
Review article

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Controlling indoor allergens

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Objectives: Reading of this article reinforces the reader's knowledge of the role of allergen exposure in relation to asthma and its severity, as well as the relevance of allergen avoidance in the treatment of asthma.

Data Sources: Initial literature search for existing evidence-based guidelines, reviews, and meta-analyses was carried out, and further literature searches were performed to review individual randomized controlled trials. Evidence level was graded according to the Scottish Intercollegiate Guidelines Network recommendations.

Results: There is good evidence for the link between mite and cockroach allergen exposure and sensitization, and between sensitization and asthma. For pet allergens, some studies found that exposure to pets in early life was associated with specific immunoglobulin E sensitization and allergic disease later in childhood, whereas others reported a protective effect. The effectiveness of allergen reduction in the treatment of asthma is suggested by studies in which the patients improve substantially when moved into the low-allergen environment of hospitals or high-altitude sanatoria. Because of limitations in the design of the most clinical of studies, we do not yet have a conclusive answer on the effectiveness of domestic aeroallergen avoidance.

Conclusions: Minimizing the impact of identified environmental risk factors is an important first step to reduce the severity of asthma. Although environmental control is difficult, it should be an integral part of the overall management of sensitized patients. However, what is unclear is which patients would benefit and by how much, and whether the intervention is cost-effective. These questions will be answered satisfactorily only by large randomized trials.

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INTRODUCTION

Among numerous other factors (eg, poverty with limited access to medical care and smaller probability of being prescribed inhaled corticosteroids), exposure to indoor allergens has been related to asthma severity.^{1–8} If indeed exposure to allergens in the home contributes to asthma severity, then reducing exposure should be a part of an overall management of the disease. However, limitations in the design of the most clinical studies have meant that we

do not yet have an answer as to whether domestic aeroallergen avoidance is effective. For the purpose of this article, we performed initial literature search for existing evidence-based guidelines, reviews and meta analyses. Further literature searches were performed to review individual randomized controlled trials. Evidence level was graded according to the Scottish Intercollegiate Guidelines Network recommendations as follows: Ia, evidence obtained from meta-analysis of randomized controlled trials; Ib, evidence obtained from at least one randomized, controlled trial; IIa, evidence obtained from well designed, controlled study without randomization; IIb, evidence obtained from at least

one other type of well designed, quasi-experimental study; III, evidence obtained from well designed, nonexperimental, descriptive studies, such as comparative studies, correlation studies, and case studies; and IV, evidence obtained from expert committee reports or opinions and/or clinical experience of respected authorities.

ALLERGEN EXPOSURE IN HOME INCREASES ASTHMA SEVERITY IN SENSITIZED INDIVIDUALS

In an experimental situation following a controlled challenge with low dose of allergen, which mimics a “real life” situation, sensitized asthmatic subjects experience an increase in nonspecific airway reactivity,⁹ and can have the characteristic eosinophilic infiltration of the airways and an increase in pro-inflammatory cytokines (eg, interleukin 5).¹⁰ However, the evidence of a similar relationship between personal exposure in homes and severity of symptoms or markers of airway inflammation is less convincing.

Important data on the relationship between cockroach allergen exposure in home and asthma severity were obtained in the National Co-operative Inner City Asthma Study.¹¹ Children who were allergic to cockroaches and exposed to high levels of cockroach allergens in the domestic dust samples had 3.6-fold higher hospitalization rates, more primary care unscheduled medical visits for asthma, more missed school days, and more days with symptoms and nights with disturbed sleep than other children. Neither increased exposure to cockroach allergen alone nor allergy to cockroaches by itself was associated with greater morbidity.

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There is further indirect epidemiologic evidence from the United Kingdom that high level of exposure to allergens may be associated with severe asthma in school children. A study conducted among 11- to 16-year-old children reported that the strongest risk factors for severe asthma were pet ownership (which may indicate high exposure to pet allergens) and the use of non-feather bedding.¹² If the association between non-feather pillows and severe asthma was assumed to be causal, it could account for 53% of the severe asthma in this population. Interestingly, polyester pillows contain five to eight times more mite, cat, and dog allergen than feather pillows.¹³⁻¹⁵

Several cross-sectional studies investigated the relationship between domestic allergen exposure and disease severity in patients with established asthma. A significant correlation was observed between nonspecific bronchial reactivity, peak expiratory flow rate variability, pulmonary function, and dust mite allergen levels in beds in subjects sensitized to mites.¹⁶ Further, patients with brittle asthma are significantly more often both sensitized and exposed to high levels of allergens (mite, cat, and dog) to which they are allergic, compared with patients with mild disease.¹⁷ Exhaled nitric oxide (a marker of airway inflammation) is much higher in asthmatic patients who are both sensitized and exposed to the sensitizing allergen compared with those who are sensitized but not exposed.¹⁸ A recent study reported that the combination of allergic sensitization with high domestic exposure allergens and respiratory viral infection substantially increases the risk of hospital admission (odds ratio >8).¹⁹ However, demonstrating the link between exposure and asthma severity or risk of admission to hospital does not equate to demonstrating the benefits of allergen avoidance.

Allergen Exposure and Response to Treatment

There is some indirect evidence that allergen exposure may affect the response to pharmacologic treatment.²⁰

A significant reduction in glucocorticosteroid receptor-binding affinity was observed in ragweed-allergic asthmatic patients during the pollen season as compared with pre- and postseason measurements. Further, peripheral blood mononuclear cells of patients allergic to ragweed obtained outside the pollen season and those of asthmatic patients allergic to cats but not exposed to cat allergen developed significantly lower glucocorticosteroid receptor-binding affinity after incubation with ragweed and cat allergen in vitro. These findings may suggest that *high allergen exposure in sensitized individuals* could contribute to poor asthma control by both maintaining the inflammatory process in the airways and reducing the effectiveness of steroid treatment. As yet, however, there is no evidence that personal exposure in homes can exert a similar effect.

Allergen Exposure and Asthma Severity: Is There a Threshold for Symptoms?

There is a considerable variability between individuals in the magnitude of response to the same levels of allergen exposure. In a group of individuals with similar levels of specific immunoglobulin (Ig)E antibodies (or similar size of skin wheal), some will develop respiratory symptoms only if they are exposed to high levels of allergens, whereas others apparently require very low exposure for the same effect. It is likely that the quantity of allergen necessary to induce and maintain airway inflammation, bronchial reactivity, and symptoms varies between individuals over a wide range. Thus, it is unlikely that there is a threshold concentration that could be generally applicable to every individual, and below which no adverse effect on airway responsiveness, symptoms, or variability in lung function would occur. The relationship between allergen exposure in homes and symptoms of asthma among sensitized patients is complex, and simple threshold levels for provocation of asthmatic symptoms are almost certainly not appropriate. However, sensitized patients are likely to have more

severe disease if their exposure to offending allergen is high, rather than when it is low.

ENVIRONMENTAL CONTROL IN THE TREATMENT OF ASTHMA

The first controlled attempts to treat asthma by environmental manipulation began during the first few decades of the 20th century. In 1925 the Leopold brothers treated patients with asthma and other allergic disorders by moving them into a dust free room.²¹ A few years later, Storm van Leeuwen et al²² demonstrated that asthmatic patients improved when moved from their homes into the climate chamber. The effectiveness of allergen reduction in the treatment of asthma was suggested by studies in which the patients were moved into the low-allergen environment of hospitals²³ or high-altitude sanatoria in the Swiss and Italian Alps.²⁴⁻²⁹ These studies were not controlled, and there is a possibility that other domestic factors (eg, lack of exposure to environmental tobacco smoke) contributed to the observed improvement in asthma control. Nevertheless, allergen avoidance is the most plausible reason for clinical success, and the beneficial effect shown in *all* of the high-altitude studies is very important proof of the principle. These studies suggest that to have a clinical benefit: 1) it is essential to achieve and maintain a major reduction in allergen levels; and 2) once low-allergen environment is accomplished, it may take considerable time until the control of disease improves.

The important question is whether effective allergen avoidance in homes (ie, substantially reducing allergen levels) can be achieved by measures which are flexible to suit individual needs as well as cost-effective. The challenge facing physicians is to give appropriate advice on how to create a low-allergen home environment to suitable patients who may benefit from such an intervention. First, it is important to take a careful history and then establish to which allergens the patient is sensitized. Skin testing or specific

serum IgE data should be interpreted within the context of the clinical history, and environmental control strategies should be tailored to the patient's individual needs.

ALLERGEN AVOIDANCE IN PATIENTS' HOMES: PRACTICAL MEASURES

A thorough knowledge on aerodynamics of allergen-bearing particles is important in designing successful abatement strategies.

Distribution and Aerodynamic Characteristics of Indoor Allergens

Aerodynamic properties of mite, cat, dog, and cockroach allergens differ substantially.^{30–32} Mite and cockroach allergens are predominantly contained within relatively large particles (>10 µm in diameter) and can be detected in the air in significant amounts only after vigorous disturbance. In contrast, approximately 25% of airborne cat and dog allergen (Fel d 1 and Can f 1) is associated with small particles (<5 µm in diameter), and these allergens are readily measured in the air in houses with pets (and in most of the homes without pets; Table 1).

Differences in the aerodynamic characteristics of allergens underlie the difference in the clinical presentation of the disease. Mite and cockroach-sensitive asthmatic patients are usually unaware of the temporal relationship between allergen exposure and asthma symptoms, because the exposure is low grade and chronic. In contrast, anecdotal evidence suggests that cat- or dog-allergic patients are usually aware

of their allergy and often develop symptoms within minutes of entering a home with a pet. Interestingly, although this is usually true for patients who do not own pets, many pet-sensitive pet owners claim to be unaware of their allergy. It could be hypothesized that these individuals may be in denial, or alternatively, that in at least some of the patients a continuous exposure to extremely high levels of airborne allergen may induce a severe chronic inflammatory process in the airways, making an association between exposure and symptoms difficult to observe. Further, the data on aerodynamics of allergens suggest that while air filtration may be useful in removing cat and dog allergen from the air, it has no place in mite or cockroach avoidance.

Controlling House-Dust Mite Allergens

Mites and mite allergen reduction can be tackled in a number of ways depending on the site of contamination.

Bed and bedding. The most effective avoidance measure is to cover the mattress, duvet, and pillows with covers that are impermeable to mite allergens.³³ Either plastic covers (cheaper, but uncomfortable) or covers made of vapor-permeable or finely woven fabrics (more expensive, but also more comfortable) can be used. Mites and mite allergens can accumulate on exposed bedding, and this should be washed in a hot cycle (above 55° C) to kill the mites.³⁴ Low-temperature washing removes allergen, but dust mites can survive it.³⁵ Freezing of pil-

lows in a domestic freezer will also kill mites, after which they can be washed to remove dead mites and allergens. This may be a useful method for killing of mites on smaller cuddly toys.

Carpets and upholstered furnishings. Carpets and sofas represent a huge reservoir of mites, mite allergens, and food for mites. Ideally, one would recommend removal of carpets and the use of wooden or linoleum floor coverings. In addition, replacement of fabric-covered seating with leather or vinyl coverings, and replacement of curtains with blinds may contribute to lower personal exposure.

If carpets remain in place, several methods are available for reducing mite and mite allergen levels. Intensive vacuuming will remove large amounts of dust from the carpets, thus reducing the size of the allergen reservoir, but inadequate exhaust filtration may actually increase airborne mite allergen levels.^{36–38} Exposure of carpets to direct strong sunlight for at least 3 hours kills mites,³⁹ and can be used for rugs, etc, in appropriate regions. Steam cleaning has also been shown to kill mites and reduce allergen levels in carpets.⁴⁰

Acaricides (eg, benzyl benzoate, pirimiphos methyl) are chemicals that kill mites and are effective in laboratory conditions.⁴¹ However, applying these to carpets is time-consuming and requires repeated applications every 2 to 3 months.⁴² The main problems of chemical treatment are how to get the chemicals to penetrate deep into carpet and soft furnishings, the persistence of mite allergen until recolonization occurs, and the nuisance of frequent re-applications. Tannic acid is a product with protein-denaturing properties and has been recommended for the reduction of indoor allergen levels in house dust. However, because high levels of protein (eg, cat allergen) in the dust block its effects, vigorous vacuuming is recommended before application and it is not recommended in houses with pets.⁴³ As tannic acid only destroys allergen and does not kill mites, it can be used in conjunction with other chemicals such as benzyl benzoate.

Table 1. Aerodynamic Properties of House-Dust Mite, Cockroach, and Pet Allergens

Allergen	Particle size	Airborne level	
Mite: group 1 group 2	Predominantly large particles >10 µm	Undisturbed:	Disturbed
Cockroach: Bla g 1 Bla g 2		Undetectable with conventional assays	Detectable after vigorous disturbance Levels settle down within 15–30 minutes
Cat: Fel d 1 Dog: Can f 1	Large particles >5 µm (~75%) Smaller particles <5 µm (~25%)	Homes with animal	Homes without animal
		Detectable in all homes. Levels 4–5 times higher with animal in the room	Detectable in significant proportion of the homes even without artificial disturbance

Freezing with liquid nitrogen can kill mites.⁴⁴ However, the technique can only be carried out by a trained operator, which limits its use, especially as treatment needs to be repeated regularly. When used, both acaricides and liquid nitrogen should be combined with intensive vacuum cleaning after administration.

Sofas are particular problems both as a reservoir for allergen and as a mite nest. One approach is to control humidity in the home (see below) or to have a sofa designed with an impermeable barrier below the fabric cover.

Controlling humidity. Mites require high levels of humidity to survive; therefore, controlling humidity may be one method of controlling mite populations. However, detailed models of the humidity profile of domestic microclimates (eg, in relation to humans in bed) are not yet available. Reducing central humidity alone may be ineffective in reducing humidity in mite microhabitats (eg, in the middle of a mattress or deep within carpets).

Central mechanical ventilation heat recovery units can reduce indoor humidity in houses where outdoor humidity is low and home insulation is good. Studies in Scandinavian homes have reported successful control of house-dust mites with such units.^{45,46} However, such units have not proven effective in homes in mild, humid climate where outdoor humidity is very high and homes are relatively poorly insulated.^{47,48} Similarly, the effectiveness of portable dehumidifiers will depend critically on the type of climate and housing design.^{49,50}

Pet Allergen Avoidance

The best way to reduce exposure to cat or dog allergen is not to have one in the home. However, even after permanent removal of an animal from a home, it can take many months for the allergen reservoir levels to fall.⁵¹

Unfortunately, despite the advice by health professionals, a large number of pet-sensitized individuals will continue to live with their animal, and an attempt to control allergen levels will be needed. Airborne pet allergens in-

crease fivefold when the pet is in a room, and therefore they should be kept out of bedrooms and living room areas and preferably outside as much as possible.³² Major cat allergen Fel d 1 is produced under hormonal control primarily in the sebaceous glands and in the basal squamous epithelial cells of the skin. Castration of male cats results in a three- to fivefold reduction of Fel d 1 concentration in skin washing.⁵² Fel d 1 production is higher in male than in female cats,⁵³ but the observed sex difference in Fel d 1 secretion is too low to suggest that patients allergic to cats could benefit by getting a female rather than male cat, or by castrating their male cats.

High efficiency particulate air (HEPA) filter air cleaners can reduce the airborne concentrations of cat and dog allergens in homes with pets.⁵⁴ The high flow rate (250 m³/hour) of the HEPA air cleaner enables the air within the average room to circulate through the device approximately 10 times each hour. The absolute allergen levels in rooms containing a pet during air filtration are comparable with the baseline levels in the same rooms without active air filtration, but with the dog elsewhere in the house.⁵⁴ In addition, vacuum cleaners with built-in HEPA filters and double-thickness bags can decrease allergen levels in reservoir dust, although their effect on inhaled allergen during vacuum cleaning is far less clear. As carpets accumulate allergens, it is again recommended to remove carpets and have smooth surface floors.

Several studies have investigated the effect of cat washing on levels of Fel d 1. Klucka et al⁵⁵ compared the relative efficacy of washing with water, Allerpet-C spray (Farnam Pet Products, Phoenix, AZ), and acepromazine in decreasing cat allergen shedding in 24 cats and found no beneficial effect. De Blay et al⁵⁶ reported a reduction in airborne Fel d 1 after washing one cat weekly over a 4-week period, and similar but short-lived reduction was confirmed in a later study.^{57,58} Washing dogs with shampoo significantly reduces the levels of dog allergen in fur

and dander samples, but the levels increase to the starting values within 3 to 4 days.⁵⁹ This would suggest that the washing a pet needs to be done a minimum of twice a week to be effective. Twice-weekly washing could decrease the build-up of allergen in the dust reservoirs within the home. In addition, washing the pet regularly may reduce the level of airborne allergen in homes with pets.^{56,59} However, it is unlikely that the short-term and modest reduction in the airborne allergen achieved by washing would significantly improve asthma control in sensitized individuals.

Cockroach Allergen Reduction

Both physical and chemical procedures can be used to control cockroach populations in infested houses. Inspection is the first step in extermination. Identification of species, hiding places, and food and water sources are all helpful in their elimination. There are several available pesticides that are preferably used in gel or bait form. Typically successful treatments will provide significant reduction in 2 weeks, maximal effect within 1 month and will keep populations under control for 3 to 6 months. Household cleaning is an essential adjunct to successful allergen removal. Before applying insecticide, general cleaning should remove all possible food sources so that roaches are more likely to eat the baits. Further cleaning should be delayed for a week to avoid removal of insecticides. Removal of dead carcasses and frass can be achieved with thorough vacuuming of areas behind and under cabinets and appliances. Allergen is likely to be left adherent to walls, floors, kitchen surfaces, cupboards, appliances, and woodwork. All these must be scrubbed with water and detergent to remove allergens. Carpets and rugs should be repeatedly vacuumed. Sealing cracks and holes in plasterwork and floors can restrict cockroach access. Bedding, clothing, and curtains are also usually contaminated and must be washed.

Field trials have shown extermination to be much easier than removal of allergen.^{60,61} The best one can expect is

to reduce dust reservoir allergen concentrations by 95% with repeated cleaning 6 months after extermination.⁶²

Reduction in Fungal Allergen Exposure

Closing doors and windows and using air conditioning for cooling can reduce spore infiltration from outside. This can reduce indoor fungal allergen levels when outdoor spore counts are high.⁶³ The paradox to this practice is that interior fungal allergen concentrations are decreased from indoor sources when ventilation is increased, ie, by opening a window.⁶⁴

Air filters can be used to remove particles from the air, the most effective being the HEPA filter.^{65,66} Electronic air cleaners and negative ionizers have also been shown to have some effect on reducing spore counts.⁶⁷ A contaminated heating, ventilation, or air-conditioning system can circulate spores through a building, thereby requiring proper inspection and maintenance for prevention.⁶⁸ Because indoor fungal growth is dependent on moisture, growth can be reduced or stopped by controlling moisture.⁶⁹ For example, increase bathroom and kitchen ventilation (typically humid rooms within the home) by installing exhaust fans.

Carpets and wallpaper can harbor spores. Hard flooring is the ideal solution⁶⁴; failing this, frequent vacuuming with a vacuum with a HEPA filter and double-thickness bags will contain infestation. Wallpaper or contaminated surfaces should be washed down with 5%-bleach solution and detergent. Alternatively, a commercially available fungicide treatment can be used, but some of these are irritating and toxic.

Persons who are highly sensitive to fungal allergens should wear a particulate mask to retain spores when involved in activities that can disperse spores into the air (eg, cleaning). Individuals with severe allergy should avoid handling compost, vacuuming, or cleaning anything known to be contaminated. Measures for reducing domestic allergen exposure are summarized in Table 2.

Table 2. Practical Measures for Reducing House-Dust Mite, Pet, Fungal, and Cockroach Allergen Levels

Measure	Evidence level for effectiveness in reducing allergen	Evidence level for the clinical effectiveness
House dust mite allergen avoidance		
Encase mattress, pillow, and quilt in impermeable covers	Ib	Ib
Wash all bedding in the hot cycle (55–60°C) weekly	IIb	IV
Replace carpets with linoleum or wood flooring	Ib	IV
If carpets can not be replaced, treat with acaricides and/or tannic acid	III	IV
Minimize upholstered furniture/replace with leather furniture	III	IV
Keep dust accumulating objects in closed cupboards	IV	IV
Use a vacuum cleaner with integral HEPA filter and double-thickness bags	IIb	IV
Replace curtains with blinds or easily washable (hot cycle) curtains	IV	IV
Remove soft toys		
If impossible, hot wash/freeze soft toys	IV	IV
Pet allergen avoidance		
Remove cat/dog from the home	IIb	IV
If the pet can not be removed		
Keep the pet out of the main living areas and bedrooms	IIb	IV
Install HEPA air cleaners in the main living areas and bedrooms	IIb	IV
Have the pet washed twice a week	IIb	IV
Thoroughly clean upholstered furniture/replace with leather furniture	IV	IV
Replace carpets with linoleum or wood flooring	IV	IV
Use a vacuum cleaner with integral HEPA filter and double-thickness bags	IV	IV
Fungi		
Reduce spore infiltration from outside by closing windows, etc.	III	IV
If indoor contamination, increase ventilation and reduce moisture	III	IV
Install HEPA air filters in main living areas and bedrooms	III	IV
Use fungicide on heavily contaminated surfaces	IV	IV
Minimize upholstered furniture	IV	IV
Replace carpets with hard surface	IV	IV
Wear particulate mask when handling contaminated materials	IV	IV
Ensure regular inspection of heating and air-conditioning units to prevent contamination	IV	IV
Cockroach allergen avoidance		
Remove all possible food and water sources	IIa	IIa
Use suitable pesticide in bait form	IIa	IIa
Remove all dead carcasses and frass	IV	IV
Wash down all surfaces, floors, and walls with detergent	IV	IV
Repeatedly vacuum carpets	IV	IV
Seal cracks in walls and plaster work to reduce further access	IV	IV
Wash all bedding, clothing, and curtains	IV	IV

CLINICAL TRIALS OF ALLERGEN AVOIDANCE IN PATIENTS' HOMES

A successful clinical trial would need to achieve and maintain a major reduction in allergen levels, be sufficiently long, and have an adequate power. A Cochrane meta-analysis has recently attempted to determine whether mite-sensitive asthmatic patients benefit from measures designed to reduce their exposure to dust mite allergen in homes.⁷⁰ It concluded that current chemical and physical methods aimed at reducing exposure to dust mite allergens seem to be ineffective and can not be recommended for mite-sensitive asthmatic patients. To summarize the studies used in this meta-analysis, only 4 of 23 trials have achieved a reduction in mites/allergen levels and were sufficiently long to show an effect on outcomes (and all four studies showed evidence of clinical benefit). The conclusions of this meta-analysis are only as good as the majority of studies it includes: inadequate and inconclusive.⁷¹ Insufficient evidence of clinical efficacy does not imply the ineffectiveness of an intervention.⁷²

We have recently reviewed 31 trials of mite allergen avoidance in asthma in the literature.^{65,73-102} Data on the clinical effectiveness of allergen avoidance are conflicting, primarily because the majority of studies have been small, poorly controlled and have often used measures that did not reduce mite allergen exposure. Consequently, and not surprisingly, many failed to show clinical benefits. Of the reviewed 31 studies, 7 used air cleaners/ionizers/precipitators, which are useless in reducing mite allergen exposure.¹⁰³ Of the remaining 24, 7 showed little or no effect of avoidance measures on mites/allergen levels; 3 were uncontrolled; 1 was not randomized; 1 did not monitor the effects on mites/allergen levels; 1 showed colonization of bedding during the study; 1 one showed no difference in allergen levels between two study groups at the end of the study; and 1 used an acaricide without good evidence on the effect on mite allergens.

The final nine studies show significant reduction in mite counts and/or mite allergen levels. In 3 of these 9, although the treatment and follow up were too short, some effect was observed (eg, reduction in wheezing and bronchial hyperresponsiveness; fall in total serum IgE; reduction in the levels of eosinophil peroxidase). Only six controlled studies (all of which used bed covers) achieved a significant reduction in mites/allergen levels and were sufficiently long. All six studies showed evidence of clinical benefit (eg, improvement in lung function, symptoms and medication use, reduction in bronchial hyperresponsiveness). Although all trials of bed coverings suggest they are clinically effective, the impact of their widespread use by asthmatic patients has not been determined in a public health context. Several recently published studies have failed to provide significant further evidence on the subject.¹⁰⁴⁻¹⁰⁸

Double-blind, placebo-controlled trials of allergen avoidance are difficult to conduct; the combination of skin wheal and home visit is a potent stimulus for a change in behavior, with resulting increase in cleaning, removal of habitats, and reduction in allergen levels even in the control group. Almost every controlled study has observed a significant reduction in allergen levels and sometimes improved clinical symptoms in both active and the control group. A recent study by Carter et al¹⁰⁹ illustrated all the difficulties in conducting clinical trials of allergen avoidance. This was the first trial to examine the effect of combined dust mite and cockroach environmental control in an inner-city population in Atlanta, GA. The study used an innovative design, with children being randomized into an active and placebo intervention group, and an additional control group for which no home visits occurred until the end of a trial. Significant decrease in acute visits for asthma was observed among children whose homes were visited (both in the active and placebo intervention group) with no differences between these two groups. However, the

outcomes in two intervention groups were significantly better than in the control group of children whose homes were not visited. The implications of this study on the design of future studies were discussed in some detail in the accompanying editorial by Eggleston.¹¹⁰

Clinical Trial of Pet Allergen Avoidance

Few studies have investigated the clinical effectiveness of pet allergen control. Wood et al¹¹¹ used HEPA air cleaners in cat-allergic patients with asthma and rhinitis who were sharing their home with one or more cats. Although a small reduction in airborne Fel d 1 was observed in the active group (approximately 50%), there was no difference between the groups in any of the outcome measures during the 3 months of a study. Interesting data were recently reported, showing that reduction in Fel d 1 concentration by the use of high-efficiency vacuum cleaners can produce a significant improvement in the lung function in patients with cat sensitivity, but who did not possess a cat themselves.¹¹² Thus, it is possible that a reduction in passive exposure to pet allergens in pet-sensitized individuals may have a beneficial clinical effect.

There remains an urgent need to develop a large-scale trial of the widespread applicability of allergen avoidance and the effect on patient symptoms, exacerbation rate, use of medication, and overall health costs. One such study on the effect of mite allergen avoidance by the use of allergen-impermeable bedding on asthma control in adults is currently being carried out in the United Kingdom, and the results are expected by the end of 2002. This is a randomized, double-blind, placebo-controlled trial, with 1,500 patients being randomized. During the first 6 months of the trial (phase A) patients will take their usual inhaled steroid therapy, and during the next 6 months (phase B, months 6 to 12), patients will make a controlled reduction of inhaled steroids. The results of this study will conclusively show whether a simple intervention designed

to reduce domestic mite allergen exposure can improve the clinical control of asthma, which subgroups of patients benefit, and whether a reduction in regular inhaled steroid use can be achieved in primary-care patients.

CONCLUSION

There is good evidence for the link between mite and cockroach allergen exposure and sensitization to these allergens, and between sensitization and asthma. For pet allergens, intriguing and often conflicting data have been reported, with some studies finding that exposure to pets in early infancy was associated with specific IgE sensitization and allergic disease later in childhood, whereas others reporting an apparent protective effect. Experience from occupational asthma strengthens the argument for allergen avoidance as a part of the overall management of atopic asthma. However, limitations in the design of previous trials have meant that we do not yet have an answer as to whether domestic aeroallergen avoidance is effective. Creation of a low-allergen environment has been proven possible and studies are in progress to evaluate the effect of primary allergen avoidance on the incidence of aeroallergen sensitization.^{113,114} The next challenge will be to establish 1) whether a package of effective allergen avoidance measures in the home can make a difference to the severity of established asthma; 2) how to identify suitable patients who may benefit from such an intervention; and 3) whether a substantial reduction in allergen levels can be achieved by measures which are practical and flexible to suit the individual's needs.

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CME Examination

1–5, Custovic A, Murray CS, Gore RB, Woodcock A. 2002;88:432–442.

CME Test Questions

1. High-altitude studies suggest one of the following:
 - a. Moderate reduction in allergen levels improves asthma control.
 - b. There is no improvement in asthma control at high altitude.
 - c. Stay at high-altitude results in an improvement in asthma control which is sustained for a prolonged period after the return into a home environment.
 - d. Once very low-allergen environment is accomplished, it may take considerable time until the full improvement in the control of disease is achieved.
 - e. Allergen avoidance in homes is effective.
2. Which one of the following is true about methods of mite allergen abatement?
 - a. Bedding should be washed weekly at 40° C with standard fabric detergents.
 - b. Vigorous mattress vacuuming should be performed weekly.
 - c. Bedding encasement has been proven to reduce mite allergen exposure by at least 10-fold.
 - d. Domestic air filtration units are appropriate for the reduction of domestic airborne mite allergen.
 - e. Liquid nitrogen denatures mite allergens.
3. Which one of the following is true about methods of pet allergen abatement?
 - a. Allerpet-C is more effective than washing the pet with water.
 - b. Cat and dog washing results in the major reduction in airborne pet allergen levels.
 - c. HEPA filter air cleaners do not reduce the airborne concentrations of cat and dog allergens in homes with pets.
 - d. The use of vacuum cleaners with built-in HEPA filters and double-thickness bags results in a substantial decrease in airborne allergen levels.
 - e. After permanent removal of an animal from a home, it can take many months for the allergen reservoir levels to fall.
4. Which one of the following is true about methods of cockroach allergen abatement?
 - a. Extermination is much more difficult than removal of allergen.
 - b. Bedding, clothing, and curtains are usually not contaminated.
 - c. Identification of species, hiding places, and food and water sources are usually not very helpful in their elimination.
 - d. Both physical and chemical procedures can be used to control cockroach populations in infested houses.
 - e. There are no available pesticides for cockroach allergen control.
5. Which one of the following is true about dust mite allergen avoidance?
 - a. Large number of successful clinical trials achieved and maintained a major reduction in allergen levels.
 - b. Cochrane meta-analysis concluded that current chemical and physical methods aimed at reducing exposure to dust mite allergens are ineffective and can not be recommended for mite-sensitive asthmatic patients.
 - c. Insufficient evidence of clinical efficacy implies the ineffectiveness of an intervention.
 - d. Data on the clinical effectiveness of allergen avoidance are unequivocal and suggest beneficial effect.
 - e. Trials of bed coverings suggest that they are clinically ineffective.

Answers found on page 523.