Prediction of Residential Pet and Cockroach Allergen Levels Using Questionnaire Information

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We assessed the accuracy of questionnaire reports of cat and dog ownership and presence of cockroaches in predicting measured allergen concentrations in house dust. We collected dust samples in the homes of 932 newborns living in New England. Dust samples were taken from the main living area and the infant's bedding. Allergen content of house dust was measured by enzyme-linked immunosorbent assays (ELISA) and related to questionnaire information on past and current cat and dog ownership and presence of cockroaches. Allergen levels were dichotomized using the limit of detection and the following cut points: 1.0 μg/g and 8.0 μg/g for cat, 2.0 μg/g and 10.0 μg/g for dog, and 2 U/g and 8 U/g for cockroach allergen. For the upper cut point, both specificity and sensitivity of questionnaire-reported cat and dog ownership and presence of cockroaches were high. For the limit of detection and lower cut point, specificity was high (> 80%), whereas sensitivity was low, particularly for current cat and dog ownership (21–60%). Taking pet ownership during the preceding 2 years into account increased the sensitivity by 10%, but it remained relatively poor. In conclusion, questionnaire-reported pet ownership and presence of cockroaches predicts allergen levels above the upper cut point but is a relatively poor measure of allergen exposure above the limit of detection and the lower cut point. Knowledge of past pet ownership can improve pet allergen exposure assessment by means of questionnaire. However, for epidemiologic purposes, measured concentrations of allergens are necessary.
Key words: **allergens, cat, cockroach, dog, house dust.** ***Environ Health Perspect*** **112:834–839 (2004). doi:10.1289/ehp.6685 available via *http://dx.doi.org/* [Online 11 February 2004]**

Many asthmatics are allergic to pets. A positive association between cat allergen levels in house dust and serum-specific immunoglobulin E to cat during the first 3 years of life has been shown (Wahn et al. 1997). In recent years several studies have indicated that current and past pet ownership, particularly cat ownership, is associated with pet allergies, respiratory symptoms, and asthma (Anyo et al. 2002; Brunekreef et al. 1992; Nafstad et al. 2001; Svanes et al. 1999). However, a major deficiency in these studies involves the estimation of the participants' exposure to pet allergens. Questionnaire-reported pet ownership was used rather than measured allergen concentrations. This could have led to substantial misclassification of exposure.

Exposure to elevated levels of cockroach allergens was associated with an increased risk of skin prick test positivity and severity and morbidity of asthma and wheeze for children living in U.S. inner cities (Call et al. 1992; Eggleston et al. 1998; Gelber et al. 1993; Gold et al. 1999; Huss et al. 2001; Litonjua et al. 2001; Rosenstreich et al. 1997; Stelmach et al. 2002). In addition to visible signs of cockroach infestation (Chew et al. 1998; Gelber et al. 1993; Rauh et al. 2002), residence in an urban environment, lower socioeconomic status, nonwhite ethnicity, and degree of household disrepair have been identified as predictors for increased levels of cockroach allergens (Huss et al. 2001; Kitch et al. 2000; Leaderer et al. 2002; Sarpong et al. 1996). However, the predictability of these variables for the absence of cockroach allergens was low. For example, several authors reported significant levels of cockroach allergen for homes without reports of cockroach sighting (Chew et al. 1998; Gelber et al. 1993; Pollart et al. 1991; Rauh et al. 2002).

As part of a birth cohort study assessing the impact of environmental factors on asthma development and severity, we measured cat, dog, and cockroach allergen levels in dust samples from the homes of 932 newborns living in the northeastern United States, an area where office visits, emergency room visits, and hospitalizations for asthma are among the highest in the United States (Mannino et al. 1998). Concurrent with dust sampling, a questionnaire was administered to assess household characteristics that may be associated with measured allergen levels. Size and diversity of the study population, extensive measurement of indoor allergens, and comprehensive questionnaire information on household characteristics make this one of the most extensive databases on the nature of cat, dog, and cockroach allergen levels in homes of asthmatic children in the northeastern United States.

The focus of the present analysis is to assess how accurately questionnaire-reported cat and dog ownership and presence of cockroaches predicts measured concentrations of cat, dog, and cockroach allergen, taking into account present and past pet ownership for a period of 2 years. In contrast to the studies cited above, information on past pet ownership was available not just for 1 year, but for 2 years.

Materials and Methods

Study population. Between September 1996 and December 1998, 33,341 women delivering babies in five Connecticut hospitals and one hospital located in south-central Massachusetts were screened for inclusion in the study. Mothers who had a child at home between the ages of 3 and 10 years with a physician diagnosis of asthma were invited into the study. Of the 1,448 mothers identified as eligible for the study, 1,002 were enrolled, 334 declined to participate, and 112 could not participate for various reasons (e.g., moving out of the area, no phone).

Home interview. When the infants were between 2 and 4 months of age, trained research assistants visited the participants'

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We thank the 1,002 families in Connecticut and south-central Massachusetts who permitted us to conduct allergen dust sampling in their homes. We also thank the following hospitals from which our study population was selected: in Connecticut—Yale-New Haven, Danbury, Bridgeport, and Hartford; in Massachusetts—Bay State Medical Center.

This study was funded by grants ES07456, ES05410, and ES11013 from the National Institute of Environmental Health Sciences.

M.D. Chapman is an officer of INDOOR Biotechnologies Inc. (Charlottesville, VA), a company that manufactures ELISA systems for indoor allergen analysis. The other authors declare they have no competing financial interests.

Received 20 August 2003; accepted 11 February 2004.

homes and administered an initial questionnaire to each mother to obtain information about home and family characteristics and potential environmental exposures. For this analysis the following questions from the initial questionnaire were used:

- Which of the following animals do you keep in your home and how many? Cat, dog, hamster/gerbil/mice/guinea pigs/rabbits, bird, any other fur-bearing animal (specify).
- Does this pet go into the baby's room?
- To your knowledge; has there been a cat/dog living in your residence in the preceding 24 months? If yes: how many months ago was there a cat or dog living in your home?
- In your current home, have you observed any of the following pests in the preceding 12 months? Ants, spiders, cockroaches, termites?

Collection and analysis of dust samples. During the home interview the research assistant collected dust samples in the main living area of the home and from the infant's bedding in each home. All dust samples were collected using a standardized protocol (Leaderer et al. 2002). Collected dust samples were sifted through a 425-μm mesh sieve and weighed. Sifted dust was prepared by extracting 100 mg of the fine dust in 2 mL phosphate-buffered saline with Tween 20 and was quantitatively analyzed for the presence of major cat [*Felis domesticus* (Fel d 1)], dog [*Canis familiaris* (Can f 1)], and German cockroach [*Blatella germanica* (Bla g 1)] allergens using two-site monoclonal antibody–based enzyme-linked immunosorbent assays (ELISA) (Ingram et al. 1995; Pollart et al. 1991). Results are reported in micrograms per gram of fine dust for Fel d 1 and Can f 1 and in units per gram of fine dust for Bla g 1. The detection limit was 0.12 μg/g for Fel d 1 and Can f 1 and 0.6 U/g for Bla g 1.

Statistical analysis. Cat and dog allergen concentrations were dichotomized using the detection limit and cut points identified in the literature as potentially related to allergic sensitization (lower cut point) and exacerbation of asthma (upper cut point) (Call et al. 1992; Eggleston et al. 1998; Gelber et al. 1993). Lower and upper cut points were 1.0 μg/g and 8.0 μg/g for Fel d 1; 2.0 μg/g and 10.0 μg/g for Can f 1; and 2 U/g and 8 U/g for Bla g 1. Kappa coefficients (Landis and Koch 1977) were calculated to analyze the agreement between allergen levels measured in dust samples from the infant's bed and allergen levels measured in dust from the main living area, using four disjunctive categories: below the limit of detection, below the lower cut point, below the upper cut point, and above the upper cut point. Percentages of homes with allergen concentrations above the limit of detection, lower and upper cut point were calculated and compared with questionnaire-reported cat and dog ownership and presence of cockroaches, respectively. The accuracy of the questionnaire-reported current pet ownership and viewing of cockroaches in predicting homes with allergen levels above the limit of detection and lower and upper cut points was assessed by calculating sensitivity and specificity. The sensitivity of questionnaire data is defined as the probability that someone who is truly exposed to allergen levels above a given cutoff is classified as exposed by questionnaire data. The specificity of the questionnaire data is the probability that someone who is truly unexposed will be classified as unexposed. To simplify presentation, the present analysis was restricted to data from 932 homes for which complete data on measured allergens and questionnaire-reported cat and dog ownership and presence of cockroaches were available. Statistical significance was set at a 5% level. All statistical analysis was carried out using the statistical analysis software SAS for Windows, version 8.2 (SAS Institute Inc., Cary, NC, USA).

Table 1. Questionnaire-reported pet ownership and presence of cockroaches (n = 932).

Variables	Frequency No. (%)
Cat ownership	
Current	
> One cat	59 (6.3)
One cat	111 (11.9)
Past/none	
≤ 6 months ago	47 (5.0)
7–24 months ago	41 (4.4)
> 24 months ago/none	674 (72.3)
Dog ownership	
Current	
> One dog	37 (4.0)
One dog	181 (19.4)
Past/none	
≤ 6 months ago	57 (6.1)
7–24 months ago	57 (6.1)
> 24 months ago/none	600 (64.4)
Sightings of cockroaches, past 12 months	
Yes	185 (19.8)
No	747 (80.2)

Data from Connecticut and western Massachusetts, 1998–2000.

Results

Description of study population. The study population is described in detail elsewhere (Leaderer et al. 2002). In brief, Hispanics and African Americans were the largest minority groups, comprising 27 and 14% of the study population, respectively. One-third of the population had an annual household income < $20,000, and 41% of mothers had ≤ 12 years of education. Approximately one-fifth of the families lived in multifamily housing with four or more families.

Agreement between sampling locations. The agreement between allergen levels in dust from the main living area and dust from the infant's bed was fair for cat and cockroach allergen (kappa = 0.36 and 0.40, respectively) and moderate for dog allergen (kappa = 0.50).

Questionnaire-reported presence of cats, dogs, and cockroaches. Frequencies of questionnaire-reported cat and dog ownership and presence of cockroaches are presented in Table 1. Currently, cats or dogs were kept by 18 and 23% of the families, respectively, and an additional 9 and 12%, respectively, had kept a cat or dog at some time during the preceding 24 months. Sightings of cockroaches during the preceding 12 months were reported for approximately one-fifth of the homes.

House dust allergen concentrations. Percentage of homes with cat, dog, and cockroach allergen levels above the limit of detection, lower and upper cut point are presented in Figure 1. Results for the dust samples from the main living area and from the infant's bed are presented separately. Cat and dog allergens were detectable in most of the dust samples (≥ 70%), whereas only approximately one-fourth of the dust samples from the main living area and one-fifth of the dust samples from the infant's bed had detectable cockroach allergen. One-fifth of the main living areas had cat and dog allergen levels above the upper cut point of 8 and 10 μg/g, respectively. Allergen levels in dust samples from the infant's bedding were lower than those in the main living area. Only 17% of the infants' beds had cat

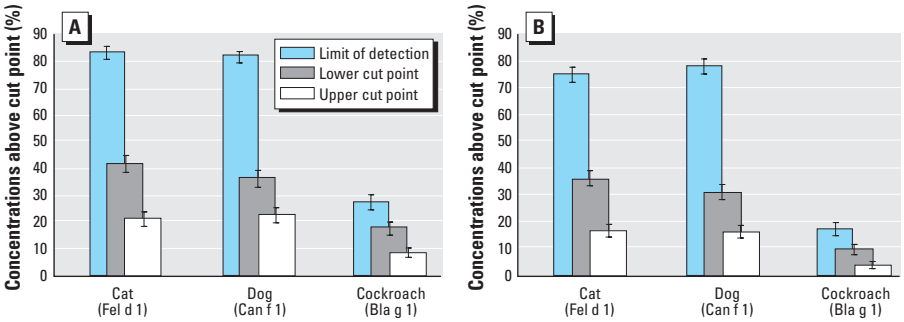

Figure 1. Percentages of homes with cat, dog, and cockroach allergen levels in (*A*) the main living area and (*B*) the infant's bed above the limit of detection and the lower and upper cut points. Limits of detection were 0.12 μg/g for cat and dog allergen and 0.6 U/g for cockroach allergen. Lower cut points were 1 μg/g, 2 μg/g, and 2 U/g, respectively; upper cut points were 8 μg/g, 10 μg/g, and 8 U/g, respectively. Error bars indicate 95% confidence intervals (CIs). Data from Connecticut and western Massachusetts, 1998–2000.

and dog allergen levels above the upper cut point. Cockroach allergen levels exceeding the upper cut point were far less frequent (9 and 4% for main living areas and infants' beds, respectively).

Percentages of cat allergen levels above the limit of detection and lower and upper cut points for homes of current and past cat owners are shown in Figure 2. Cat allergens were detectable in > 90% of the main living areas of homes where a cat was kept currently or at any time during the preceding 24 months and also in approximately 80% of the main living areas of homes where no cat was kept within the preceding 24 months. In most of the current cat owners' homes, allergen concentrations exceeded the upper cut point, whereas percentages were significantly less for homes of subjects who had had a cat within the preceding 24 months. Very few homes where a cat was not kept during the preceding 24 months had Fel d 1 levels above the upper cut point. No statistically significant difference in cat allergen concentrations in the main living area was found between homes with one cat and homes with two or more cats (Figure 2). The association between cat ownership and cat allergen levels in the dust samples from the infants' beds is very similar. Only percentages of allergen levels exceeding the upper cutoff points were somewhat lower. Cat allergen levels in the infant's bed were higher in homes where more than one cat was kept than in homes with one cat only. However, the difference was statistically significant for the upper cutoff only.

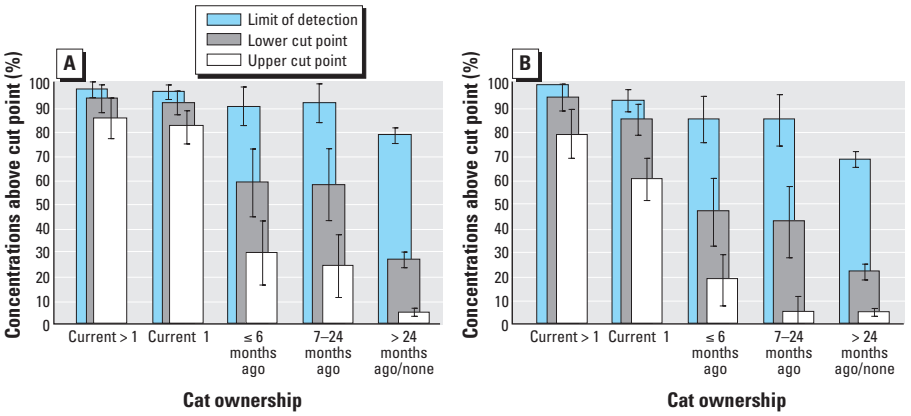

Figure 2. Percentage of cat allergen levels in (*A*) the main living area and (*B*) the infant's bed above the limit of detection (0.12 µg/g) and the lower (1 µg/g) and upper (8 µg/g) cut points related to questionnaire-reported current and past cat ownership. Error bars indicate 95% CIs. Data from Connecticut and western Massachusetts, 1998–2000.

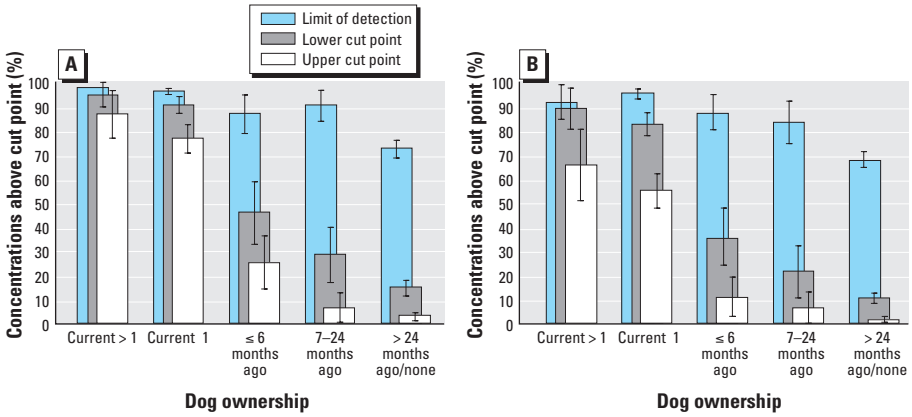

Figure 3. Percentage of dog allergen levels in (*A*) the main living area and (*B*) the infant's bed above the limit of detection (0.12 µg/g) and the lower (2 µg/g) and upper (10 µg/g) cut points related to questionnaire-reported current and past dog ownership. Error bars indicate 95% CIs. Data from Connecticut and western Massachusetts, 1998–2000.

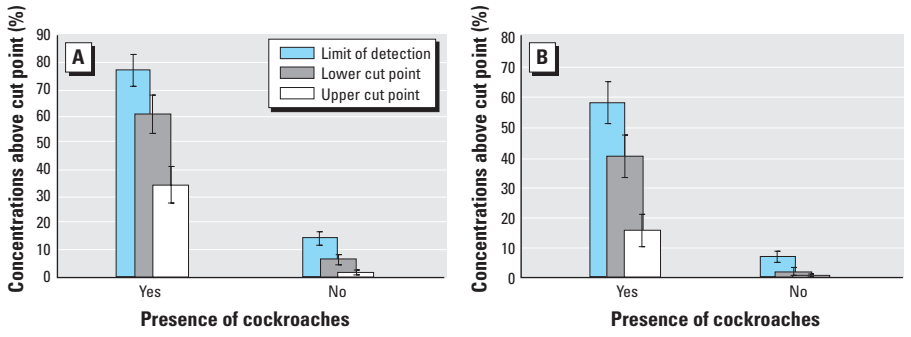

Figure 4. Percentage of cockroach allergen levels in (*A*) the main living area and (*B*) the infant's bed above the limit of detection (0.6 U/g) and the lower (2.0 U/g) and upper (8.0 U/g) cut points related to questionnaire-reported presence of cockroaches. Error bars indicate 95% CIs. Data from Connecticut and western Massachusetts, 1998–2000.

Percentages of dog allergen levels above the limit of detection and lower and upper cut points for homes of current and past dog owners are shown in Figure 3. Can f 1 was detectable in dust samples from the main living area and the infant's bed of nearly all homes where a dog was kept currently, in most of the homes where a dog was kept within the preceding 24 months, and even in three-fourths of the homes where no dog was kept within the preceding 24 months. In most of the current dog owners' homes, allergen concentrations exceeded the upper cut point. Homes where more than one dog was kept tended to have Can f 1 levels above the upper cut point more often compared with homes where only one dog was kept. Furthermore, main living areas of homes where a dog was kept within the preceding 6 months were more likely to have dog allergen levels above the lower and upper cut point compared with homes where a dog was kept between 7 and 24 months ago. The same was seen for the infants' beds. However, the difference between homes where a dog was kept during the preceding 6 months and homes where a dog was kept between 7 and 24 months previously was not statistically significant, possibly because of the small numbers of samples with dog allergens exceeding the upper cut point.

Large differences in cockroach allergen levels in dust from main living areas and infants' beds were found between homes in which cockroaches were or were not reportedly seen (Figure 4). In approximately one-third of the main living areas and 16 % of the infants' beds of homes for which the presence of cockroaches was reported, allergen levels exceeded the upper cut point, whereas allergen levels were almost always below the cut points for homes for which no presence of cockroaches was reported.

Sensitivity and specificity of questionnaire reports. The accuracy of the questionnaire-reported "current" and "current and/or past"

cat and dog ownership and presence of cockroaches in predicting allergen levels in the main living area is described in Table 2. Because the results for the infants' beds are very similar, these were not shown separately. Specificity was high for all three allergens, whereas sensitivity was low, particularly for current pet ownership and cat and dog allergens above the limit of detection and the lower cut point. Taking past pet ownership into account increased sensitivity significantly, but it remained relatively poor. For the reported presence of cockroaches, sensitivity seemed to be somewhat higher, particularly for the limit of detection and the lower cut point. However, it remains a rather poor measure of cockroach allergen exposure.

Keeping pets outside the infant's bedroom. Stratified analyses were conducted comparing cat and dog allergen levels in the infant's bed between homes where pets were kept and pets were or were not allowed in the infants' bedrooms (Figure 5). The percentage of samples with detectable allergen levels is the same for the two groups. Slightly lower percentages of dog allergen levels above the lower cut point and significantly lower percentages of cat and dog allergen levels above the upper cut point were found in homes where pets were not allowed in the infants' bedrooms.

Discussion

We assessed the sensitivity and specificity of questionnaire-reported presence of cats and dogs and sightings of cockroaches for measured levels of cat, dog, and cockroach allergens in dust samples from main living areas and infants' beds. Specificity was high for all three allergens, whereas sensitivity was low, particularly for current pet ownership and cat and dog allergens above the limit of detection and the lower cut point. Taking past pet ownership into account increased sensitivity significantly, but it remained relatively poor. Keeping cats and dogs out of the infant's bedroom was associated with a significant decrease in allergen levels above the upper cut point. For the reported presence of cockroaches, sensitivity seemed to be somewhat higher, particularly for the limit of detection and the lower cut point. However, it remains a rather poor measure of cockroach allergen exposure.

Cat and dog allergens. Our results are consistent with the results of other studies that suggested that the questionnaire-reported presence of cats is a relatively poor measure of cat allergen levels in house dust (Bollinger et al. 1996; Chew et al. 1998; Nafstad et al. 2001). Nafstad et al. (2001) showed that cat and dog allergens were present in house dust of homes where no pets were kept. Thus, complete avoidance of cat allergen is not possible.

The percentage of homes without a cat and cat allergen levels > 1 µg/g dust in this study was comparable to the percentage reported by Chew et al. (1998) for a similar group of homes. In contrast, Nafstad et al. (2001) showed that < 10% of the homes without a cat exceeded a level of 1 µg Fel d 1/g dust. A potential cause for this difference might be that cats were kept less often in the community (7 versus 19% in this study). Cat allergen can be carried to schools in cat owners' clothes, for example, and transferred to the clothes of children without cats at home (Almqvist et al. 1999).

This study shows that taking cat ownership during the preceding 2 years into account improves the sensitivity of detecting homes with cat allergen levels above the limit of detection and the two cut points by about 10%. This means that 10% more of the homes exceeding the limit of detection or the cut points are recognized as such by adding information on past cat ownership. However, 79% of the homes that never had a cat or that did not have a cat during the preceding 2 years contained detectable allergen concentrations, and 27% of these homes had allergen concentrations > 1 µg/g. Thus, Fel d 1 seems to be stable over a period of at least 2 years. This is consistent with the findings of other studies that have shown that the major cat allergen Fel d 1 is very persistent and that it is difficult to reduce cat allergen levels in people's homes. One study (de Blay et al. 1991) found that for households with cats, a combination of washing the cat weekly, reducing furnishings, vacuum cleaning, and air filtration reduced airborne cat allergen levels. Another study (Avner et al. 1997) showed that washing the cat by immersion transiently removes significant allergen from the cat. However, the effect is not maintained for as long as a week. In addition, Woodcock and Custovic (1998) showed that when the owner removes the cat, cat allergen levels remain elevated for ≥ 20 weeks. Fahlbusch et al. (2002) found 10-fold higher cat allergen levels in homes in which no cat was kept currently but had been kept within the preceding 12 months.

Several studies showed that dog ownership is associated with higher levels of dog allergens (Lindfors et al. 1999; Parvaneh et al. 1999; Woodcock et al. 2001). However, they did not focus on the impact of past and current dog ownership. Parvaneh et al. (1999) and Woodcock et al. (2001) distinguished between homes with and without a dog, whereas Lindfors et al. (1999) also took into account contact with dogs outside the home. Our study shows that sensitivity of questionnaire-reported dog ownership for detectable dog allergen increased to 42% when past dog ownership was taken into account. Sensitivity of dog ownership for Can f 1 was higher than sensitivity of

Table 2. Sensitivity and specificity of questionnaire-reported cat and dog ownership and presence of cockroaches for allergen concentrations in the main living area (%).

	> Limit of detection[a]		> Lower cut point[b]		> Upper cut point[c]	
	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
Current pet ownership[d]						
Cat (Fel d 1)	21.2	97.3	40.5	98.0	71.9	96.3
Dog (Can f 1)	28.1	98.8	59.9	97.8	81.9	94.1
Current and/or past pet ownership[d]						
Cat (Fel d 1)	31.6	92.7	53.7	91.3	83.9	87.6
Dog (Can f 1)	41.7	92.7	72.8	85.9	90.7	80.9
Presence of cockroaches[d]						
Cockroach (Bla g 1)	55.8	93.9	67.9	90.7	78.3	85.9

Data from Connecticut and western Massachusetts, 1998–2000.
[a]0.12 µg/g for Fel d 1 and Can f 1 and 0.6 U/g for Bla g 1. [b]1 µg/g for Fel d 1, 2 µg/g for Can f 1, and 2 U/g for Bla g 1. [c]8 µg/g for Fel d 1 10 µg/g for Can f 1, and 8 U/g for Bla g 1. [d]Yes/no.

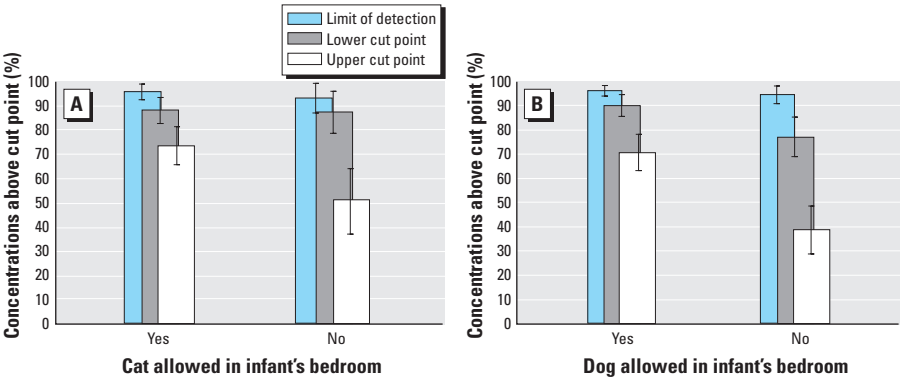

Figure 5. Percentage of cat and dog allergen levels in the infant's bed above the limit of detection and lower and upper cut points related to presence of (*A*) cat and (*B*) dog in the infant's bedroom. Error bars indicate 95% CIs. Data from Connecticut and western Massachusetts, 1998–2000.

cat ownership for Fel d 1, but was still not very high. One very recent study showed that exposure to two and more dogs or cats, but not exposure to one dog or cat, in the first year of life is associated with a significantly lower risk of allergic sensitization at 6 to 7 years of age, (Ownby et al. 2002). The authors discuss differences in allergen and endotoxin exposure as potential causes. Our study does not indicate any major differences in allergen exposure between homes with one and homes with more than one dog or cat, respectively.

Cat and dog allergen levels in dust from the infant's bed were also very high when the cat or dog was not allowed in the infant's bedroom. Only the percentage of allergen levels above the upper cut point was significantly decreased by keeping the cat or dog out of the bedroom. This supports the fact that cat and dog allergens are ubiquitous because of passive transport (Ledford 1994). Thus, keeping the cat or dog out of the infant's bedroom does not prevent allergen exposure in general, but prevents exposure to very high levels of allergens. The relevance of this finding for the infant's health is not clear. However, it is unlikely that intermediate exposures to Fel d 1 or intermittent exposures have the same health impact as persistent high-level exposures. If a study is focused on the effects of persistent high-level exposures, then questionnaire-reported presence of cats or dogs in the home (or in the infant's bedroom) might be useful as an estimate of exposure.

Cockroach allergen. Prevalence of detectable cockroach allergen levels (27 and 17%) was low compared with that in other studies, which focused more on U.S. inner-city homes (Rauh et al. 2002; Rosenstreich et al. 1997). In accordance with other studies, cockroach allergen in house dust was strongly related to the reported presence of cockroaches in the homes (Chew et al. 1998; Gelber et al. 1993; Rauh et al. 2002). Sensitivity of questionnaire-reported presence of cockroaches for detectable Bla g 1 concentrations was 56%, suggesting that approximately half of the homes with measurable cockroach allergen did not report the presence of cockroaches. Specificity was lower for presence of cockroaches than for current cat and dog ownership but still high, suggesting that most of the homes with allergen concentrations below the limit of detection had no reports of cockroach presence. Therefore, we conclude that questionnaire-reported presence of cockroaches is a relatively weak predictor for the presence of cockroach allergen in house dust, because exposure to cockroach allergen is likely to occur even when no sightings of cockroaches are reported, which is consistent with the findings of Chew et al. (1998).

Agreement between sampling locations. The agreement between allergen levels in dust from the main living area and dust from the infant's bed was fair to moderate. Thus, more than one dust sample per home is needed to assess the infant's exposure to allergens at home. Exposure to allergens in dust from the infant's bed is considered to be of major importance because the infants come into closest contact with the allergens while sleeping in their beds.

Implications for the analysis of health effects. It is unlikely that intermediate or intermittent exposures to allergens have the same health impact as persistent high-level exposures. Because questionnaire reports of cat and dog ownership and presence of cockroaches have been shown to be reasonable measures for allergen levels above the upper cut point, they can be used to estimate exposure in studies focusing on the effects of persistent high-level exposure. However, the sensitivity for allergen levels above the limit of detection and the lower cut point is low. Therefore, they should not be used to assess the health impact of intermediate or intermittent exposures to Fel d 1, Can f 1, and Bla g 1. The latter is of particular importance for Bla g 1 because low-level exposure to cockroach allergen has adverse health effects (Gold et al. 1999; Litonjua et al. 2001).

Strengths and limitations. Strengths of the present study include the large number of households sampled (n = 932), the fact that these were all homes of asthmatic children, and the diversity of the study population. Participating families represented four ethnic groups (white, 55%; African American, 14%; Hispanic, 27%; and others, 4%); family incomes ranging from < $20,000 (30%) to ≥ $100,000 (15%); multifamily (21%) and single-family (79%) housing; and both urban and suburban environments. The size and diversity of this study population may make the results more generalizable to other asthmatic populations.

There are also several potential limitations. A point-in-time measurement of indoor allergen concentrations was presented and hence may not accurately reflect longer-term exposures. Dust samples were not available for kitchens, where cockroach allergens would be expected to be highest. Thus, the home cockroach allergen concentrations may have been underestimated. Furthermore, the present analysis was done on the assumption that the presence of pets and sightings of cockroaches obtained by means of questionnaire-based interview were measured without error. Research assistants visited and walked through the families' homes, but did not inspect hidden areas (e.g., under sink cabinets) for cockroaches. Thus, some misclassification probably occurred. All homes included at least one asthmatic child, so the homes may not be representative of the general population. Moreover, although the study population is large and diverse in terms of socioeconomic status and covers both urban and suburban housing, it was drawn from one region of the United States. How the allergen levels measured in this study compare to allergen levels in other geographic and climatic areas is not known.

Conclusion

This study demonstrates that questions on current pet ownership and presence of cockroaches can be used to predict allergen levels above the upper cut point but are relatively poor measures for allergen exposure above the limit of detection and the lower cut point. Knowledge about past pet ownership can improve pet allergen exposure assessment by means of questionnaire. However, for epidemiologic purposes, measured concentrations of allergens are necessary to more accurately assess residential levels and minimize exposure misclassification. Keeping cats and dogs out of the infant's bedroom decreases the prevalence of allergen levels only above the upper cut point, but not above the lower cut point and the detection limit.

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