of the home were somewhat problematic. We expect that the main variables with the best predictive power in our study (type of home, presence of a cat, presence of carpeting, etc.) would have better reproducibility than the questions about home dampness.

Cat Allergen

We found that a report of one or more cats currently in the household is the best predictor for *Fel d 1* levels ≥ 1 and ≥ 8 $\mu\text{g/g}$ of dust. However, as noted in other studies, homes without cats often have detectable cat allergen, although they do not usually have high levels of cat allergen (2, 20). Sources of cat allergen in homes without cats include residual allergen from former cat occupants and allergen shed from clothing of visitors or from occupants who have visited homes with cats. A group of cat questions might be made more sensitive by including questions specifically directed toward these allergen sources.

Dust Mite Allergen

The best predictor of dust mite allergen (≥ 2 and ≥ 10 $\mu\text{g/g}$) in bed, bedroom floor, and family room dust samples was type of building. Other investigators have reported a similar association, and have speculated that multifamily buildings are draftier (i.e., have higher air exchange rates) and are subsequently drier than single family homes (21, 22). However, we did not find a significant difference in humidity in any season for the two dwelling types in Boston. We did see a significant difference in temperature during the heating season between the two dwelling types, with apartments having higher average temperatures than houses/duplexes. Increased temperature could lead to warming of surfaces and resultant decreases in microenvironmental relative humidity (water activity). The type of building may have more reliably represented the relevant humidity and/or temperature conditions that affect dust mite populations and subsequently allergen levels than the short-term measurements of these environmental variables made during a single home visit. Although type of building was generally predictive of dust mite allergen levels, as much as 27% of apartments still had *Der f 1* or *Der p 1* ≥ 2 $\mu\text{g/g}$ in dust samples from bedrooms and/or family rooms.

Other important predictors of dust mite allergen levels were the type of surface vacuumed (i.e., smooth versus carpeted floors, carpet thickness < 1 cm versus ≥ 1 cm, plastic-encased versus cloth mattresses) and the season of sample collection. These variables were significant in the studies from The Netherlands and the United Kingdom (4, 23). However, in contrast to the Dutch and British studies, we did not find that other variables such as frequency or temperature of washing sheets, age of carpet and mattress, age of dwelling, number of occupants, or use of air-conditioning were significantly predictive of dust mite allergen levels (4, 24–26). Possible reasons why we did not find significant associations with these variables include (1) different types of carpets and mattresses compared with other studies, (2) inability to accurately define and therefore control for age of building (35% [41 of 118] of the respondents in apartments did not know the age of their building compared with only 8% [31 of 380] of their house/duplex counterparts), (3) different settings for temperature of washing laundry compared with that in other studies, and (4) sporadic use of air-conditioners in our study homes. This study was also limited by only having allergen measurements for 1 d from each home rather than multiple measurements. The lack

of an association between presence of carpeting and high dust mite allergen levels in family rooms was probably due to the pooled nature of the family room dust sample, which included dust from upholstered furniture as well as from floors.

Seasonal factors are important for dust mite allergen recoveries. A fall peak in dust mite allergen levels was observed, probably reflecting a peak population of dust mites in late summer as was found in Virginia (27). Clinicians should recognize that climatic factors in addition to home characteristics can control dust mite populations and their subsequent allergen production.

Cockroach Allergen

The most predictive factors for detectable cockroach allergen (levels ≥ 0.025 U/g) were type of building, boric acid use, and summer or fall sampling period. Apartment buildings provide a unique habitat for cockroaches. If one apartment becomes infested, then cockroaches can easily migrate to other apartments. Even though individual tenants may be able to reduce the extent of cockroach infestation in individual apartments, amelioration of infestation in the entire building may be necessary to eliminate cockroach populations in any given apartment.

The association between boric acid use and high *Bla g 1* and *Bla g 2* levels might be due to interference with the ELISA; on the other hand, the association is more likely related to the fact that boric acid is generally used only when cockroach infestation is a recognized problem. In homes that used boric acid, the number of cockroaches may have been reduced, but levels of allergen that have been associated with sensitization remain in the dust (11, 12). As Mollet and colleagues (28) also observed in Virginia, homes in our study that were sampled in the summer and fall months were more likely to have detectable cockroach allergen than those sampled during winter or spring. The observed seasonal increase is probably related to the cyclic patterns in cockroach populations.

Of the 53 homes reporting cockroaches, approximately half had cockroach allergen levels above 2 U/g. Pollart and colleagues (9) found 20% of homes not reporting signs of cockroaches had *Bla g 2* levels ≥ 2 U/g. Only 4% (16 of 416) of our homes not reporting cockroaches had *Bla g 2* levels that were this high. Of interest was not only that report of cockroaches predicted high (≥ 2 U/g) cockroach allergen levels, but also that many homes (212 of 442) in which cockroaches were not seen, had detectable cockroach allergen. In cockroach-sensitized symptomatic asthmatics, perhaps cockroach allergen concentrations need to be measured even when cockroach infestation is not obvious.

Conclusions

Boston is an urban/suburban community with climate and housing characteristics similar to other Northeastern U.S. cities, but different from those in many other regions of the United States and the world. For example, in regions where apartments are not as dry and hot in the winter as Boston apartments, mite infestations may be similar in both apartment and single-family houses. Additionally, cockroaches may thrive in both apartments and single-family houses in continuously hot and humid climates. Cultural differences such as the use of different types of bedding might influence dust mite allergen levels. For example, German and Dutch studies have found that mattresses with animal blankets and no plastic sheeting have higher dust mite allergen concentrations than do those without these characteristics (24, 29). In the United States, most infant's mattresses are encased in plastic and few

have woolen blankets. Nevertheless, the overall finding of this study is likely to be generalizable: although certain home characteristics predict the presence of high levels of certain allergens, allergen exposure can be present even in the absence of that characteristic.

Clinicians should be concerned about the possibility of continued exposure to significant concentrations of allergen if their dust mite sensitized asthmatics do not improve symptomatically even after the removal of carpets and enclosure of mattresses in plastic casing. Cat-sensitized asthmatics might have some exposure to cat allergen even if they do not have a cat, although keeping a cat will most likely expose them to far higher levels. Investigators designing longitudinal studies of allergens as predictors of the development of asthma and allergy need to be cautious in the use of reported home characteristics as surrogates for allergen exposure.

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