CONCENTRATIONS OF CAT AND DUST MITE ALLERGENS IN 93 U.S. OFFICE BUILDINGS

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ABSTRACT
The concentrations of cat (*Fel d*1) and dust mite (*Der f*1 and *Der p*1) allergens were measured in 93 of 100 BASE buildings. Sample mass ranged from 0.005–0.65 g (Median: 0.17 g) and was similar for all floor types and in summer and winter. *Fel d*1 was detected in 235 samples (94%) [Range: below detection limit (<DL)–19 µg/g; Median: 0.3 µg/g] but exceeded 8 µg/g (a sensitization threshold) in only two buildings. *Der f*1 and *Der p*1 were found in 113 (45%) and 128 (51%) samples (Ranges: <DL–53 µg/g and <DL–25 µg/g; Medians: <DL and 0.01 µg/g). Mite allergen exceeded 2 µg/g (a sensitization threshold) in five buildings and 10 µg/g (a symptom threshold) in three of those buildings. Mean *Fel d*1 concentrations were significantly higher in summer. No consistent patterns were observed between allergen concentrations and summer or winter temperature, summer humidity, building age, cleaning practices, or occupancy.

INDEX TERMS
Allergens, Cats, Dust mites, Bioaerosols, Offices

INTRODUCTION
In 1994 the U.S. Environmental Protection Agency (EPA) initiated a major study of indoor air quality in public and commercial office buildings called Building Assessment Survey and Evaluation (BASE). A total of 100 buildings were studied following a *Standardized EPA Protocol for Characterizing Indoor Air Quality in Large Office Buildings* (USEPA, 1994). Dust samples were collected for three major indoor allergens to expand the existing database on potential exposures to these known agents of allergic rhinitis and asthma in public and commercial office buildings. Cats and mites are among the few biological agents for which evidence of a causal relationship with asthma has been established (IOM, 2000). Skin test reactivity to animal allergens (primarily cat antigens) and house dust mites has been found in >25% of the population (IOM, 1993). A literature review concluded that pet allergens are found everywhere and vary with visits by persons with pets, presence of textile surfaces, cleaning standards, ventilation and activity, and season (higher in the heating season) (Ahlbom et al., 1998).

METHODS
Dust samples were collected for allergen measurement in 93 of the 100 BASE buildings. Buildings from all 10 climate zones were studied, with 44 buildings sampled in winter and 49 in summer. Settled dust was collected from the floor or carpet in the immediate vicinity of one or more of three randomly selected sites in each building. Carpets were chosen as the sampling site, if available, because carpeting is common and dust and allergens accumulate in

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carpets (IOM, 1993). A minimum of 0.5 m^2 of carpet was sampled for 2 min with a small vacuum cleaner (e.g., Eureka Mighty Mite) using an aspirator tube that held a 19×90-mm, cellulose, extraction thimble. A maximum of 1 g of dust was collected or an area of 10 m^2 was vacuumed, whichever came first. Dust samples were sieved at 425 μm and analyzed for cat allergen (*Felis domesticus, Fel d*1) and two house dust mite allergens (*Dermatophagoides farinae, Der f*1, and *Dermatophagoides pteronyssinus, Der p*1).

RESULTS

Table 1 summarizes buildings characteristics that may be related to dust and allergen accumulation in buildings, and Table 2 summarizes cleaning practices that also may be related to dust accumulation or moisture that could support active mite populations. None of the listed building characteristics or cleaning practices independently was associated with sample mass or either allergen concentration (data not shown).

Table 1. Building characteristics for 100 BASE buildings

	Age (years)	**Typical Occupancy** (persons)	**Occupied Floor Area** (m^2)	**Occupant Density** (persons/m^2)	**Area per Occupant** (m^2/person)	**Operation** (hours/ week)
Median	25	625	8500	0.06	16.3	53
Range	1–147	87–7130	630–98000	0.01–0.56	1.8–103	26–168

Table 2. Cleaning frequency in 100 BASE buildings

	Office Cleaning	**Vacuuming**	**Wet Mopping**	**Dry Mopping**
Daily	86	73	76	57
Weekly	5	16	7	5
As needed	3	5	3	2
Bi-weekly	1	2	1	1
Monthly	1	1	3	0
Annually	2	0	0	0
Other	2	3	2	6
None	0	0	8	29

Table 3 identifies the floor finishes that were recorded as the primary and secondary types overall in the buildings. Most of the 258 dust samples were collected from carpets (N=203, 79%) or rugs (N=28, 11%). Although wood floors were the second most common primary floor finish, only one sample was collected from a wood floor. Overall, only 3.5% of dust samples were collected from floors with smooth surfaces (tile, 6; hard, 1; vinyl, 1; or wood, 1). Insufficient information was recorded to identify the type of floor surface for 18 samples (Other, 7%). Samples were obtained from one, two, or all three sites in 5 (5%), 12 (13%), and 75 (81%) of the buildings, respectively; four samples were collected in one building.

The median amount of dust that was collected in the 199 samples that were weighed was 0.17 g, and similar amounts of dust were collected in summer and winter (Medians: 0.17 and 0.17 g; Minimums: 0.01 and 0.02 g; Maximums: 0.48 and 0.65 g, respectively). The largest amount of dust was collected from an Other or Carpeted floor (Maximum: 0.65 and 0.60 g, respectively) and the least from a Smooth floor (Minimum: 0.005 g).

Table 3. Overall floor finishes in 100 BASE buildings

	Carpet	Wood	Tile	Concrete	Other
Primary Floor Type	91	12	2	0	2
Secondary Floor Type	8	31	2	2	5
Total Occurrence	99	43	4	2	7

ALLERGEN CONCENTRATIONS

Approximately one-third of the samples contained all three allergens, but only 10 (4%) contained none. Cat allergen was detectable in almost all (94%) of the samples and approximately one-third contained only cat allergen (Table 4, Figures 1 and 3). *Der f*1 and *Der p*1 were detected in approximately half of the samples (45% and 51%, respectively) (Figures 2 and 4), but rarely were found in the absence of cat allergen (6 samples, 2.4%).

Table 4. Number and percentage of 251 samples in which allergens were detected

Fel d	*Der f*	*Der p*	Number	Percentage
+	+	+	81	32.3%
–	–	–	10	4.0%
+	–	–	85	33.9%
–	+	–	1	0.4%
–	–	+	1	0.4%
+	+	–	27	10.8%
+	–	+	42	16.7%
–	+	+	4	1.6%

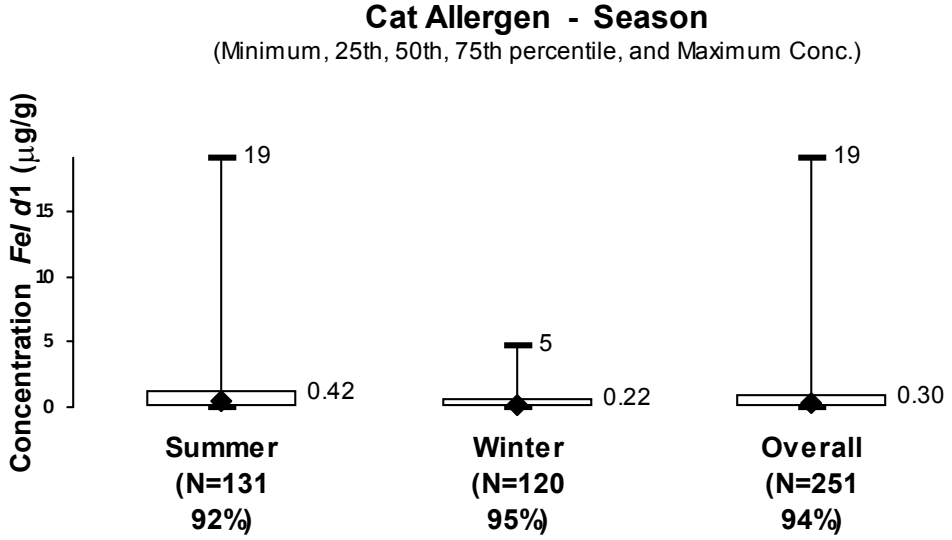

Figure 1. Comparison of Concentration of Cat Allergen in Summer and Winter (median and maximum values shown, N = number of samples, % = percentage of samples in which *Fel d*1 was detected).

The minimum allergen concentrations that were measured in both seasons and from all floor types were below the detection limit of 0.01 µg/g of dust. Significantly higher mean concentrations of cat allergen were seen in summer than winter samples (p=0.0057) (Figure 1). Mean concentrations of dust mite allergens were somewhat higher in winter than summer but the differences were not statistically significant (p=0.122 and p=0.329) (Figure 2). Nor were any consistent patterns observed when the samples that were collected in each season were sorted by summer or winter temperature or by summer humidity (data not shown).

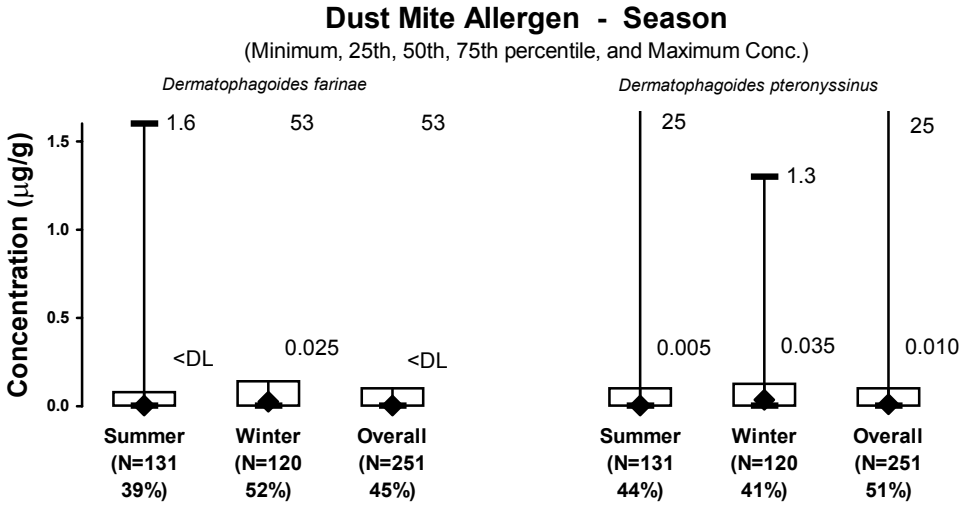

Figure 2. Comparison of Concentration of Dust Mite (*Der f*1 and *Der p*1) Allergens by season.

Table 5 shows the number and percentage of BASE samples in the concentration ranges that have been proposed as guidelines for the risk of sensitization (cat allergen: >8 µg/g; mite allergen: >2 µg/g) and symptom provocation in already sensitized persons (cat allergen: not established; mite allergen: >10 µg/g) (Hung et al., 1993; IOM, 1993).

Table 5. Number and percentage of 251 BASE dust samples by allergen concentration range

	Low				Moderate		High	
***Fel d*1**	**<0.01 µg/g**		**0.01–1 µg/g**		**1–8 µg/g**		**>8 µg/g**	
	16	6.4%	179	71.3%	54	21.5%	2	0.8%
Dust mites	**<0.01 µg/g**		**0.01–2 µg/g**		**2–10 µg/g**		**>10 µg/g**	
***Der f*1**	138	55.0%	108	43.0%	3	1.2%	2	0.8%
***Der p*1**	123	49.0%	126	50.2%	1	0.4%	1	0.4%

The numbers of samples from rugs and smooth-surface floors were too few to determine if the concentrations differed by floor type (Figures 3 and 4), but all allergens were detected in smaller fractions of samples from smooth floors or rugs than from carpets. In addition to the maximum measurements shown in Figure 4, *Der f*1 antigen was found in excess of 2 µg/g in 5 winter samples from 3 buildings (2.5, 5.3, 6.1, and 10.9 µg/g) and *Der p*1 at 2.6 µg/g in one summer sample.

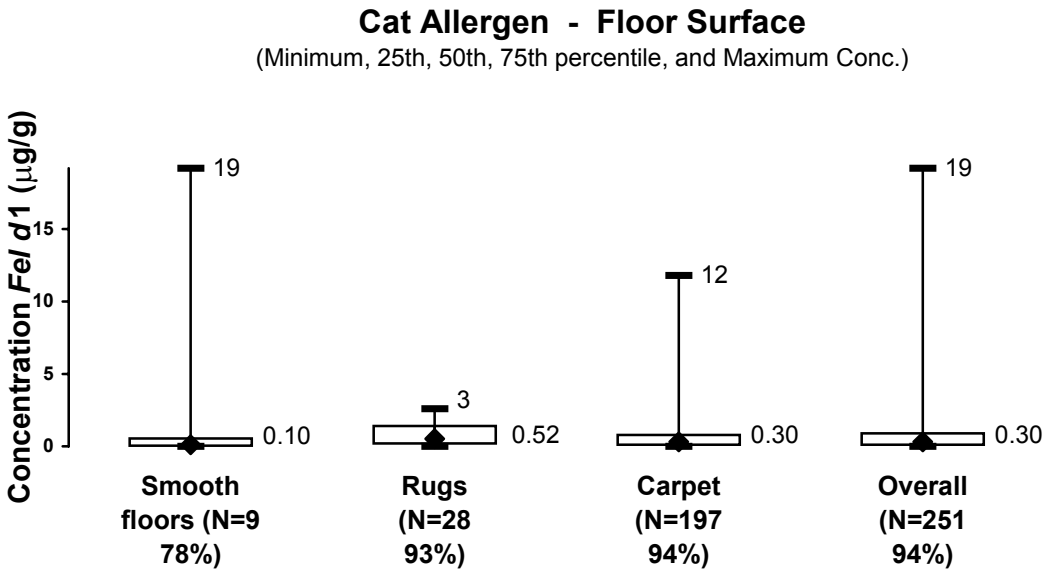

Figure 3. Comparison of Concentration of Cat Allergen in Dust from Different Floor Surfaces.

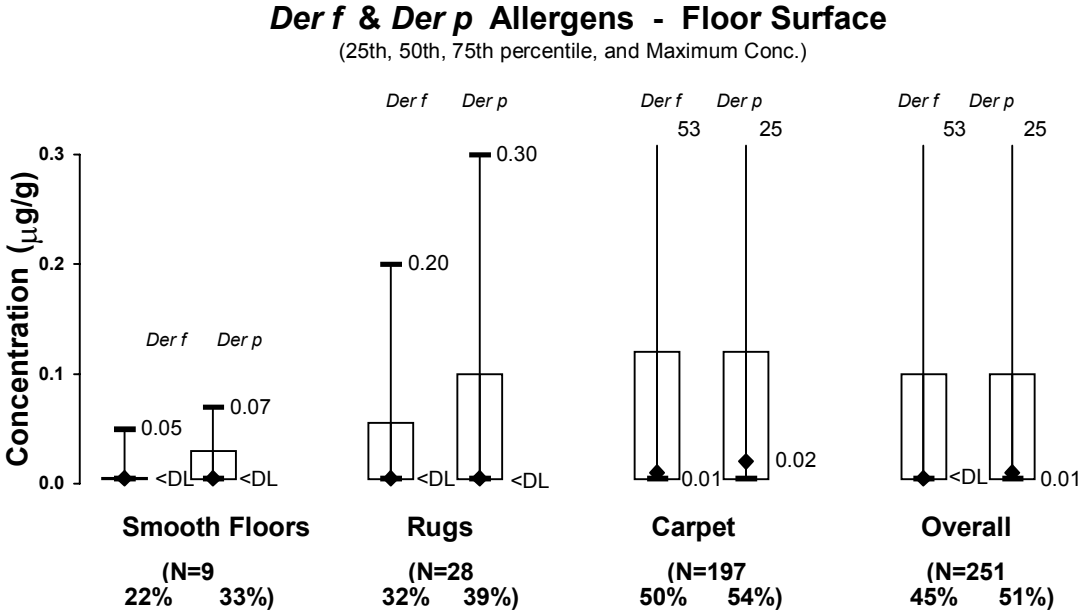

Figure 4. Comparison of Concentration of Dust Mite (*Der f*1 and *Der p*1) Allergens from Different Floor Surfaces.

DISCUSSION

Typically, laboratories extract 0.10 g of dust to analyze allergen content, which can be considered a target minimum amount to collect, although a larger sample would allow replicate assays as well as analyses other than allergen content. The median amount of dust that was collected in the BASE study was 0.17 g. Fifty-three percent of the samples equaled or exceeded 0.10 g and 181 samples (70%) contained at least half that mass. Small amounts of dust may have been collected because the BASE buildings were reasonably clean and more dust could not be extracted from 10^2-m of floor surface. It is unclear whether allergen concentrations expressed per unit of dust mass (µg/g) or area sampled (µg/m^2) better predicts exposure. Collecting insufficient dust to perform all desired analyses results in incomplete

data and difficulty in reaching conclusions. However, collection of dust from areas that may not truly reflect potential occupant exposure to previously suspended or readily re-aerosolized particles (e.g., vacuuming around the perimeter of a room, in corners, under desks, or behind shelves in order to obtain sufficient sample—as was reported for seven BASE samples) also is questionable. Therefore, investigators should report their sampling methods in detail (e.g., criteria for selecting sampling sites, floor surface, area vacuumed, and sampling time) as well as the total amount of dust that was collected and the amount used for analysis.

Dust samples from BASE buildings were assayed for only three allergens (cat and two dust mites). Baseline information on cockroach, dog, rodent, and bird antigens in office buildings also is of interest. Future analyses will investigate possible associations between allergens and occupant activities, building characteristics, cleaning practices, and indicators of building dampness as well as an explanation for the higher summer concentration of cat allergen. Likewise, the contributions to occupant symptoms of exposure to allergens and Gram-negative bacteria (the source of endotoxin, which can act as an adjuvant) will be evaluated.

CONCLUSIONS AND IMPLICATIONS

Cat allergen was found in almost all BASE buildings even though cats seldom enter offices. The source of cat allergens was assumed to be flakes of cat skin and dried saliva shed by persons in contact with pets at home (Ahlbom et al., 1999). Dust mite allergens were detected in approximately half of the samples. Possible sources of these allergens again are the occupants and their belongings (IOM, 1993, 2000) but also colonization of suitable habitats in offices, such as carpets and upholstered furniture that provide mites with food (primarily human skin flakes), moisture, warmth, and protection. Although exposure to cat and dust mite allergens in office workplaces may be fairly common, the concentrations of these allergens exceeded the threshold levels that have been associated with sensitization or symptom provocation in only nine samples from seven buildings.

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REFERENCES

Ahlbom A, Backman A, Bakke J, et al. 1998. “NORDPET” Pets indoors — a risk factor for or protection against sensitization/allergy. *Indoor Air*. 8:219–235.

Hung LL, Lewis FA, Yang CS, et al. 1993. Dust mite and cat dander allergens in office buildings in the Mid-Atlantic region. *Proceedings of IAQ92 Conference*, San Francisco, California. pp. 163-170. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

IOM. 1993. Magnitude and dimensions of sensitization and disease caused by indoor allergens; Agents, sources, source controls, and diseases; Engineering control strategies. In *Indoor Allergens*. Washington, DC: Institute of Medicine, pp. 44–85, 86–130, 206–232.

IOM. 2000. Indoor biologic exposures. In *Clearing the Air: Asthma and Indoor Air Exposures*. Washington, DC: Institute of Medicine, pp. 105–222.

U.S. Environmental Protection Agency, 1994. “The United States Environmental Protection Agency’s Large Building Studies Quality Assurance Overview Document,” Office of Research and Development and Office of Air and Radiation, U.S. Environmental Protection Agency, Washington, DC, USA, November 1, 1994.