Airborne dust and allergen generation during dusting with and without spray polish

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Background: Dusting is a commonly used method for dust removal from surfaces in the home. However, the process of dusting may contribute to airborne dust levels by disturbing dust particles from a surface and failing to remove it from the indoor environment.
Objective: We sought to measure the quantity of allergen-laden dust disturbed into the air during dusting and discover whether applying spray polish to either the dusty surface or the cleaning cloth reduced this amount.
Methods: A common furniture polish was tested for its ability to prevent dust particles and major house dust mite (Der p 1) or major cat (Fel d 1) allergen from becoming airborne during dusting. Tests were completed with a repeatable mechanized dusting procedure with polish sprayed onto either a cleaning cloth or directly onto a surface, and this was compared with a control procedure with a standard duster. Airborne dust was measured with an air-particle counter and by means of anti-Der p 1 or anti-Fel d 1 ELISA.
Results: Considerable quantities of dust became airborne during dusting. When polish was sprayed onto the cleaning cloth, the concentration of airborne dust particles was reduced by a mean of 83.4%, house dust mite allergen by 50.3%, and cat allergen by 57.4% when compared with dry-cloth controls. Spraying polish directly onto the surface was even more effective at reducing the generation of airborne particles (92.9%) and allergens (Der p 1 by ≥95% to below the sensitivity of the ELISA and Fel d 1 by 95%). All reductions were significant when compared with dry-cloth controls ($P < .01$, Mann-Whitney *U* test).
Conclusions: This study showed that application of a polish spray to either the surface or the cloth during dusting greatly reduced dust and allergen evolution into the air, which should reduce exposure to airborne allergens in the home. (J Allergy Clin Immunol 2002;109:63-7.)

***Key words:** Dusting, airborne particles, dust, house dust mite, cat, allergen, polish*

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Asthma is a major debilitative disease that is on the increase throughout the world.[1] The process of specific sensitization to house dust mite allergen is directly related to exposure.[2,3] Severity of asthma symptoms is also related to allergen exposure, and it is probable that sensitized patients exposed to high levels of allergens will usually have more severe disease than those exposed to low levels of allergens.[4] Exposure to an allergen stimulus can result in bronchospasm, rhinitis, or dermatitis in sensitive individuals.[5] In the home environment exposure often occurs after disturbance of an area that contains large amounts of allergen and dust. These reservoirs are often carpets, soft furnishings, and bedding.[6,7] Predominant allergens found in the home are house dust mite (*Dermatophagoides pteronyssinus*, Der p 1), cat (*Feline domesticus*, Fel d 1), cockroach, and bird. The Der p 1 allergen-carrying particle is approximately 10 to 40 µm in diameter and contains more than 10 mg/mL house dust mite allergens. Fel d 1 is generally found on smaller particles less than 5 µm in diameter that remain airborne for a prolonged period after disturbance.[5] Removal of allergen from the home environment is an effective strategy to avoid allergen stimulus.[3] However, cleaning techniques used to remove dust and allergen can inherently disperse dust into the air.[6] It is well documented that vacuum cleaners can contribute to airborne dust and allergen levels by means of leakage from the exhaust and disturbance of the floor surface.[8,9] However, disturbance of airborne dust and allergen during other household cleaning activities, such as dusting, have not been quantified.

This work uses a mechanized dusting procedure to determine the amount of airborne particles and allergen disturbed into the air during cleaning and the affect of a prespray of household furniture polish onto either the dust-covered surface or the cleaning cloth. Measurement of both airborne particles and allergen concentration was completed because a change in the number of airborne particles after dusting would not necessarily reflect a change in the concentration of airborne allergen.

METHODS

Dust preparation and distribution

Dust was collected from vacuum cleaner bags that were known to have high levels of Der p 1 and Fel d 1 allergen. The dust was sieved, and the fraction below 53 µm in diameter was used for the tests. One gram of dust was distributed evenly over a 0.28 × 0.18–m section of a piece of wood veneer (measuring 0.57 × 0.29 m) with a fine mesh.

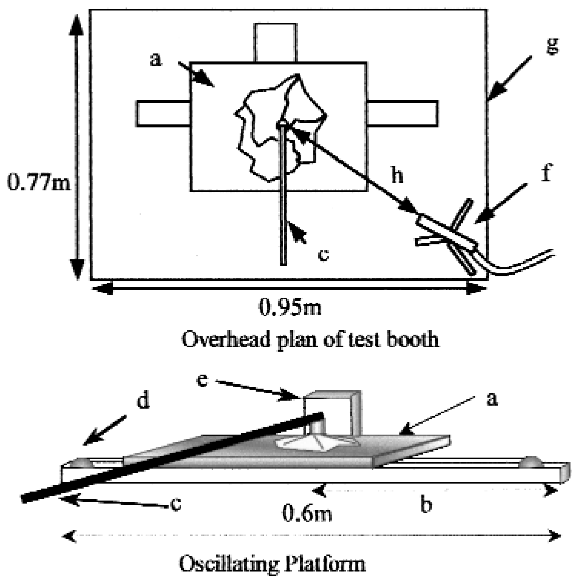

FIG 1. A, Overhead plan of test booth. **B**, Oscillating platform. *a*, Wood veneer attached to platform; *b*, 0.3-m translation length of platform; *c*, clamped arm holding small motor-driven spindle with attached cleaning cloth; *d*, motor-driven cable and pulley that move the platform; *e*, platform motor; *f*, sampling tube for either air-particle counter or allergen-collection tests; *g*, opening door of booth; *h*, 0.4-m distance between sampling tube and cleaning cloth.

Test chamber and apparatus

Tests were completed in a test chamber measuring 0.95 × 0.77 × 0.58 m with an opening at one end to allow for polish spraying, adjustment of the equipment, cleaning, and ventilation between tests (Fig 1, *A*). The chamber was tightly sealed during the air-sampling experiments.

The mechanized dusting procedure used an oscillating platform (Fig 1, *B*) onto which the wood veneer was attached with adhesive tape. A motor-driven rotating spindle was clamped in position over the wood. The cleaning cloths were attached to this to perform the dusting function in the experiments. When activated, the oscillation of the platform had a maximum translation of 0.3 m. The cotton cleaning cloths (0.25 × 0.22 m) contacted the whole area to which dust had been applied with a constant pressure. One oscillation of the platform was completed in 3 seconds, and the rotating spindle completed 120 revolutions per minute, which provided a repeatable way of dusting the surface. After each experiment, the cleaning cloths and surface were carefully removed from the chamber. The cloth was discarded, and the surface was cleaned of any remaining dust. Internal surfaces were washed with a damp cloth, and the chamber was ventilated for a minimum of 20 minutes, sealed, and left for a further 10 minutes for the air to stabilize. The household polish aerosol used in the tests contained 20% solvents (oils, silicones, and waxes), 65% water, and 15% liquid petroleum gas and had a volume median droplet diameter of 185 μm. The polish aerosol can was weighed before and after each experiment to determine the weight of aerosol released.

Measurement of airborne dust concentration with an air-particle counter

Airborne particle concentrations were measured with an air-particle counter (APC 300A, Malvern Instruments). This quantified particles from 0.5 to 25 μm in diameter. The polish-on-surface experiments were completed to determine the effect of a prespray of polish onto a dust-covered surface on the amount of dust disturbed into the air during the cleaning process. When investigating the dusting process in a laboratory environment with an air-particle counter, all sources of airborne particles must be quantified. In the polish-on-surface experiments airborne particles were expected to originate from background air, dust disturbed from the wood surface by the cleaning cloth, polish aerosol particles, and dust disturbed from the wood surface by the forward velocity of the polish spray. In the polish-on-cloth experiments airborne particles were expected to originate from background air and dust disturbed from the wood surface by the cleaning cloth because the polish was sprayed onto the cloth away from the test booth. In the following experiments each of these sources of airborne particles were isolated and quantified to enable conclusions to be made on the effect of polish use on the amount of dust disturbed into the air.

Measurements were completed with the air-particle counter before each experiment, and the background airborne particle counts were subtracted from those recorded in each of the tests, and therefore all results shown in the Figures have been corrected for the background air-particle count.

Particles disturbed from the dust-covered wooden surface by the action of the cleaning cloth were quantified by placing a dust-covered surface on the platform and then activating the oscillating platform and rotating the spindle attached to the cleaning cloth for 30 seconds. The air-particle counter then immediately started its first 1-minute sample and continued until it had collected 5 samples. Tests completed without spraying polish were identified as dust-only control tests. The same procedure was completed in tests in which polish was applied, with the addition of spraying polish onto the entire dust-covered surface from a distance of 0.25 m (average of 2.08 g [SE, 0.08 g] for polish-on-surface tests), or the cloth (average of 2.03 g [SE, 0.02 g] for polish-on-cloth tests) before the 30-second cleaning process commenced. The dust-only control experiments, polish-on-surface experiments, and polish-on-cloth experiments were repeated a total of 5 times, and results are shown in Fig 2. The polish-on-surface results shown in Fig 2 have been corrected for polish droplets produced by the spray onto the dust-covered surface and therefore show only the dust particles disturbed by the cleaning cloth. It has been found in experiments not presented here that the amount of dust disturbed from the surface by the forward velocity of the polish spray was negligible.

Quantification of airborne allergen concentration

The experiments identified as dust-only control tests, polish-on-surface tests, and polish-on-cloth tests in the air-particle count experiments were repeated with minor modifications to allow for airborne allergen collection. The cleaning process was extended to 5 minutes to generate sufficient airborne allergen (Der p 1 or Fel d 1) to be detected with an ELISA.[10-12] Air was sampled from the test chamber during this time at 18 L/min through a 25-mm diameter glass-fiber filter paper (Pall Gelman Laboratory) in an in-line filter holder (Pall Gelman Laboratory). The sampler was located 0.4 m from the cleaning cloth. This procedure was completed a total of 5 times to collect Der p 1 allergen and 10 times for Fel d 1 allergen. After sampling, the filter paper and collected dust were removed and carefully placed in an Eppendorf tube to which 1 mL of 1% BSA in PBS with 0.05% Tween was added to elute captured allergen. Samples were assayed with either anti-Der p 1 or anti-Fel d 1 ELISA (all antibodies from Indoor Biotechnologies).[1-3]

RESULTS

Generation of airborne dust particles during dusting

Fig 2 shows the total number of airborne particles recorded in the dust-only control tests compared with the

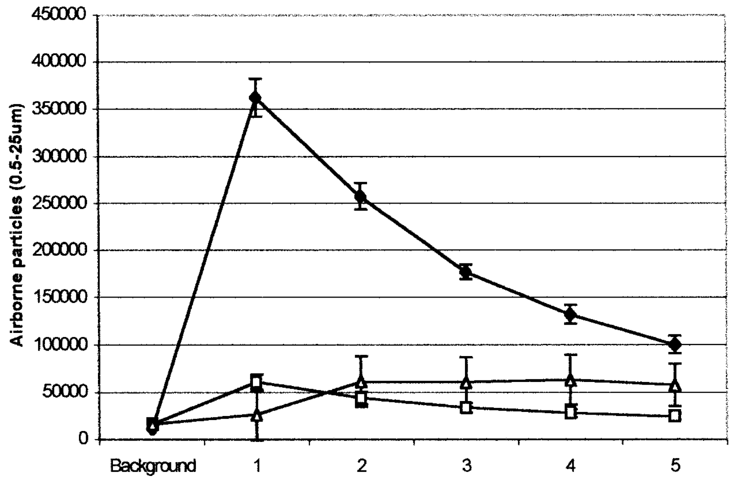

FIG 2. Comparison of airborne particles produced during dusting with and without a prespray of polish onto either the cloth or the surface. Polish-on-surface data have been corrected to remove the average number of particles disturbed by the polish spray onto the dusty surface. All data shown have had the background level of particles removed (5 replicas; SEs shown). *Circles*, Dry-cloth controls; *squares*, polish on cloth; *triangles*, polish on surface.

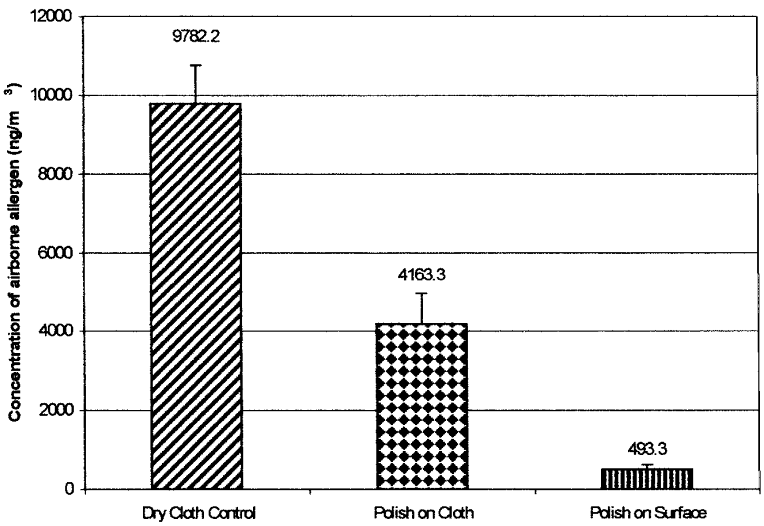

FIG 3. Concentration of airborne cat allergen (Fel d 1) after dusting with and without polish sprayed onto either the cloth or the surface (10 replicas; SEs shown).

tests when polish was applied to the surface or the cleaning cloth before cleaning (polish-on-surface and polish-on-cloth tests, respectively). These results indicate that dusting with polish sprayed onto the surface generated far less airborne particles than dusting with a dry cloth, such that the concentration of particles was reduced by up to 92.9% after 1 minute. Statistical analysis indicated that particle concentration was significantly lower ($P < .01$, Mann-Whitney *U* test) up to 3 minutes after sampling commenced.

Application of polish to the cleaning cloth also substantially reduced the concentration of particles becoming airborne during dusting. The polish-covered cloth disturbed up to 83.4% fewer particles than the dry-cloth control after 1 minute. The difference was significant ($P < .01$) for the entire sampling period.

Generation of airborne allergen during dusting

Fig 3 shows the amount of airborne cat allergen (Fel d 1) generated during dusting with and without polish sprayed onto the surface or the cleaning cloth. The results showed that airborne Fel d 1 allergen concentration was reduced by 95% by application of polish to the surface.

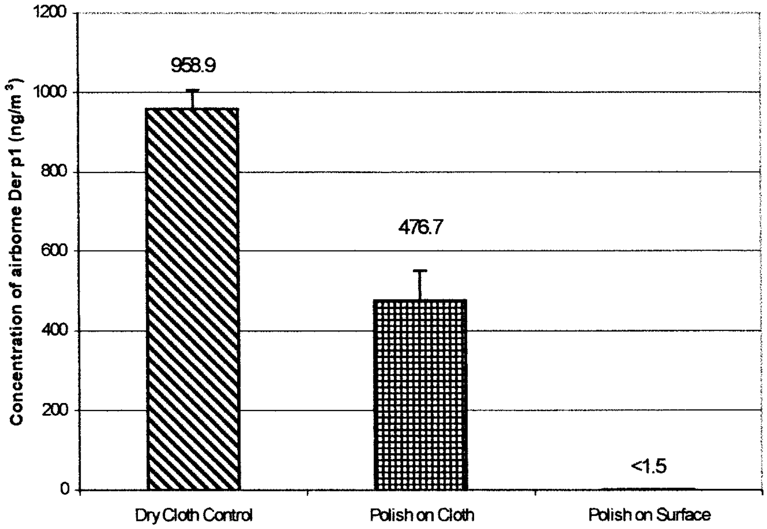

FIG 4. Concentration of airborne house dust mite allergen (Der p 1) after dusting with and without polish sprayed onto either the cloth or the surface (5 replicas; SEs shown).

Statistical analysis indicated the reduction achieved was significant ($P < .01$, Mann-Whitney *U* test). When polish was applied to the cleaning cloth, the concentration of Fel d 1 allergen disturbed into the air by the dusting process was also reduced (57.4%). The difference was statistically significant ($P < .01$).

Fig 4 shows the concentration of airborne Der p 1 allergen generated during the cleaning experiments. Spraying polish onto the surface before cleaning reduced the level of airborne Der p 1 generated to below the level of sensitivity of the Der p 1 ELISA (<4 ng/mL), indicating a reduction of at least 95%. Airborne Der p 1 allergen was significantly reduced if polish was sprayed onto the cleaning cloth before dusting (50.3%, $P < .01$).

DISCUSSION

This investigation has shown that considerable quantities of dust particles and allergens are dispersed into the air during dusting with a clean, dry dusting cloth. The mechanized dusting procedure used in the experiments prevented operator error and increased the reproducibility of the tests. Dry dusting evolves particles into the air immediately, as shown by the peak in concentration at 1 minute (Fig 2). Concentration then falls as these particles disperse in the chamber and precipitate from the air. No such steep increase was seen when either the surface or cloth had polish applied, with the concentration of particles that became airborne significantly reduced by up to 92.9% in some instances. This indicates that dust particles are locked onto the surface or the cloth by the polish and are available for removal by the cleaning cloth with less risk of becoming airborne. The observed effect was probably caused by the polish dampening the dust.

Evolution of airborne cat allergen was reduced by 95%, and house dust mite allergen was reduced by at least 95% to below the sensitivity of the ELISA during dusting with the polish on the surface, confirming that the very low particle concentrations in the particle-count data translate to a reduction in airborne allergen. It was expected that airborne allergen concentration should be reduced along with the concentration of airborne dust because this effect has previously been demonstrated.[13] When the allergen concentration results are compared for surface and cloth polish application, the surface spray was most efficient at preventing disturbance of allergen into the air. This may be because spraying the polish onto the surface ensured a better coverage of the dust than relying on contact with the cloth.

It had been thought possible that spraying a polish onto a dust-covered surface would disturb a large proportion into the air, thus negating any benefit of reduced disturbance during cleaning. However, results obtained by the authors using the same apparatus as in these tests have shown that this is not the case and that the polish wets the surface dust without disturbing a measurable amount of dust. Therefore a surface spray of polish before cleaning is a very efficient way of reducing reentrainment of dust and allergen particles into the air. However, if the polish spray locked the dust onto the surfaces in the home and prevented its removal, this would be a negative effect because the allergen would still be present to trigger an allergic response. Further experiments are required to address this, but a visual assessment of the cleaning cloths and surface after these experiments showed that the majority of dust adhered to the cloth after cleaning, leaving the surface dust free. A more realistic situation in which dust was present on uneven surfaces was not quantified in these experiments and could be investigated in the future.

The enhanced cleaning with reduced airborne dust generation measured after a polish spray should result in lower user exposure and could give a significant benefit of less allergic stimulation in the home environment.

REFERENCES

1. Kuehr J, Frischer T, Meinert R, Barth R, Forster J, Schraub S, et al. Mite allergen exposure is a risk for the incidence of specific sensitisation. J Allergy Clin Immunol 1994;94:44-52.
2. Woodcock A, Custovic A. Role of the indoor environment in determining the severity of asthma. Thorax 1998;53:547-51.
3. Boner AL, Niero E, Antolini I, Valletta EA, Gaburro D. Pulmonary function and bronchial hyperreactivity in asthmatic children with house dust mite allergy during prolonged stay in the Italian Alps (Misurina, 1756m). Ann Allergy 1985;54:42-5.
4. Platt-Mills TAE, Heymann PW, Longbottom JL, Wilkins SR. Airborne allergens associated with asthma: particle sizes carrying dust mite and rat allergens measured with a cascade impactor. J Allergy Clin Immunol 1986;77:850-7.
5. Lewis RD, Breysse PN, Lees PSJ, Diener-West M, Hamilton RG, Eggleston P. Factors affecting the retention of dust mite allergen on carpet. Am Ind Hyg J 1998;59:606-13.
6. Swanson MC. Correlations between levels of mite and cat allergens in settled and airborne dust. J Allergy Clin Immunol 1989;83:776-83.
7. Woodfolk JA, Luczynska CM, de Blay F, Chapman MD, Platts-Mills T. The effect of vacuum cleaners on the concentration and particle size distribution of airborne cat allergen. J Allergy Clin Immunol 1993;91:829-37.
8. Hegarty JM, Rouhbankhhsh S, Warner JA, Warner JO. A comparison of the effect of conventional and filter vacuum cleaners on airborne house dust mite allergen. Respir Med 1995;89:279-84.
9. de Blay F, Spirlet F, Gries P, Casel S, Ott M, Pauli G. Effects of various vacuum cleaners on the airborne content of the major cat allergen (Fel d 1). Allergy 1998;53:411-4.
10. Chapman MD, Heymann PW, Wilkins SR, Brown MB, Platts-Mills TAE. Monoclonal immunoassays for the major dust mite (Dermatophagoides) allergens, Der p1 and Der f1, and quantitative analysis of the allergen content of mite and house dust extracts. J Allergy Clin Immunol 1987;80:184-94.
11. Luczynska CM, Arruda LK, Platts-Mills TAE, Miller JD, Lopez M, Chapmann MD. A two-site monoclonal antibody ELISA for the quantification of the major *Dermatophagoides* spp. allergens, Der p1 and Der f1. J Immunol Methods 1989;118:227-35.
12. Chapman MD, Aalberse RC, Brown MJ, Platts-Mills TAE. Monoclonal antibodies to the major feline allergen, Fel d I. II. Single step affinity purification of Fel d I, N-terminal sequence analysis and development of a sensitive two-site immunoassay to assess Fel d I exposure. J Immunol 1988;140:812-8.
13. Gaynor PT, Hughes JF. Dust anchoring characteristics of electret fibres with respect to Der p1 allergen carrying particles. Med Biol Eng Comput 1998;36:615-20.