

The distribution of cat and dust mite allergens on wall surfaces

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This study was undertaken to determine the distribution of cat and dust mite allergens on wall surfaces and to assess the value of wall-wipe samples as a measure of allergen exposure. Paired samples were collected from 31 homes, 20 homes with cats and 11 homes without, by vacuuming 1 m² of carpet and by wiping 1 square foot of an adjacent wall. Felis domesticus allergen I (Fel d I) was detected in 30 of 31 settled dust samples (range, not detectable to 832,000 mU/gm; median, 10,250 mU/gm) and in 27 of 31 wall-wipe samples (range, not detectable to 113.7 mU per filter; median, 1.2 mU per filter). There was a significant correlation between Fel d I content in settled dust and wall-wipe samples ($r_s = 0.73$; $p < 0.001$). To assess the reproducibility of the wall-wipe method, multiple wipe samples were obtained from 20 homes, revealing a mean coefficient of variation of 110%. In contrast to Fel d I, although Dermatophagoides farinae allergen I was detected in 23 of 25 settled dust samples (range, not detectable to 11,888 ng/gm; median, 1178 ng/gm), it was detected in only four of 25 wall-wipe samples. We conclude that cat allergen, but not dust mite allergen, is widely distributed on wall surfaces and that wipe samples provide a simple and effective means of assessing household exposure to cat allergen. (J ALLERGY CLIN IMMUNOL 1992;89:126-30.)

Key words: Cat allergen, dust mite, house dust

During the last several years, a great deal of information has been gathered on the distribution of cat and dust mite allergens in home environments. Most studies have used settled dust samples for analysis,¹⁻⁵ and a few studies have measured airborne-allergen concentrations.^{6,7} We have found both cat and mite antigens to be virtually ubiquitous in the settled dust of Baltimore homes.^{1,8} In the present study, we attempted to characterize the distribution of these allergens on wall surfaces, a potentially important reservoir for indoor allergens about which no data are currently available. In performing this study, we also studied the use of wall-wipe samples in the assessment in indoor-allergen exposure, since this technique is much less cumbersome than the collection and extraction of settled dust or air samples.

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Abbreviations used

Fel d I: *Felis domesticus* allergen I

Der f I: *Dermatophagoides farinae* allergen I

CV: Coefficient of variation

METHODS

Thirty-one homes were identified for study. These homes included 20 homes with cats and 11 homes without cats. One or more wall-wipe samples were obtained from the living room or bedroom of each home by making five vertical and five horizontal swipes over a 1 square foot area of wall space at an elevation of approximately 4 feet with a 25 mm round glass-fiber filter (Millipore Corp., Bedford, Mass.), premoistened with 0.4 ml of normal saline. Filters were folded and placed directly into a 3 ml syringe after the sample was collected. In addition, after the wall wipe was obtained, a sample of settled dust was collected from an adjacent floor space by vacuuming 1 m² for 2 minutes with a hand-held vacuum cleaner (Douglas Rx 365 Hand Vac, model No. 6735, Douglas Products, Walnut Ridge, Ark.). At least one wipe sample was obtained from each home, and in 20 homes, three wipe samples were collected from each of three walls in a given room to assess the reproducibility of our techniques. For calculation of correlation coefficients, the first sample obtained was used in all instances.

Settled dust samples were extracted and assayed as previously described.⁸ Samples were collected from the vacuum cleaners, sieved through a 0.3 mm brass mesh to produce fine dust, and then extracted at a 1:20 weight to volume concentration in borate-buffered saline. Wall-wipe samples were extracted by adding 1.5 ml of borate-buffered saline to the filter in the 3 ml syringe and then rotating the syringe overnight at 4° C. The extract was then collected by forcing the fluid from the syringe with the plunger. Extracts were frozen at -20° C and then analyzed with two-site monoclonal ELISAs. The monoclonal antibodies, developed and kindly provided by Dr. Martin Chapman, are specific for *Fel d I*,⁹ the major allergen of the domestic cat, and *Der f I*,¹⁰ the major dust mite allergen in Baltimore. The *Fel d I* assay has lower limits of sensitivity of 10 mU/gm for settled dust and 0.1 mU per filter for wipe samples based on the cat reference standard of National Institutes of Health (Office of Biologics and Research Resources, Bethesda, Md.) containing 10.5 U of *Fel d I* per milliliter (note: 1 U of *Fel d I* equals approximately 4 µg of *Fel d I*). The *Der f I* assay has lower limits of sensitivity of 20 ng/gm for settled dust and 0.3 ng per filter for wipe samples based on the University of Virginia *Der f I* standard No. 86/01.

Statistical analysis was performed with nonparametric methods, including the Wilcoxon's signed-rank test and the Spearman's correlation coefficient.

RESULTS

Fel d I was detected by wall-wipe sample analysis from 27 of the 31 homes studied (Fig. 1). Levels ranged from 0.11 to 113.7 mU per filter with a median for all homes of 1.2 mU per filter. There was a significant difference in the *Fel d I* levels of homes with and without cats (median, 2.8 versus 0.2; $p < 0.0001$), although there was a moderate degree of overlap in this regard. Of the four homes with no detectable *Fel d I* in the wall-wipe samples, three samples were from homes without cats in which very low levels of *Fel d I* were found in the settled dust (all, <300 mU/gm), whereas the fourth sample was from a home with a cat with a moderately high level in the settled dust (78,260 mU/gm).

Fel d I content in settled dust samples ranged from nondetectable in one home to 832,000 mU/gm with a median value of 10,250 mU/gm (Fig. 2). Again, a significant difference was noted in cat-antigen content between homes with and without cats (median, 46,495 versus 238; $p < 0.0001$), and for the settled dust samples there was less overlap in this regard. Consistent with previous studies, most homes without cats had detectable cat allergen with levels generally <1000 mU/gm,⁸ although one home without cats in this study did have a *Fel d I* level of 10,250 mU/gm.

As illustrated in Fig. 3, there was an excellent correlation in *Fel d I* content between wall-wipe samples and settled dust samples ($r_s = 0.73$; $p < 0.001$).

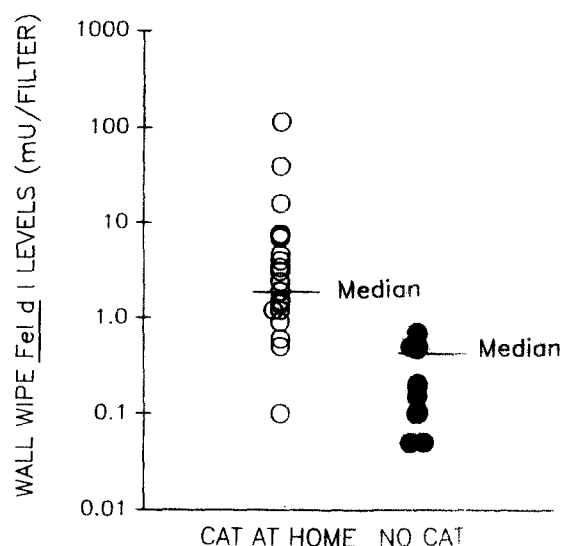


FIG. 1. *Fel d I* levels in wall-wipe samples, comparing homes with and without cats ($p < 0.0001$). Assay has a lower limit of sensitivity of 0.1 mU per filter.

There was only one major aberration, that being the home noted above with significant *Fel d I* content in settled dust but none detectable by wall wipe. If that sample is excluded from the calculation of the correlation coefficient, the $r_s = 0.82$.

To assess the reproducibility of the wall-wipe sampling method, multiple wipe samples were obtained from 20 homes. A total of nine samples were obtained from each home by wiping three locations on three different walls within a given room. Although *Fel d I* levels within a room were qualitatively similar in most homes, tenfold variability in antigen content between samples was commonly found (Fig. 4). Many homes have both positive and negative samples, and in two homes, single samples of the set of nine had no detectable *Fel d I*, whereas the remaining eight homes had clearly detectable levels. Overall, CVs ranged from 20% to 220% with a mean CV for all 20 homes of 110%.

To provide a control with another common indoor allergen that exists in a very different physical state, *Der f I* measurements were made in 25 homes. Only four homes had detectable levels by wall-wipe analysis (maximum value, 6.8 ng per filter). In settled dust samples, *Der f I* was detected in 23 of 25 homes with a maximum value of 11,888 ng/gm and a median of 1178 ng/gm. No correlation was found between wall-wipe and settled dust samples for *Der f I* (Fig. 5). Although all homes with *Der f I* detectable by wall wipe had settled dust levels >4000 ng/gm, one home with a level in settled dust >8000 ng/gm had no detectable *Der f I* on nine different wall-wipe samples.

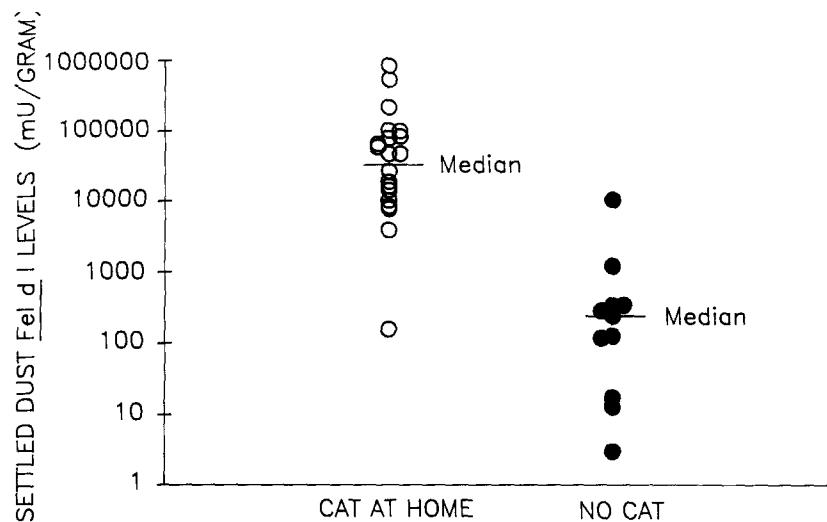


FIG. 2. *Fel d I* levels in settled dust samples, comparing homes with and without cats ($p < 0.0001$). Assay has a lower limit of sensitivity of 10 mU/gm of dust.

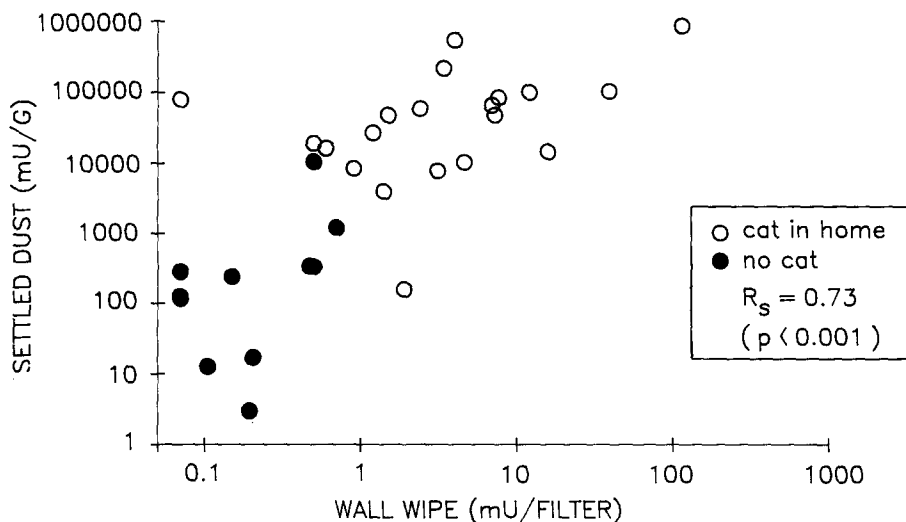


FIG. 3. Correlation in *Fel d I* content between settled dust and wall-wipe samples ($r_s = 0.73$; $p < 0.001$). Homes with cats ($\circ$); homes without cats ($\bullet$).

DISCUSSION

This study is the first of wall-wipe sampling for the assessment of indoor allergen exposure. We found that cat allergen was easily detected in wall-wipe samples from most homes and that these levels correlated with the levels found in settled dust samples. Dust mite antigen, in contrast, was rarely detected on wall surfaces. These findings have several important implications.

It is evident that cat antigen is deposited on wall (and probably many other surfaces) surfaces and that

this represents another major reservoir for this important allergen within a home. The tendency for this allergen to become airborne is currently unknown, but we would speculate that under some conditions it is very likely to be resuspended and contribute to respiratory symptoms. In addition to inhalation, however, this wall-bound allergen may also gain access to the airway in substantial concentrations when residents touch the wall, contaminate their hands, and then touch the mucosa of the eye or nose. Although the issue of dermal contamination has never been care-

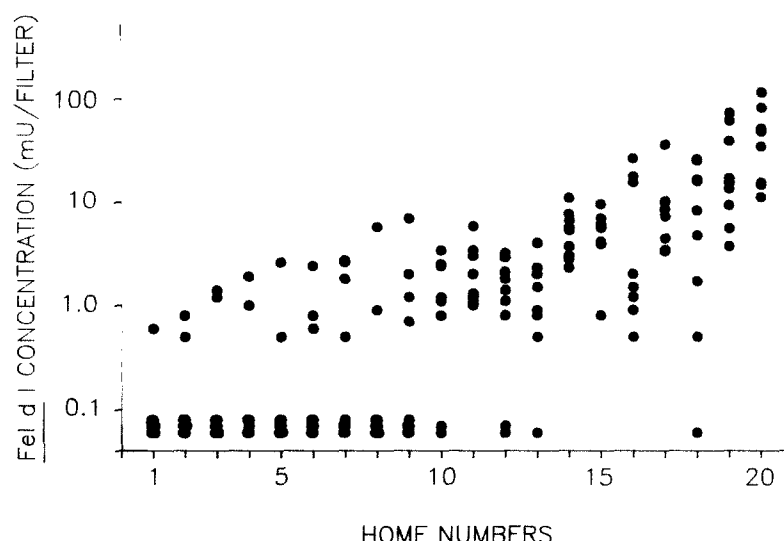


FIG. 4. Multiple wall-wipe samples were obtained from 20 homes to assess reproducibility. Samples revealed a mean CV of 110% (range, 20% to 220%).

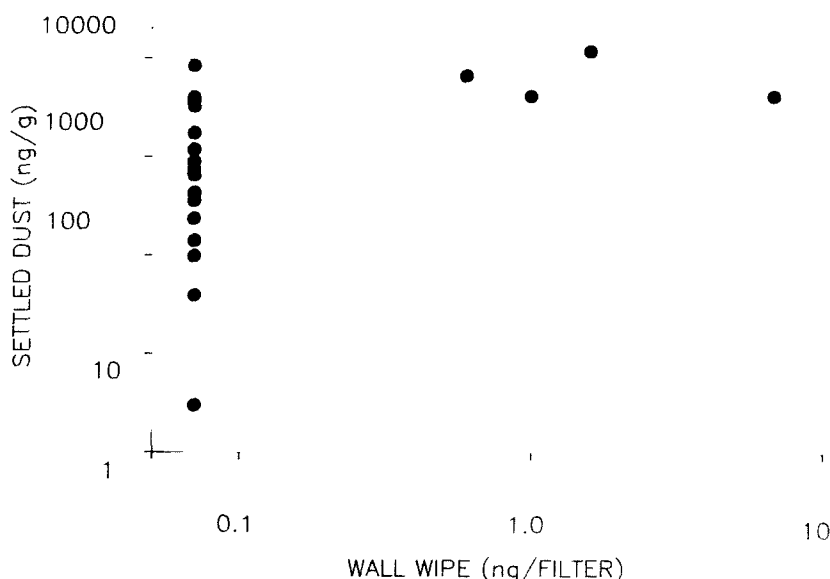


FIG. 5. No correlation was detected in *Der f* I content between settled dust and wall-wipe samples. *Der f* I was detected in 23 of 25 settled dust samples and in only four of 25 wall-wipe samples. Lower limits of detection were 0.3 ng per filter and 20 ng/gm for wall-wipe and settled dust samples, respectively.

fully studied with regard to allergen exposure, it is almost certainly of importance in the case of a ubiquitously distributed antigen, such as *Fel d* I. In fact, the quantities of antigen that we collected by simply wiping 1 square foot of wall are similar to the quantities delivered in cat inhalation challenges.¹¹

Next, the correlation in *Fel d* I content between the wipe and settled dust samples suggests that wipe sam-

ples are potentially a useful marker of cat-allergen exposure. Our current techniques are limited by the fact that their predictive value is only fair when all homes are considered. If these techniques could be perfected, however, it would provide a significant advance because of the ease with which wipe samples may be obtained and transported as compared to dust or air samples. The wipe-sample techniques are ex-

tremely simple and efficient, especially when these are compared to the cumbersome process of collecting, sieving, weighing, and extracting a settled dust sample. With the growing interest in the measurement of indoor allergens as a clinical tool, these possibilities have even greater implications.

Another drawback to the wipe-sample technique is the significant variability in antigen content that occurs within a room. Our data indicate that there may be both "hot" and "cold" spots with regard to cat allergen within a given room, most likely related to differences in cat mobility or ventilation patterns within the room. Practically, this means that multiple wipe samples would need to be obtained to assure a reasonable assessment of cat-allergen exposure. It is also important to recognize, however, that similar data are not currently available with regard to settled dust analysis.

In contrast to cat antigen, it appears that wipe samples have little use in the assessment of dust mite exposure and that walls do not represent an important reservoir for mite antigens. The differences between cat and dust mite antigens in this regard most likely stem from differences in particle size,^{7, 12} with the smaller and more buoyant cat-allergen particles having a greater opportunity to adhere to a wall. It could be speculated that differences in adherence properties and electrostatic charge could also be playing important roles, but there are no data to support this notion at present. These findings have significant implications as we attempt to devise improved allergen-specific environmental control measures.

Thus, although the techniques of wall-wipe analysis are as yet quite primitive, we believe they are a very useful adjunct in the study of indoor allergen exposure. Furthermore, we believe that walls and other surfaces represent a very important reservoir for certain indoor allergens that has heretofore been largely ignored.

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