
Distribution and removal of cat, dog and mite allergens on smooth surfaces in homes with and without pets

Larry G. Arlian, PhD*; Jacqueline S. Neal, BS*; Marjorie S. Morgan, PhD*; Christine M. Rapp, MS*; and Armin L. Clobes, PhD†

Background: Removing allergen from the indoor environment should be a primary strategy for the management and treatment of allergic disease.

Objective: The aims of this study were to characterize the distribution of dog, cat, and mite allergen on hard surfaces in homes with and without pets and to evaluate the efficiency of removing allergen from hard surfaces by wiping with a dry dust cloth and by vacuum cleaning using the dustbrush attachment.

Methods: The amount of allergen collected from adjacent areas of two smooth floors, a wall, and finished furniture by wiping with a Pledge Grab-it dust cloth (S. C. Johnson & Son, Inc, Racine, WI) and by brush-vacuuming were compared for 24 homes with and without pets. In addition, the areas first wiped with the dust cloth were then brush-vacuumed and the amounts of allergen collected by the first and second cleaning were compared.

Results: A key finding was that 23 of the 24 homes had Can f 1 allergen on one or more of the sampled areas regardless of whether a dog was present. Most homes with pets and many homes without pets had Can f 1 and Fel d 1 allergens on walls, smooth floors, and finished furniture. Carpets were the major reservoir for pet allergens in homes with pets whereas allergen was more uniformly distributed in homes without pets. Little mite allergen was found on hard surfaces even when it was present in carpets.

Conclusions: Dog and cat allergens are prevalent on walls, smooth floors, and finished furniture in homes with and without pets. Dry dusting with a Grab-it dust cloth was an effective cleaning method for removing allergen from hard smooth surfaces.

Ann Allergy Asthma Immunol 2001;87:296–302.

INTRODUCTION

Dog, cat, and house dust mite allergens are common in homes. Cat and dog allergens occur not only in homes with pets but in homes, schools, day-care centers, and workplaces where there are no pets.^{1–13} Likewise, mite allergen may be present on walls and floors in homes, schools, day nurseries, and the workplace when there is no thriving population of mites, but the levels of allergen on these surfaces are usually very low.^{9,11}

Carpets are a major reservoir for cat- and dog-allergen carrying particles in homes. The major allergens of cats (Fel d 1) and dogs (Can f 1) are mostly carried on small particles (<5 μm) that become airborne during disturbances.^{14,15} After a disturbance, the small particles remain airborne for long periods and are subject to drift throughout the home. They can adhere to vertical surfaces (walls) and settle on horizontal surfaces (finished furniture and smooth floors). In addition, particles can be transferred on clothing to other places within and between homes and to schools or workplaces where there are no pets.

The presence of cat and dog allergens on walls, hard furniture, and smooth floors in homes and their re-

moval have not been extensively investigated. Wood et al¹¹ have reported the presence of significant quantities of cat allergen on walls in homes. They speculated that it is likely that some of this allergen on walls could become resuspended and inhaled, thereby contributing to respiratory symptoms.¹¹ The distribution of dog allergen on walls has not been investigated.

Major reservoirs of mite allergen in homes are carpets, bedding, mattresses, and fabric-covered soft furniture. Little, if any, group 1 mite allergen has been reported on walls.¹¹ Most group 1 and 2 mite allergens are carried by large particles (>20 μm)^{6,16} that become airborne during vigorous disturbances and settle quickly (<20 minutes) after the disturbance. A recent study reported that 20.6% of Der p 2 was associated with small particles that were 1.1 to 4.7 μm in diameter.⁶ Some of these small and large particles could settle on smooth floors and finished furniture and adhere to walls.

In this study, one aim was to compare the cat, dog, and mite allergen levels and their distribution on smooth floors (wood or vinyl), hard-surfaced furniture, and walls to those of carpets in the family room. The second aim was to compare the removal of allergen from hard-surfaced, finished furniture, smooth floors, and walls using a commercially available dust cloth (Pledge Grab-It, S. C. Johnson & Son, Inc, Racine, WI) or by vacuum cleaning using the dusting attachment.

METHODS

Selection of Homes

Dust samples were collected from 24 homes located in the greater Dayton,

* Wright State University, Dayton, Ohio.

† S.C. Johnson & Son, Inc, Racine, Wisconsin.
Received for publication April 13, 2001.

Accepted for publication in revised form July 20, 2001.

Ohio area. The study was approved by the Wright State University Institutional Review Board. Each house was selected because it met the following criteria.

1. It had at least one area with a large amount of smooth, hard-surface wall to provide two adjacent 1-m² areas of equivalent wall in terms of height from the floor and exposure to airborne dust. This was usually the family room or another high traffic area.

2. It had two hard surface floors (eg, vinyl, hardwood, tile) in two separate rooms (eg, kitchen, bathroom, family room). All floors had at least two adjacent 1-m² areas with equivalent traffic patterns and exposure to dust and dirt.

3. It had sufficient hard furniture surfaces (eg, dressers, chests of drawers, end tables, bedside tables, desks, bookshelves) to provide two adjacent surfaces of equivalent area (in one or more rooms). In most homes the furniture was in bedrooms and family rooms.

4. The floors, furniture, and walls were not cleaned for at least 7 days.

The study homes were selected so that 6 had no indoor pets (N 1 to 6); 6 had dogs only (D 1 to 6); 6 had cats only (C 1 to 6); and 6 had both dog(s) and cat(s) (B 1 to 6).

Dust Sampling

For each home, appropriate areas of smooth flooring in two separate rooms and a wall (from baseboard to 1 meter above) were selected for sampling. In most homes, this was the kitchen and a bathroom that were vinyl-covered. Two adjacent 1-m² areas for each surface were selected and marked out using masking tape. The tops of furniture (several pieces) were selected, measured, and divided in half using tape to provide equivalent surfaces for the dust cloth and vacuum sampling.

At each sampling area (floor 1, floor 2, wall, furniture), half of each area was dusted by wiping with a Pledge Grab-it dust cloth. The adjacent area was then dusted with a vacuum cleaner using the dustbrush attachment. After this, the first area (cloth dusted) was

dusted again with a vacuum cleaner using the dustbrush attachment. This sampling process was repeated for each of the four sampling sites for a total of 12 samples per home.

To clean with a dust cloth, a Grab-it cloth was cut in half and then wrapped around a foam block. The cloth sampling area on the bottom of the block was 14.5 × 10.0 cm. The foam block containing the dust cloth was then placed onto the surface to be sampled and the 1 m² of area wiped in the X and Y directions twice. The dust cloth was then placed into a 50-mL centrifuge tube after use.

Brush-vacuum samples were collected on filters cut from a 200-thread count cotton/polyester sheet cut to the same size as the Grab-it cloth. The filter was placed into a dust trap that was attached to the hose of a portable Hoover vacuum cleaner (model S7065-060) as previously described.¹⁷

Using the dustbrush attachment, the surface area adjacent to the surface just sampled by the dust cloth was then vacuumed using the same X and Y pattern, twice in each direction. The sheet was removed from the dust trap and placed into another 50-mL centrifuge tube. A third sample was collected at each sample site by brush-vacuuming the area previously cleaned with the dust cloth. A clean brush and dust trap were used for each sample.

Allergen Analysis

Each sample was extracted overnight in 40 mL of B-PBST buffer (0.5% bovine serum albumin, Dulbecco phosphate buffered saline, 0.05% Tween 20, 0.05% sodium azide) on an orbital shaker. An aliquot of liquid was removed, centrifuged at 14,000 *g* for 5 minutes, and the supernatants collected and frozen until analyzed. The concentrations of Der f 1, Der p 1, Fel d 1, and Can f 1 allergens in the supernatants were determined according to the manufacturer's instructions using ELISA kits obtained from Indoor Biotechnologies (Charlottesville, VA).

Statistical Analysis

Data for means are presented ± standard error. Paired samples were compared using the Student's *t* test assuming unequal variances.

RESULTS

Comparison between Wiping with a Dry Dust Cloth and Vacuuming with the Dustbrush Attachment

The mean total quantity of Fel d 1 and Can f 1 allergen collected by the dust cloth from finished furniture, of Fel d 1 from walls, and of Can f 1 from smooth floors was not significantly greater ($P > 0.05$) than that collected from adjacent areas by the brush-vacuuming method (Table 1). In comparison, significantly ($P < 0.05$) more Can f 1 was collected from walls and Fel d 1 from smooth floors by wiping with the dust cloth compared with brush-vacuuming. However, in all cases the Grab-it dust cloths collected more allergen (1.05 to 3.40 times) than the brush-vacuuming method. Therefore, to compare the distribution of allergen on smooth surfaces, the dust cloth method was used.

Distribution of Cat Allergen

Dust from hard surfaces and carpets in homes with cats had significantly ($P < 0.05$) more Fel d 1 than homes without cats (Table 2). However, homes without cats had detectable levels of Fel d 1 on smooth walls, floors, and furniture tops (range 0.00 to 3.23 $\mu\text{g}/\text{m}^2$, Table 3). Six of 12 homes without cats had detectable levels of Fel d 1 on floors but none exceeded 2 $\mu\text{g}/\text{m}^2$. Three of the 12 homes without cats had detectable levels of Fel d 1 on walls but, again, none exceeded 2 $\mu\text{g}/\text{m}^2$. Four of these homes had detectable levels of Fel d 1 on furniture and these levels were higher with 2 homes exceeding 2 $\mu\text{g}/\text{m}^2$.

In homes with detectable levels of cat allergen, there was a strong and significant correlation ($r^2 = 0.8468$, $P < 0.0001$) between the amount of allergen on smooth floors and the amount on carpet. However, there was less correlation between the amount on carpets and that on walls ($r^2 = 0.5480$,

Table 1. Mean Quantity of Allergen ($\mu\text{g}/\text{m}^2$) Removed

Location	Allergen	n	Dust cloth (DC)	Vacuum brush (VB)	DC/VB†
Furniture	Fel d 1	15	10.91 $\pm$ 3.17	8.87 $\pm$ 2.68	1.23
Furniture	Can f 1	18	13.53 $\pm$ 4.23	9.92 $\pm$ 2.84	1.36
Walls	Fel d 1	13	2.62 $\pm$ 0.63	1.39 $\pm$ 0.40	1.88
Walls	Can f 1	16	8.70 $\pm$ 2.79*	2.86 $\pm$ 0.74	3.04
Smooth floor 1	Fel d 1	15	15.96 $\pm$ 5.54*	8.90 $\pm$ 4.14	1.79
	Can f 1	17	29.76 $\pm$ 9.19	28.41 $\pm$ 9.59	1.05
Smooth floor 2	Fel d 1	15	12.42 $\pm$ 4.29*	7.15 $\pm$ 2.65	1.74
	Can f 1	18	30.68 $\pm$ 8.38	27.34 $\pm$ 10.25	1.12

Allergen ($\mu\text{g}/\text{m}^2$) removed from adjacent areas on the tops of hard finished furniture, vertical walls, and surfaces of smooth floors by wiping with a dust cloth or vacuuming with a dustbrush attachment. Only those sites (24 samples) with detectable allergen recovered by at least one of the sampling methods are included.

* Amount of allergen collected by the dust cloth was significantly greater ($P < 0.05$) than that collected by the vacuum brush method of cleaning.

† DC/VB - The amount of allergen collected by the dust cloth divided by the amount recovered by the vacuum brush.

$P < 0.0001$) and furniture ($r^2 = 0.3838$, $P < 0.0001$). In the homes with cats, there were significantly ($P < 0.01$) greater amounts of Fel d 1 present on horizontal surfaces (smooth floors and furniture) compared with Fel d 1 on the vertical surfaces (Table 2). The level of Fel d 1 in carpets was 465 times greater in homes with cats compared with homes without cats (Table 2). In these homes, carpets were the main reservoir for Fel d 1 with levels that were 13, 89, and 18 times greater than on smooth floors, walls, and furniture, respectively.

Distribution of Dog Allergen

Seven of the 12 homes without dogs had detectable Can f 1 on smooth surfaces and 11 of the 12 had Can f 1 in the carpet (Table 4). Interestingly, the mean levels of Can f 1 on walls and furniture in the homes without dogs

was not significantly less ($P > 0.05$) than for homes with dogs (Table 5). However, all but one of the 12 homes with dogs had Can f 1 on at least one hard surface (Table 4). In homes without dogs, the levels of Can f 1 on hard surfaces and on carpets were similar. The mean Can f 1 per m^2 in carpets was significantly ($P < 0.01$) greater (107 times) in carpets of homes with dogs compared with carpets in homes without dogs (Table 5). In homes with dogs, carpet dust was the main reservoir for Can f 1 and contained significantly ($P < 0.01$) more allergen/ m^2 than smooth floors, walls, and finished furniture (12, 47, and 24 times, respectively; Table 5). Horizontal surfaces (smooth floors and finished furniture) had more than two times more Can f 1 allergen than did vertical surfaces (walls).

Seven of the 12 homes without dogs had detectable levels of Can f 1 (range 0.13 to 134.30 $\mu\text{g}/\text{m}^2$) on smooth floors with 3 homes having $>10 \mu\text{g}/\text{m}^2$. These same seven homes had detectable levels of Can f 1 on finished furniture (range 0.20 to 44.45 $\mu\text{g}/\text{m}^2$) with one of these being $>10 \mu\text{g}/\text{m}^2$. Five of the 12 homes without dogs had detectable levels of Can f 1 on walls (range 0.08 to 21.56 $\mu\text{g}/\text{m}^2$) with 2 of these having $>10 \mu\text{g}/\text{m}^2$.

Distribution of Mite Allergen

Sixteen, 21, and 17 of the 24 homes had no detectable Der f 1 or Der p 1 on smooth floors, walls and furniture, respectively (Table 6). The levels of mite allergen on these hard surfaces were very low and in only one home was group 1 mite allergen $>2.0 \mu\text{g}/\text{m}^2$ of surface area. The group 1 allergen levels for smooth floors, walls, and furniture were 0.12 to 12.12, 0.15 to 0.67, and 0.15 to 1.01 $\mu\text{g}/\text{m}^2$, respectively. Most homes (8 of 11) with detectable mite allergen on at least one hard surface had detectable levels in carpet dust. Of these, 6 had detectable levels of group 1 allergen on smooth floors, 5 on furniture, and 2 on walls. However, 4 homes with detectable levels in the carpet did not have detectable levels on hard surfaces. Interestingly, there was no detectable mite allergen in carpets of homes with cats only (Table 6, homes C 1 to 6). There was also no correlation between the amount of mite allergen in carpet samples and that on hard surfaces.

Table 2. Mean Quantity of Cat Allergen (μg Fel d 1/ m^2) Removed from Hard Surfaces

Location	Cats	No cats	Cats/no cats†
Furniture	13.05 $\pm$ 3.73‡ (n = 12)	0.59 $\pm$ 0.32 (n = 12)	22.11
Walls	2.60 $\pm$ 0.71‡ (n = 12)	0.23 $\pm$ 0.14 (n = 12)	11.30
Smooth floors	17.55 $\pm$ 4.05‡ (n = 24)	0.19 $\pm$ 0.10 (n = 24)	92.37
Carpets	232.36 $\pm$ 91.15* (n = 11)	0.50 $\pm$ 0.21 (n = 12)	464.72

Mean quantity of cat allergen removed by the dust cloth and collected from the carpet by vacuuming in homes with and without cats.

* Amount of allergen collected in the homes with cats was significantly greater ($*P < 0.05$ or $\dagger P < 0.01$) than that collected in the homes without cats.

† cats/no cats - The amount of allergen collected in homes with cats divided by the amount collected in homes without cats.

Table 3. Quantity of Cat Allergen (μg Fel d 1/ m^2) in Homes without Cats (N1–6 and D1–6) and with Cats (C1–6 and B1–6)

Home No.	Floor 1	Floor 2	Wall	Furniture	Carpet
<i>Homes without a resident cat</i>					
N1	0	0	0	0	0.19
N2	0	1.55*	1.53	2.34	1.64
N3	0.29	0	0	0	0.42
N4	0	0	0	0	0
N5	0.56	0.29	0.27	3.23	2.10
N6	0	0	0	0	0
D1	0	0	0	0	0.22
D2	1.48	1.83	0.96	1.16	0
D3	0.22*	0.31*	0	0	0
D4	0	0	0	0	0.18
D5	0	0	0	0	0.22
D6	0.14	0	0	0.40	1.06
<i>Homes with a resident cat</i>					
C1	2.42	29.97	0.69	10.01	141.60
C2	0	0	0	0	28.02
C3	14.23	3.90	0	4.56	50.27
C4	3.00	1.60	1.07	10.94	11.90
C5	22.31	2.40	6.80	11.50	140.66
C6	24.67	26.26	2.53	45.35	232.40
B1	0.80	0.60	0.13	0.71	33.96
B2	69.56	47.73	4.22	24.28	728.50
B3	55.60	45.13	6.75	23.70	888.97
B4	19.02	7.39	4.14	7.23	297.10
B5	0	6.82	3.01	15.55	2.56
B6	25.38	12.38	1.98	2.76	n.s.

Data for hard surfaces are for samples collected by dust cloth unless otherwise indicated. Carpet samples were collected by vacuuming.

* Hard surface sample collected by vacuuming.

n.s. - No sample taken because home had no carpet.

Comparison of Removing Allergen from Hard Surfaces by Using the Dust Cloth Followed by Brush-Vacuuming

To estimate the amount of allergen remaining after wiping with the dust cloth, we collected two sequential samples from the same surface area of smooth floors, finished furniture, and walls (Table 7). The area was first wiped with a dust cloth (first cleaning). Then, this was followed with brush-vacuuming of the same area (second cleaning). To determine the percentage of dust pick-up by the dust cloth, the amount of allergen recovered by the dust cloth was divided by the total amount of allergen recovered (first dust cloth cleaning + second brush-vacuum cleaning) to yield the percentage of the total removed by dust cloth. The dust cloth removed 94, 93, and 87% of the total amount of Fel d 1 collected from furniture, walls, and

smooth floors, respectively (Table 7). Likewise, the dust cloth collected 90, 88, and 80% of the total amount of Can f 1 that was recovered from these surfaces (Table 7).

DISCUSSION

A key finding of this study was that detectable levels of dog allergen were present on walls, finished furniture, smooth floors, or carpets in all but one of the homes without dogs. Likewise, 67% of homes without cats had Fel d 1 on one or more of the surfaces sampled. In some of the homes with pets, the highest level for Can f 1 or Fel d 1 was on a smooth floor, wall, or finished furniture and not on the carpet. Passive transfer of these allergens on clothing, the previous presence of a cat or dog, or visitation by pets apparently were responsible for transporting these pet allergens into the homes without a resident pet. During 1996, 11.2 and

15.4 million U.S. households had cats and dogs, respectively.¹⁸ Given that so many homes have pets, it is therefore not surprising that many homes without pets had pet allergens. The higher number of homes that have dogs may explain why more homes without pets had dog allergen than had cat allergen.

As expected, we found that there were significantly greater amounts of Fel d 1 and Can f 1 in individual homes with pets compared with those homes without pets. In homes with cats, 67 and 58% had $>10 \mu\text{g}/\text{m}^2$ of Fel d 1 on smooth floors and finished furniture, respectively, whereas no homes without cats exceeded this amount on any surface. Likewise, in homes with dogs, 75, 25, and 50% had $>10 \mu\text{g}$ Can f 1 per m^2 on smooth floors, walls, and finished furniture, respectively, whereas only 25% of homes without dogs exceeded this level on one or more hard surfaces.

Table 4. Quantity of Dog Allergen ($\mu\text{g Can f 1/m}^2$) in Homes without Dogs (N1–6 and C1–6) and with Dogs (D1–6 and B1–6)

Home no.	Floor 1	Floor 2	Wall	Furniture	Carpet
<i>Homes without a resident dog</i>					
N1	45.03	3.31	21.56	4.04	5.55
N2	0	0	0	0	0
N3	0	0	0	0	0.10
N4	3.63	4.01*	0	2.39	0.14
N5	0.69	0.35	0.37	0.91	0.35
N6	134.30	61.3	4.88	7.14	22.96
C1	0.13	0.63	0.08	0.23	5.88
C2	14.79	22.44	16.81	44.45	0.25
C3	0	0	0	0	1.13
C4	0	0	0	0	3.21
C5	0	0	0	0	1.49
C6	1.34	0.21	0	0.20	0.97
<i>Homes with a resident dog</i>					
D1	73.76	69.46	16.72	14.87	541.63
D2	0	0	0	0	313.72
D3	41.94	123.50	7.64	30.24	334.94
D4	0	3.27	5.63	53.63	195.15
D5	18.07	13.47	4.89	15.63	684.67
D6	17.86	35.38	11.80	47.39	524.84
B1	2.32	2.50	0.52	0.92	59.03
B2	15.84	48.83	1.42	2.07	208.78
B3	5.73	10.62	1.86	3.76	548.11
B4	94.60	86.27	41.98	14.17	532.21
B5	21.04	45.16	2.42	5.90*	163.70
B6	14.85	25.52	0.68	1.47	n.s.

Data for hard surfaces are for samples collected by dust cloth unless otherwise indicated. Carpet samples were collected by vacuuming.

* Hard surface sample collected by vacuuming.

n.s. - No sample taken because home had no carpet.

Our study clearly shows that carpet is the major reservoir for pet allergen in homes with pets. The mean levels of Can f 1 per m^2 of carpet surface area in homes with dogs were 12, 47, and 24 times higher than for smooth floors, walls, and finished furniture, respec-

tively. For Fel d 1, the levels were 13, 89, and 18 times higher in carpets than for floors, walls, and furniture, respectively. In homes without pets, passive transfer into these houses results in a more uniform distribution on carpets and hard surfaces. Especially in homes

with pets, much attention should be directed at cleaning carpets or removing them from homes in favor of smooth floors where allergen is much more easily removed.

We also found very little Der f 1 and Der p 1 on the hard surfaces in any of the homes even when there were detectable levels of mite allergen in carpets. There may be several explanations for this finding. Thriving mite populations are not usually found on hard surfaces because of the lack of a hospitable environment. Mite allergen is carried on heavy particles that settle quickly after a disturbance; thus, it does not drift and settle on hard surfaces. Also, apparently little is carried on feet from carpets to hard floor surfaces, or what is carried is removed by typical cleaning routines. The quantities of mite allergen passively transferred onto clothing are small.

Table 5. Mean Quantity of Dog Allergen ($\mu\text{g Can f 1/m}^2$)

Location	Dogs	No dogs	Dogs/no dogs†
Furniture	15.35 $\pm$ 5.43 (n = 12)	4.95 $\pm$ 3.65 (n = 12)	3.10
Walls	7.96 $\pm$ 3.42 (n = 12)	3.64 $\pm$ 2.15 (n = 12)	2.19
Smooth Floors	32.10 $\pm$ 7.02* (n = 24)	12.01 $\pm$ 6.18 (n = 24)	2.67
Carpets	373.34 $\pm$ 61.09‡ (n = 11)	3.50 $\pm$ 1.87 (n = 12)	106.67

Mean quantity of dog allergen removed from hard surfaces by the dust cloth and collected from the carpet by vacuuming in homes with and without dogs.

* Amount of allergen collected in the homes with dogs was significantly greater (* $P < 0.05$ or ‡ $P < 0.01$) than that collected in the homes without dogs.

† dogs/no dogs - The amount of allergen collected in homes with dogs divided by the amount collected in homes without dogs.

Our data illustrate the need to direct pet allergen removal or cleaning measures at not only carpets, but also smooth floors, walls, and furniture in both homes with pets and those without pets. Whether or not the levels of pet and mite allergen we found on hard surfaces in homes are clinically relevant is not known. The significance of the amounts of allergen reported by other studies is unclear. The reported amounts were calculated by extrapolation to “ μg allergen per gram of dust” although the amount of dust collected from a hard surface was much less than 1 g. As in our previous study of pillows,¹⁹ we chose to measure allergen in terms of total allergen recovered from 1 m² of surface because hard surfaces typically yield very little dust (quantities in milligrams) compared with the gram quantities collected by vacuum sampling of carpets. However, regardless of the small amount of dust on these hard surfaces, presumably some of this allergen, particularly in homes with pets, can become airborne and be inhaled. Likewise, the allergen-bearing surfaces may be touched and can directly cause atopic dermatitis, or rhinitis may result when contaminated hands/fingers rub the mucosal areas of eyes and nose.

Our data clearly show that it is important to include cleaning walls, furniture, and smooth floors along with carpets when undertaking measures to reduce exposure to these indoor allergens to treat rhinitis and asthma. Avoiding allergens should be a primary strategy for the management and treatment of allergic disease.^{20,21} Allergen avoidance has been shown to be an effective treatment for individuals sensitive to indoor allergens.^{22–24} Washing, vacuuming, and dusting are all options for removing allergen from hard surfaces. Dry dusting and vacuuming are simpler than washing and are more commonly performed in routine housekeeping. In this study, we determined how much allergen could be removed by dry dusting using a commercially available dust cloth (Grab-it) and by vacuuming these hard

Table 6. Quantity of Mite Allergen (μg Der f 1 + Der p 1/m²) in Homes

Home no.	Floor 1	Floor 2	Wall	Furniture	Carpet
N1	0	0	0	0	0.72
N2	0	0	0	0	1.14
N3	0.12	0.43	0.15	0	4.42
N4	0	0	0	0	0
N5	0	0.30	0	0.52	20.58
N6	3.22	12.12	0	1.01	108.55
C1	0	0.64*	0	0	0
C2	0	0.30	0.48	0.44	0
C3	0	0	0	0	0
C4	0	0	0	0.06	0
C5	0	0	0	0	0
C6	0	0	0	0	0
D1	0	0	0	0	0
D2	0	0	0	0	9.86
D3	0	0.21	0	0	1.08
D4	0	0	0	0	0.57
D5	0	0	0	0	0
D6	0	0.51*	0	0.30	17.85
B1	0.38	1.19	0	0.34	0.45
B2	0	0	0	0.15	43.17
B3	0	0	0	0	0
B4	0	0	0.67	0	2.45
B5	0	0	0	0	0
B6	0	0	0	0	n.s.

Data for hard surfaces are for samples collected by dust cloth unless otherwise indicated. Carpet samples were collected by vacuuming.

* Hard surface sample collected by vacuuming.

n.s. - No sample taken because home had no carpet.

Table 7. Mean Amount of Allergen ($\mu\text{g}/\text{m}^2$) Removed Sequentially from the Tops of Hard Furniture, Walls, and Smooth Floors when the Same Area was First Cleaned with a Dust Cloth and then Brush-Vacuumed

Location	Allergen	First cleaning (dust cloth)	Second cleaning (brush vacuum)
Furniture	Fel d 1	10.91 $\pm$ 3.17† (n = 15)	0.67 $\pm$ 0.24 (n = 15)
Furniture	Can f 1	14.32 $\pm$ 4.41† (n = 17)	1.53 $\pm$ 0.64 (n = 17)
Walls	Fel d 1	2.62 $\pm$ 0.63† (n = 13)	0.19 $\pm$ 0.09 (n = 13)
Walls	Can f 1	8.19 $\pm$ 2.67* (n = 17)	1.14 $\pm$ 0.54 (n = 17)
Smooth floors	Fel d 1	15.20 $\pm$ 3.63† (n = 28)	2.29 $\pm$ 0.82 (n = 28)
Smooth floors	Can f 1	30.23 $\pm$ 6.11† (n = 35)	7.63 $\pm$ 2.60 (n = 35)

* Amount of allergen collected by the first cleaning was significantly greater (*, $P < 0.05$ or †, $P < 0.01$) than that collected by the second cleaning.

surfaces. This study showed that dusting with a dust cloth that captured allergen was an effective means of removing allergen from hard surfaces.

ACKNOWLEDGMENTS

We thank Jeff Schumann, DiAnn Vyszanski-Moher, and Andrea Alexander for their technical assistance and

aid in manuscript preparation. This research was supported by a grant from S.C. Johnson & Son, Inc, Racine, WI.

REFERENCES

1. De Blay F, Chapman MD, Platts-Mills TA. Airborne cat allergen (Fel d I): environmental control with the cat in situ. *Am Rev Respir Dis* 1991;143:1334–1339.
2. Enberg RN, Shamie SM, McCullough J, Ownby DR. Ubiquitous presence of cat allergen in cat-free buildings: probable dispersal from human clothing. *Ann Allergy* 1993;70:471–474.
3. D'Amato G, Liccardi G, Russo M, et al. Clothing is a carrier of cat allergens. *J Allergy Clin Immunol* 1997;99:577–578.
4. Sakaguchi M, Inouye S, Irie T, et al. Airborne cat (Fel d I), dog (Can f I), and mite (Der I and Der II) allergen levels in the homes of Japan. *J Allergy Clin Immunol* 1993;92:797–802.
5. Ingram JM, Sporik R, Rose G, et al. Quantitative assessment of exposure to dog (Can f 1) and cat (Fel d 1) allergens: relation to sensitization and asthma among children living in Los Alamos, New Mexico. *J Allergy Clin Immunol* 1995;96:449–456.
6. Custovic A, Woodcock H, Craven M, et al. Dust mite allergens are carried on not only large particles. *Pediatr Allergy Immunol* 1999;10:258–260.
7. Parvaneh S, Ahlf E, Elfman LH, et al. A new method for collecting airborne allergens. *Allergy* 2000;55:1148–1154.
8. Munir AK, Einarsson R, Schou C, Dreborg SK. Allergens in school dust. I. The amount of the major cat (Fel d I) and dog (Can f I) allergens in dust from Swedish schools is high enough to probably cause perennial symptoms in most children with asthma who are sensitized to cat and dog. *J Allergy Clin Immunol* 1993;91:1067–1074.
9. de Andrade AD, Charpin D, Birnbaum J, et al. Indoor allergen levels in day nurseries. *J Allergy Clin Immunol* 1995;95:1158–1163.
10. Schwartz B, Lind P, Graff-Lonnevig V, et al. Sequential quantitative measurements of cat, dog and mite allergenic molecules in dust from allergenic homes. *J Allergy Clin Immunol* 1986;127:972–975.
11. Wood RA, Mudd KE, Eggleston PA. The distribution of cat and dust mite allergens on wall surfaces. *J Allergy Clin Immunol* 1992;89:126–130.
12. Wood RA, Eggleston PA, Lind P, et al. Antigenic analysis of household dust samples. *Am Rev Respir Dis* 1988;137:358–363.
13. Wood RA, Chapman MD, Adkinson NF Jr, Eggleston PA. The effect of cat removal on allergen content in household-dust samples. *J Allergy Clin Immunol* 1989;83:730–734.
14. Custovic A, Smith A, Pahdi H, et al. Distribution, aerodynamic characteristics and removal of the major cat allergen Fel d 1 in British homes. *Thorax* 1998;53:33–38.
15. Custovic A, Green R, Fletcher A, et al. Aerodynamic properties of the major dog allergen, Can f 1: distribution in homes, concentration and particle size of allergen in the air. *Am J Respir Crit Care Med* 1997;155:94–98.
16. Tovey ER, Chapman MD, Wells CW, Platts-Mills TA. The distribution of dust mite allergen in the houses of patients with asthma. *Am Rev Respir Dis* 1981;124:630–635.
17. Arlian LG, Bernstein D, Bernstein IL, et al. Prevalence of dust mites in the homes of people with asthma living in eight different geographic areas of the United States. *J Allergy Clin Immunol* 1992;90:292–300.
18. American Veterinary Medical Association, Center for Information Management. U.S. Pet Ownership, Demographics Sourcebook. AVMA: Schaumburg, IL, 1997:1–135.
19. Arlian LG, Morgan MS, Goelz, JF. Quantitation of dust mites and allergen in small dust samples. *J Allergy Clin Immunol* 1999;104:707–709.
20. Arlian LG, Platts-Mills TA. The biology of dust mites and the remediation of mite allergens in allergic disease. *J Allergy Clin Immunol* 2001;107(Suppl):S406–S413.
21. Platts-Mills TA, Vaughan JW, Carter MC, Woodfolk JA. The role of intervention in established allergy: Avoidance of indoor allergens in the treatment of chronic allergic disease. *J Allergy Clin Immunol* 2000;106:787–804.
22. Platts-Mills TA, Tovey ER, Mitchell EB, et al. Reduction of bronchial hyperactivity during prolonged allergen avoidance. *Lancet* 1982;2:675–678.
23. Simon HU, Grotzer M, Nikolaizik WH, et al. High altitude climate therapy reduces peripheral blood T lymphocyte activation, eosinophilia, and bronchial obstruction in children with house-dust mite allergic asthma. *Pediatr Pulmonol* 1994;17:304–311.
24. Boner AL, Peroni D, Sette L, et al. Effects of allergen exposure-avoidance on inflammation in asthmatic children. *Allergy* 1993;48(Suppl):119–124.

Requests for reprints should be addressed to:
Larry G. Arlian, Ph.D.
Department of Biological Sciences
Wright State University
3640 Col. Glenn Hwy.
Dayton, OH 45435
E-mail: larry.arlian@wright.edu