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## Environmental control of indoor biologic agents

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**RH** Relative humidity

The indoor environment contains unique pollutants, such as environmental tobacco smoke and indoor allergens. In addition, air pollutants may reach higher levels indoors than outdoors, and in some instances may exceed the national standards for outdoor exposure. Nonindustrial indoor settings, such as offices, residences, and vehicles, also have air quality problems. Although the role of occupational air pollutants (organic and inorganic) in causing complaints in the workplace has

been clearly documented, the relationship between poor air quality and health complaints is often controversial. The main causes of poor indoor air quality are an inadequate ventilation or fresh air intake, biologic contamination of the indoor environment, and an accumulation of noxious compounds. A list of important indoor air pollutants is shown in ■Table I.

**TABLE I.** Major indoor air pollutants

|                                                                                          |
|------------------------------------------------------------------------------------------|
| Respirable particles                                                                     |
| NO, NO <sub>2</sub>                                                                      |
| CO                                                                                       |
| CO <sub>2</sub>                                                                          |
| Biologic agents (indoor allergens)                                                       |
| Domestic mites                                                                           |
| Furry pets (cats, dogs, rabbits, gerbils, mice, rats, hamsters, guinea pigs, and others) |
| Birds                                                                                    |
| Insects (cockroaches, fleas)                                                             |
| Molds (outdoor and indoor molds) and bacteria in air-conditioning units                  |
| Formaldehyde                                                                             |
| Radon and radon daughters                                                                |
| Volatile organic compounds                                                               |
| Semivolatile organic compounds                                                           |
| Asbestos                                                                                 |

Because indoor allergen concentrations are higher in homes than in public places, a greater effort should be made to control allergens at home. A reason for this difference may be the more aggressive chemical treatment of carpets in public places. However, in some instances high mite, cat, and dog allergen levels have been detected in schools and day care centers. These findings have important implications for families who are practicing allergen avoidance at home because the effort and time spent controlling allergen exposure could be jeopardized by exposure in the school environment.<sup>1</sup> Studies conducted in schools have demonstrated that carpets contain high levels of a variety of allergens including pollen, cat, dog, food, mite, and mold allergens.<sup>2</sup> Carpets in schools and homes are an important reservoir of allergens.

The control measures discussed in this review can be applied, with minor modifications, to both homes and public places.

Before strategies of environmental control in “dirty environments” are designed, several factors, such as dampness and ventilation, should be considered. Studies in North America indicate that dampness in homes is widespread, in the range of 40% to 60%.<sup>3</sup> The association of dampness in the home with respiratory symptoms is substantial, with odds ratios of 1.5 to 2.5. Moisture within homes and the concomitant growth of mold, bacteria, and mites are substantial contributors to infectious and allergic respiratory diseases. Dust mite allergen and endotoxin levels are directly related to indoor humidity. The most effective ways to control microbial growth are shown in ■Table II.

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**TABLE II.** Effective ways to control microbial growth

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1. Install exhaust fans vented to outdoors, powerful enough to remove moist air from kitchens and bathrooms.
  2. Vent dryers to the outdoors.
  3. Ventilate the attic and basement crawl space to reduce excess moisture. A polyethylene ground cover can be placed on top of the soil in the crawl space.
  4. Clean the basement floor drain frequently with a disinfectant to prevent the buildup of microorganisms.
  5. Provide extra ventilation if green lumber or wet wood is used for construction.
  6. Put a vapor retarder under the concrete slab floor and add waterproofing materials to the outside of the foundation if you are building a new house or an addition.
  7. Use storm windows or double-pane windows to control condensation.
  8. Repair leaks and eliminate standing water immediately.
  9. Use dehumidifiers
  10. Maintain a clean house
  11. Avoid wall-to-wall carpeting (!)
- 

Increasing fresh air ventilation through a house is a useful corrective measure. Ventilation is defined as the unaided movement of air into and out of the house. Ventilation rates are determined by differences between indoor and outdoor air temperatures, by differences in temperature within the house, and by wind velocity and direction. As a result, natural ventilation rates will vary widely depending on the weather, the location and orientation of the home, and the positions of windows and doors. Natural ventilation improves indoor air quality, but it has several limitations. It is an inefficient means to dilute contaminants in a home, because air is not uniformly distributed and the flow cannot be controlled. Increased ventilation could also increase pollen and mold spore levels, if outdoor counts are elevated.

An alternative to natural ventilation is mechanical ventilation systems, which use electric fans and blowers to pull fresh air inside, to circulate the air through the building or apartment, and to exhaust stale indoor air to the outside. Bathroom and kitchen exhaust fans, air-to-air heat exchangers, and

heat pump ventilators are types of mechanical ventilation used to maintain indoor air quality. Ceiling fans simply recirculate indoor air, which reduces dampness caused by condensation but has little effect on the concentration of contaminants. Inadequate ventilation is probably one of the main causes of poor indoor air quality. However, a study has challenged the idea that increasing fresh air circulation could significantly benefit the management of poor indoor air quality.<sup>4</sup>

The efficiency of ventilation is influenced by fresh air availability, fresh air movement and distribution (dilution), the presence of mass and energy pollutants, occupancy factors and filtration and control methods. Most mechanical ventilation systems in large buildings primarily use recirculated air during hot or cold weather. Setting mechanical air handling systems to deliver outside air and opening windows are inexpensive remedial actions in homes but are frequently not achievable in the workplace.

A reduction in the air exchange rate results from several "home improvement" methods. Installation of weather stripping reduces air exchange rates by 1%, caulking of window seals by 3%, the addition of storm windows by 6%, increasing the insulation by 10%, and sealing of air ducts by 23%. The recommended rate exchange of fresh air in homes is 0.33 air exchanges per hour. The American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE Standard 62-1989) has established minimum ventilation rates acceptable for residential areas. These include a minimum of 15 cubic feet per minute (cf-min) per person in the living area; 100 cf/min intermittent or 25 cf/min continuous in the kitchen; 50 intermittent or 20 cf/min continuous in the bathroom, and 100 cf/min per car in the garage.

## Environmental Control of Biologic Indoor Air Pollution

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The first requirement for achieving environmental control of indoor air is to identify, remove, isolate, and/or replace the source of the pollutants. However, certain sources cannot be easily controlled, particularly when the source is in or on human beings. For example, contagious diseases such as influenza, viral upper respiratory tract infections, chicken pox, and tuberculosis are controlled only by reducing exposure to infected individuals.

Source control of indoor air pollution may not be easily achieved, and corrective measures may be costly. For example, removal of a domestic pet from the home of an individual who is allergic to cats has emotional barriers, which make implementation difficult. Removal of carpeting and furniture containing house dust mite or cat allergens is costly. Major expenses may be incurred with the installation or modification of ventilation systems or air-conditioning units. Building owners, managers, or home owners must be convinced that the modification and expenditure is essential and that a substantial health benefit will follow. Medical advice should be obtained to determine the relative contribution of the indoor environment on the affected subject's medical problem. Other factors such as outdoor allergic sensitivities, occupational exposure, cigarette smoking, and medical problems must be identified.

## Mold and bacteria

Mold and bacterial contamination can be prevented or diminished by limiting the access of outdoor aerosols to the indoor environment. Adequate filtered air for dilution of indoor contaminants should be provided. Ideally, a constantly renewed source of filtered outdoor air should be maintained.

Indoor humidity should be maintained below 60%. The intrusion of moisture should be prevented, and the use of water spray devices should be limited. Existing contamination can be reduced by air cleaning or surface decontamination. Electrostatic precipitators and high-efficiency particulate air filters are commonly used filters in houses. The electrostatic precipitators do remove the majority of large particles, but removal of smaller particles is limited. These filters remove intact bacteria and most mold spores but not the metabolic products of these organisms. These filters require regular maintenance and overload rapidly. High-efficiency particulate air filters remove microbial contamination and have a steady state that depends on particulate collection efficiency, the amount of air passing through the filter, and the strength of the pollutant source.

Hard surfaces should be cleaned with a 5% to 10% solution of sodium hypochlorite (bleach), which kills microorganisms, but this will not prevent recontamination. Humidifiers and vaporizers should be scoured regularly, and fabrics should be cleaned in hot water. Carpets cannot be effectively cleaned unless they are removed and commercially processed.

The following measures have been recommended<sup>5</sup> to reduce indoor mold contamination: (1) increase ventilation, (2) heat all rooms during the winter, (3) avoid line drying clothes indoors, (4) repair insulation defects, (5) increase cleaning, (6) increase bathroom ventilation, and (7) reduce the number of indoor plants and keep them healthy.

The effect of cleaning air ducts on clinical symptoms has not been studied in a controlled manner. Commercial firms offer duct cleaning treatments that are effective, at least immediately, in reducing mold and bacteria counts. ■ Table III shows the predominant genera of mold and bacteria in 16 homes in central Florida. ■ Table IV shows the results achieved in a home after duct cleaning. Similar results were obtained in other homes.

**TABLE III.** Frequency of isolation of mold and bacteria in air ducts of 17 central Florida homes\*

| <b>Benera</b>          | <b>% Bldg</b> | <b>Mean CFU/m<sup>3</sup></b> | <b>Range</b> |
|------------------------|---------------|-------------------------------|--------------|
| <i>Bacillus</i>        | 94.1          | 1100                          | 450-4700     |
| <i>Staphylococcus</i>  | 88.2          | 1150                          | 150-2700     |
| <i>Corynebacterium</i> | 64.7          | 1250                          | 200-2600     |
| <i>Penicillium</i>     | 35.2          | 1000                          | 150-4250     |
| <i>Mucor</i>           | 41.1          | 100                           | 50-1250      |
| <i>Cladosporium</i>    | 29.2          | 1500                          | 100-3750     |
| <i>Aspergillus</i>     | 29.2          | 300                           | 100-700      |
| <i>Curvularia</i>      | 23.5          | 150                           | 100-200      |
| <i>Rhizopus</i>        | 17.6          | 300                           | 50-800       |
| <i>Drechslera</i>      | 17.6          | 100                           | 50-150       |
| Gram negative          | 11.7          | 350                           | 150-300 rods |

|                        |      |      |         |
|------------------------|------|------|---------|
| Nonsporulating         | 11.7 | 100  | 50-100  |
| <i>Nocardia</i>        | 5.8  | 600  | 100-600 |
| <i>Graphium</i>        | 5.8  | 1250 | 1250    |
| <i>Paecilomyces</i>    | 5.8  | 300  | 300     |
| <i>Syncephalastrum</i> | 5.8  | 750  | 900     |

Bldg, Building.

\*Courtesy of Pure Air Control Services.

**TABLE IV.** Mold and bacteria concentrations in CFU/m3 before and after duct-garde treatment\*

| Genera                   | Before | After | % Reduction |
|--------------------------|--------|-------|-------------|
| <i>Aspergillus niger</i> | 200    | 0     | 100         |
| <i>Aspergillus</i>       | 150    | 0     | 100         |
| <i>Rhizopus</i>          | 400    | 0     | 100         |
| <i>Penicillium</i>       | 75     | 0     | 100         |
| <i>Bacillus</i> no. 1    | 850    | 50    | 94          |
| <i>Bacillus</i> no. 2    | 325    | 100   | 69          |
| <i>Staphylococcus</i>    | 1125   | 50    | 95          |
| Total                    | 3125   | 200   | 93.6        |

\*Courtesy of Pure Air Control Services.

## Domestic mites

Some knowledge of house dust mite biology is required to understand the different methods that are currently available to control house dust mites.<sup>6 8</sup> The water loss of the mite body regulates colonization and population growth. House dust mites are able to extract water vapor from unsaturated air by means of a hygroscopic salt solution in the supracoxal gland. If the humidity falls below a critical level, the salts crystalize, obstruct the entrance of the gland, and slow down the rate of dehydration. The process of water uptake also depends on the temperature. *Dermatophagoides farinae* maintain water balance and survive at relative humidities of about 45% at 25° C, and 65% at 30° C. The ability to survive at relative humidities below saturation accounts for their successful colonization of human dwellings. Although house dust mites are considered perennial allergens, mite populations are affected by seasonal changes. Peak house dust mite population densities occur in the summer in temperate climates, and the lowest levels occur during the late winter months. Several studies in the United States have demonstrated a seasonal rise in mite numbers, which correlated with increases in humidity.<sup>9 14</sup> Studies in Ohio and Virginia demonstrated an

increase in mite numbers and mite allergen levels during the summer months.<sup>9, 13, 14</sup> Mite allergen levels were determined monthly for a year in 12 homes in central Virginia. This study demonstrated that more than 20-fold variations in antigen P 1 equivalents can occur in house dust samples collected in various sites within homes. Mite allergen levels increase in July, with mean levels of antigen P1 equivalents in house dust significantly higher in the months of August to December than in April and May. This study also demonstrated that mite allergen levels remain high even after a decline in the mite population, especially in sofas.<sup>14</sup> Arlian et al.<sup>13</sup> demonstrated that seasonal fluctuations in mite numbers significantly correlated with the changes in relative humidity ( $p < 0.01$ ) in five homes in Ohio. Mean mite numbers increased during May through July and were maximum in August of 1977 and in late June to early July of 1978. Mite populations declined during the fall and were lowest during December through April. The authors suggested that house dust mites survive dry winter months in homes as desiccation-resistant pharate protonymphs.<sup>13</sup>

Data from 20 mite seasonal variation studies performed in different parts of the world and analyzed by M. J. Colloff<sup>8</sup> demonstrated that the geometric mean of the maximum mite density in mattresses was 13.3 times greater than the mean minimum density. This study demonstrated that the mite population is at its peak between July and October in northern, temperate latitudes and that in subequatorial regions the peak occurs early in the year. This change reflects the seasonal climatic reversal in the southern hemisphere. The seasonal variations in mite numbers ranged from a minimum of 2.1 times, reported by Chang and Hsieh,<sup>15</sup> to a maximum of 108 times, reported by Lascaud.<sup>16</sup>

On the basis of these data, it seems that in temperate climates late winter and early spring are the best times of the year to clean mattresses and carpets very aggressively to kill the few mites that survived the winter. Theoretically, this would reduce the chances of having a large infestation during the summer months.

Environmental control measures to reduce symptoms in individuals allergic to mites have been contradictory. Asthma symptoms and bronchial hyperreactivity in subjects allergic to mites have been shown to improve after removal of the subject from mite-infested environments.<sup>17, 18</sup> Other studies have evaluated the influence of allergen avoidance by relocating patients to a higher altitude.<sup>19, 20</sup> One of these studies analyzed serum markers of eosinophil activation in children with allergic asthma.<sup>19</sup> Histamine provocative concentration causing a 20% fall in forced expiratory volume in 1 second was unaltered during the study period, whereas serum levels of eosinophil cationic protein and eosinophil protein X showed significant increases with exposure to mite allergens. The serum levels of myeloperoxidase, as well as chemotactic factors for both neutrophils and eosinophils, were unaltered during allergen exposure. The total IgE level significantly increased during exposure. The authors concluded that serum markers of eosinophil activity (eosinophil cationic protein and eosinophil protein X) are sensitive indices of allergen exposure in children with atopic asthma and that allergen avoidance reduced the levels of these markers.

Successful studies on dust avoidance have used rigid avoidance measures in bedrooms, including removal of carpets, covering of mattresses, and regular washing of bedding in hot water. A successful mite control program should combine the killing of mites and the removal, immobilization, or denaturation of mite allergens throughout the house. The reduction of dust mite

allergen level required to achieve clinical improvement has not been determined. However, *Der p 1* concentrations of approximately 10 µg/gm of dust have been considered a risk factor for development of symptomatic mite allergic asthma in children.<sup>20</sup>

Several methods to kill mites have been proposed. They include the use of acaricides and physical methods, such as heating, freezing, and drying. The use of acaricides presents potential problems of toxicity to human beings and pets. Several chemicals are currently in use. Pirimiphos methyl (Actelic, Imperial Chemical Industries, Ltd., Macclesfield, Cheshire, U.K.), a mosquito insecticide with acaricidal activity is currently used to protect grain against storage mites.<sup>21</sup> A compound of benzoic acid esters and acrylate polymers is an effective acaricide and is currently used as a household acaricide in Europe and the United States.<sup>22 23</sup> A benzyl-tannate complex solution, a combination of an acaricide and an allergen-reducing agent, is currently being marketed in Australia.<sup>24</sup> A study demonstrated the acaricidal effect of pure caffeine. Caffeine-treated *D. pteronyssinus* cultures showed a significant decrease in mite numbers and in mite allergen after 2 months.<sup>25</sup>

The weekly washing of bed linens is of benefit to patients if the temperature of the water destroys mites ( $\geq 130^{\circ}$  F). Warm or cold water does not kill mites, and washing live mites out of a fabric is difficult. Bleach also kills house dust mites. Electric blankets are also effective in reducing relative humidity and the concentration of house dust mites in the surface of mattresses. Encasing mattresses, pillows, and blankets in plastic covers is also an important strategy in avoiding mite allergens.

Liquid nitrogen has been successfully used to control mite populations.<sup>26 27</sup> Dorward et al.<sup>27</sup> demonstrated a 95% reduction of live mites after 8 weeks of liquid nitrogen treatment of the mattresses of 10 patients with asthma compared with a 19% reduction in the control group. The treated group had a significant improvement in symptom scores and lung function test results.

Humidity is a major limiting factor on the growth of house dust mites. Mites are able to absorb water vapor from unsaturated air until the absolute indoor humidity is below 7 to 8 gm/m<sup>3</sup> (equivalent to approximately 50% relative humidity [RH] at 20° C). At lower humidities, mites die of dehydration. Korsgaard et al. observed that an RH above 60% in the house limits the effectiveness of mite reduction measures.<sup>28 29</sup> Because subjects allergic to mites improved significantly in a controlled environment with an RH of 40% to 50%, individuals allergic to mites should be advised to control the relative humidity in their homes. Low humidity (<50%) also prevents growth of mold and bacteria. Inadequate ventilation, a consequence of attempts to conserve energy, also seems to be an important risk factor for house dust mite sensitization in temperate regions.<sup>30</sup>

Because RH is the most important abiotic factor influencing the reproduction, survival, geographic distribution, and seasonal fluctuations of domestic mites, the reduction of the RH in the bedroom of individuals with asthma who are allergic to mites is commonly recommended by allergists. However, little information is available on the effectiveness of humidity reduction within a home. At this point, this recommendation is based more on common sense than on scientific data. There is evidence that beds in rooms with RHs above 64% contain significantly more mites than those in rooms with lower humidities, that pyroglyphid mite populations are greater during months with higher humidity,

and that damp houses have more mites than dry houses.

The reduction in humidity by airing bedrooms (combined with extensive cleaning and replacement of floor covers) was used in a controlled clinical trial in Denmark.<sup>29</sup> In this study there was only a limited reduction in indoor humidity in spite of an increased number of airing hours per day. The concentration of house dust mites did not diminish, and no clinical improvement was observed.

It has been suggested that keeping the indoor humidity below 7 gm/kg by ventilation is sufficient to eradicate house dust mite populations.<sup>28 29</sup> The complete removal of house dust mites was achieved in 11 of 16 mattresses in Denmark within a year by using a mechanical ventilation system in new flats.<sup>31</sup> The cold, dry winter climate in Scandinavia contributes substantially to the feasibility of maintaining a low indoor humidity. A study in Madrid, Spain showed no significant clinical improvement in eight of 10 patients with mite-sensitive asthma who used a portable dehumidifier in their bedrooms for 4 months. They concluded that in cities where the RH is low, further reduction of humidity does not result in a reduction of mite concentrations or an improvement in symptoms.<sup>32</sup>

A reduction in the exposure to mite allergens may be achieved by removing mite allergens by vacuuming, damp cleaning, denaturing mite allergens, and encasing mattresses and pillows. A 3% tannic acid solution is used in the United States to denature mite allergens in house dust.

Attempts to remove mites from furniture by vacuuming are generally unsuccessful because the mites attach themselves to upholstery fibers.<sup>33</sup> Vacuum cleaning removes surface dust and fecal pellets, which otherwise become airborne, but inadequate suction and a leaking bag temporarily increase the concentration of house dust mite aeroallergens.<sup>34</sup> Mite allergens become airborne during cleaning activities, and they have been detected in large (10 µm) and small (<5 µm) particles, the latter of which can readily enter the small airways of the lung.<sup>34 37</sup> Therefore masks should be used by individuals allergic to mites during house cleaning activities.

The effect of dry cleaning on mite allergen levels has been investigated in dust collected from five blankets before and after dry cleaning with perchloroethylene.<sup>38</sup> *Der p I* and *Der f I* allergen levels were 78% lower after dry cleaning, and group I allergen levels per square meter of dry-cleaned blankets were 98% lower. The authors concluded that mite allergens were not denatured by perchloroethylene and that the effect of dry cleaning resulted from physical washing out of dust and allergens.

Air filtration only removes airborne allergens and can have a significant impact on allergen exposure only when low amounts of allergen become aerosolized. Mite allergens only become airborne during domestic cleaning activities. This is especially true for mite group I and II allergens; few data are available on the aerobiology of other mite allergens. Studies on the clinical benefit of air filtration devices have been inconclusive.<sup>39 40</sup>

## Fur-bearing animals

Fur-bearing animals should be avoided by sensitized individuals. Even avoidance may not be totally

effective, because mammalian allergens can be transported on clothing of individuals who come in contact with such animals in other locations. Studies have demonstrated that there is a variability in cat allergen shedding and that male cats shed more allergen than female cats.<sup>41</sup> These results are consistent with the observation that some cats provoke more symptoms than others. There is evidence that *Fel d I* production is under hormonal control and that the castration of male cats significantly reduces allergen production. The consequent injection of testosterone significantly increases *Fel d I* production.<sup>42</sup> Washing cats weekly is effective in reducing cat allergen concentrations in homes,<sup>43</sup> although this concept has been challenged.<sup>44</sup> Cat allergens can remain airborne for extended periods of time.<sup>34, 45, 46</sup> This could explain why individuals allergic to cats experience allergic symptoms immediately in the presence of a cat.

Symptomatic benefits of removing a cat from the home may not become apparent for several weeks because of the large reservoir of animal allergens in settled dust.<sup>47</sup> A 3% tannic acid solution is effective in reducing cat allergen concentrations by denaturing cat allergens and can be used in these cases.<sup>48</sup> Most environmental control work for fur-bearing animals has been done with cats; however, it is suspected that such information is applicable to gerbils, guinea pigs, dogs, hamsters, and other furry pets.

## Insects

Sensitization to cockroach allergens is very common in the low socioeconomic stratum of American society.<sup>49</sup> It represents a major challenge for the medical, scientific, and political community. Experimental evidence suggests that exposure to cockroach allergens is responsible for sensitization, because individuals exposed to low levels are less likely to develop cockroach-specific IgE. Other variables such as availability of food for these insects, overall hygiene, indoor humidity, and educational levels may be related to the onset of sensitization and symptoms. A more strict and focused environmental control program should be used to limit exposure to these arthropods in the home. A study by Sarpong et al.<sup>50</sup> demonstrated that the use of 1.5% diazinon and regular cleaning reduced a median *Bla g II* level of 12.4 U/gm to 2 U/gm 1 month after extermination. These levels remained stable for the next 2 to 3 months and then began to rise slowly. Regular thorough cleaning of the homes and pest control for cockroaches and fleas are the ideal methods for controlling these insects and their allergens in the home. It has been demonstrated that fleas can also contribute to the allergenicity of house dust in areas of heavy flea infestation.<sup>51</sup>

## Summary of Control Measures

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The methods for the prevention and control of poor indoor air quality have not been adequately evaluated, and there are no approved standards for the majority of suspected biologic agents. Additional information is needed about the dynamics of production of indoor pollution, decay rates, and environmental factors that promote or create the sources of indoor air pollutants. Environmental control depends on such knowledge. Determination of the threshold concentrations that cause symptoms and sensitization is needed to devise and evaluate control methods. Each indoor

environment is unique, and the air quality may vary from room to room. Therefore recommendations on indoor environmental control measures are usually incomplete and less effective without a thorough investigation of the entire building.

The fundamental objectives of environmental control, as described in a recent review of this subject,<sup>52</sup> are: (1) to prevent or minimize occupant exposures that can be deleterious to health and (2) to provide for the comfort and well-being of the occupants. This group recommended the following measures:

1. To improve the design, installation, use, and maintenance of residential and commercial heating, ventilation, and air-conditioning systems
2. To expand the scope of the Carpet Policy Dialogue group of the Environmental Protection Agency to consider the serious problem of carpets as a source and reservoir of indoor allergens
3. To develop consensus standard recommendations to control moisture in naturally and mechanically ventilated buildings
4. To develop standardized tests for rating the effectiveness of vacuum and air cleaners in removing allergen-containing particles
5. To evaluate the role of air cleaning in control of allergic disease
6. To develop a public use guideline on moisture and allergen control in buildings
7. To determine the relative efficacy of currently recommended environmental control strategies and develop cost-effective strategies to control aeroallergens throughout the lifetimes of residencies and other buildings.

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