

Allergy Treatment: Environmental Control Strategies

William R. Reisacher, MD

KEYWORDS

- Allergy treatment • Allergy and environment • Allergy triggers
- Allergen avoidance • Allergic asthma • Allergic rhinitis
- Inflammatory load • Dust mites • Dander

Key Points: ALLERGY TREATMENT: ENVIRONMENTAL CONTROL

- Environmental control strategies prove a strong foundation for further allergy management
- There are many sources, besides true allergens, that may contribute to the “inflammatory load”
- Decreasing a patient’s exposure to outdoor allergens is a realistic goal
- The impact of indoor allergens on the patient’s symptoms should be considered, both at home and in the school or workplace
- The Focus of avoidance strategies is on “reducing” levels of allergens, rather than “eliminating” them
- Patients should be provided with a written copy of all recommendations, which should be reviewed often and kept simple.

This information is designed to help physicians and allergy care providers understand:

- The role of environmental control in the treatment of allergic disease
- The concept of “the inflammatory load”
- The current studies that have been published on environmental control
- The factors that influence levels of indoor and outdoor allergens
- Different methods to decrease a patient’s exposure to indoor and outdoor allergens
- The problems related to nonallergic symptom triggers
- Special considerations for school and workplace avoidance
- The role of environmental control in the prevention of allergic disease

Disclosure: Phadia, Speaker’s Bureau.

Department of Otorhinolaryngology, The Allergy Center, Weill Cornell Medical College, New York-Presbyterian Hospital, 1305 York Avenue, 5th Floor, New York, NY 10021, USA

E-mail address: Wir2011@med.cornell.edu

Otolaryngol Clin N Am ■ (2011) ■–■

doi:[10.1016/j.otc.2011.03.019](https://doi.org/10.1016/j.otc.2011.03.019)

0030-6665/11/\$ – see front matter © 2011 Elsevier Inc. All rights reserved.

oto.theclinics.com

- The various products available on the market to assist in avoidance
- How to make a plan with the patient to implement environmental control strategies.

Once the diagnosis of allergy has been made, the next step is to discuss environmental control strategies, also referred to as avoidance, with the patient. It is best to have this conversation after reviewing the results of specific allergy testing, either through skin or blood testing, but it is also reasonable to discuss these strategies based on the history alone. Most of them carry very little risk.

Nevertheless, there is often a great deal of resistance to initiating these strategies, on the part of both the physician and the patient. Discussing avoidance takes a great deal of time out of the physician's busy schedule. The physician may also not be very familiar with these strategies or has read studies that fail to demonstrate a significant benefit. Many patients are already under the erroneous impression that there is nothing that can be done for allergies, and this is compounded by the commonly held belief that avoidance does not work. For those patients searching for a quick and easy method to relieve their allergy symptoms, a discussion about these strategies is the last thing they want to hear.

It is universally accepted that allergen exposure is a precursor to sensitization, and there are many situations in which the benefits of environmental control are undeniable. If the allergic reaction is immediate and dramatic, the patient will intuitively link the exposure with the symptom and begin practicing environmental control strategies, such as avoiding a home where a cat is present or by staying indoors on a hot, windy day. But in other situations the reactions may be delayed, related to multiple exposures, or more difficult to recognize when symptoms are chronic.

Most of the current studies designed at quantifying the benefits of environmental control for allergic rhinitis have been low-power studies with inconsistent follow-up periods, variability in patient populations, and a lack of blinding. The 2010 review by the Cochrane Collaboration on dust mite avoidance measures concluded that they "may be of some benefit in reducing rhinitis symptoms," but the evidence was not strong.¹ In addition, most of these studies have looked at only one isolated intervention, whereas the genetic and environmental complexities of allergic rhinitis and asthma most likely require a multifaceted treatment approach.²

Conceptually, the management of allergies can be thought of as a pyramid with 3 levels (**Fig. 1**). The classic triad of allergy management includes environmental control,

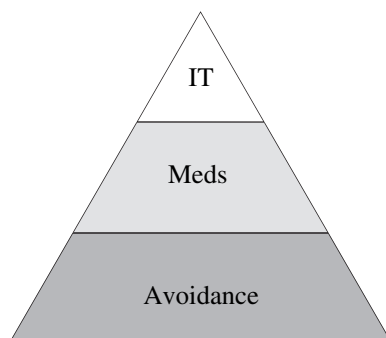


Fig. 1. The classic triad of allergy management. Environmental control strategies (Avoidance) form the foundation of this pyramid. Meds, pharmacotherapy; IT, immunotherapy.

pharmacotherapy, and immunotherapy. Environmental control forms the foundation of this pyramid, but it is actually not a treatment for allergic inflammation. Rather, it is a strategy to prevent further inflammation. Allergic symptoms may continue to gain momentum beyond the period of exposure, a phenomenon known as the “priming” effect, and for this reason avoidance alone may not seem to help at first. Every structure needs a strong foundation, but a person cannot live in the foundation alone. Environmental control sets the stage for effective treatment with pharmacotherapy and possibly immunotherapy, and for this reason, “there is no avoiding avoidance!”

CONCEPT OF THE “INFLAMMATORY LOAD”

To understand how allergen avoidance can help the allergic patient, one must first understand the concept of the “inflammatory load.” The inflammatory load represents the sum of all allergens, irritants, and other immune stimulators that a patient is exposed to at any given time. When the inflammatory load is high, so are the levels of circulating allergic and inflammatory mediators. In this situation, small challenges with other stimulators may result in worsening symptoms. Direct contributors to the inflammatory load may enter the body through the respiratory tract, digestive tract, or skin. Indirect contributors to the inflammatory load include illness, stress, or problems with mucosal barriers such as high gastrointestinal permeability and IgA deficiency.

Everything that contributes to the allergic load raises the level of inflammation toward a critical threshold, much like water being added to a bucket. When the level rises above the rim, water begins to spill out and the patient becomes symptomatic. The role of avoidance is to slow down the flow of water from that source, keeping the level below the threshold. This analogy helps explain why avoiding one or two antigens can increase a patient’s tolerance to other antigens that the patient is not actively avoiding. If needed, pharmacotherapy and immunotherapy may be used to increase the patient’s overall threshold which, in effect, gives that patient a larger bucket.

OUTDOOR ALLERGENS

Patients are often dismayed upon learning that they are allergic to outdoor allergens because they believe that for such allergies nothing can be done. Although the outdoor environment cannot be changed, the focus for these patients is on recognizing when to enter that environment and preventing those allergens from entering the indoor environment. In order for pollen to be allergenic, it must satisfy the criteria set forth in 1931 by A.A. Thommen (**Box 1**).

Box 1

Allergenic pollen criteria

In order for pollen to produce allergic symptoms, it must:

- Come from a seed-bearing plant
- Be produced in large amounts
- Be buoyant enough to allow for airborne spread
- Be widely distributed, particularly near areas of human habitation
- Have sensitizing potential

Pollen

Pollen represents the male reproductive cells of most plants. Pollens are lightweight proteins, which may travel for many miles on the wind; they are relatively large in size, ranging from 15 to 50 μm , which does not allow them to easily penetrate the lower airway. In the Northern parts of the United States, trees pollinate from February through May, grasses pollinate from June through July, and weeds pollinate from August until the first frost of the year. Three consecutive days with temperatures above 65°F (18.5°C) allow for pollination. The pollination season is longer in warmer climates, and the phenomenon of global warming may also extend the time pollen is normally in the air.

Patients will use many names to describe their pollen allergies.

“Rose fever” is a term commonly applied to springtime allergies, but the pollen from brightly colored flowers is spread by insects and, therefore, does not enter the respiratory tract. This process is known as entemophilous spread, as opposed to airborne, or anemophilous, spread. Keep in mind that patients may still develop nasal symptoms from the odor of blooming flowers.

“Hayfever” is a term often applied to fall allergies, when hay is being harvested, but the true offender is ragweed. In the springtime, many patients notice a yellow coating of pine tree pollen on their cars and become convinced that this is what they are allergic to. This heavy pollen is actually not very allergenic because it does not remain airborne for long enough to cause symptoms. It is a clear sign, however, that pollination is actively occurring.

Patients who are allergic to pollen suffer most on hot, dry, windy days. Pollen counts tend to be highest from 5 to 10 AM. If possible, patients should shift activities, such as running or gardening, from the morning to the evening during their active season; they should limit yard work and wear a mask when working outside. Patients should also be instructed to close their windows before going to bed and open the doors and windows only for limited times during the day when necessary. Even basic air-conditioning filters are able to filter out large pollen particles, and this appliance should be used as much as possible, either on the “cool” or “vent” settings. For those patients commuting to work in the morning, they should close the car windows and use the recirculation feature of the air-ventilation system, if present.

Patients should be advised to remove their clothes and shower immediately when they return home at night, particularly after being in the park or hiking in the woods. Pollen may stick to the clothing, skin, and hair, and may be particularly problematic in patients with long hair. The clothing should be placed in a hamper or a closet that is not in the bedroom, but never placed on the bed. The bedroom needs to be the patient’s “safe haven,” the one place in the house where there is a low level of allergens. Washing bed sheets and pillowcases in hot water frequently during the season will help accomplish this. Outdoor pets should also be kept out of the bedroom and should be washed after spending extended time outdoors. After showering, patients should change into clothing that is not worn outdoors.

Many patients who are allergic to pollens discover that when they travel to other regions their allergies improve, and they may be tempted to relocate to that region. In the past this was one recommendation for the treatment of pollen allergies, but is generally not practical nowadays. If the patient does intend to relocate, they must be informed that the genetic ability to form allergies to pollen in the environment will surely move with them. Patients may experience relief for the first few years depending on their new environment, but this “holiday” from allergies may begin to fade as they develop new sensitivities.

Mold

Mold is a ubiquitous organism on the Earth, which is found in both the indoor and outdoor environments. Mold spores are present in the air throughout the year, unless the ground is covered by snow, and outdoor spore counts are about twice as high as indoor levels. Spores are able to survive freezing and boiling, and may range in size from 5 to 50 μm . In general, particles less than 10 μm are able to gain access to the lower airway, and this explains why mold is a potent trigger for asthma. Both the spores and the fragments of mycelia are allergenic.

Mold requires warmth, moisture, and organic debris to grow. It is attracted to damp, shady areas where decaying vegetation is present. Spore counts peak after the sun sets, and therefore cause more symptoms during the evening as opposed to the morning for pollen-allergic patients. Many patients believe that they are allergic to grass because they are symptomatic after cutting the lawn. Although the grass in the lawn is typically too short to pollinate, the clippings that stick to the blade on the underside of the lawnmower are a perfect medium for mold growth. When the lawnmower is started again, the mold particles are propelled into the air.

Although mold is a perennial allergen, there are seasonal spikes that might fool the patient and clinician into thinking that pollen is the offending allergen. In colder climates, when snow begins to thaw in the early spring, many of the mold spores that have been dormant for the entire winter suddenly become airborne. Because of the rain seen in the late spring, early summer is also a time when airborne mold spores are elevated. During the fall, the leaves decaying on the ground also serve as a perfect medium for mold growth. Mold counts are generally higher in areas near stagnant bodies of water, such as lakes or marshes.

It is not possible to eliminate mold from the outdoor environment, but performing regular surveys around the exterior home and surrounding property is a good way to recognize trouble spots. Steps should be taken to thin out dense vegetation that is close to the house or lying on the roof. Any trees and bushes that are dead or decaying near the house should be removed and leaves raked away from the foundation. Firewood should be moved away from the house. The roof must be inspected for any holes or signs of excessive wear, and any leaky gutters or improperly installed flashing repaired. Water should be diverted away from the foundation and any low-lying areas filled in. Professional masons and landscapers may be needed to get the job done properly.

INDOOR ALLERGENS

It has been estimated that a person born in the 1990s in the United States will spend more than 90% of his or her life indoors.³ This fact is not difficult to understand when one considers all the “creature comforts” available. Between home theater, video conferencing, central air conditioning, and groceries that can be ordered over the Internet, it is surprising we leave our houses at all! Moreover, spending more time indoors provides more opportunity for exposure to multiple indoor allergens. In a cross-sectional study of representative homes in the United States, 46% had high levels of 3 or more allergens.⁴

Not only are we spending more of our time indoors, the indoor climate itself is changing. With the rising costs of energy, homes are being made more airtight and energy-efficient than ever before. Higher indoor temperature and humidity also lead to elevated levels of allergens such as dust mites and mold. For the patient this means

that there is more time to become sensitized to indoor allergens as well as more time to react to their presence.

Dust

By far, dust and dust mites are the most common and important indoor allergens. In addition to dust mites, “house dust” is actually a combination of natural and synthetic fibers, organic debris, lysine sugars, pollen, mold, insect parts, food particles, and hair from pets and humans. Dust mite antigen is less allergenic than “house dust,” but it is the single most representative antigen from this mixture. Dust mite is the most common allergen in children and young adults with asthma and eczema, and dust mite allergy is a predictor of asthma development. Dust mites are also a significant allergen in patients with isolated allergic rhinitis.⁵

Dust mites are microscopic members of the Arachnid family. These mites are blind and are unable to drink; they must absorb water from the air, which is why they enjoy climates that are over 50% relative humidity. Dust mites also enjoy low altitudes (lower than 3500 ft [1077 m]) and temperatures between 65° and 84°F (18.5°–29°C). Dust mites live in the same environment as humans because they feed off organic debris such as shed hair and skin cells. These mites exist in bed sheets, mattresses, pillows, carpets, furniture stuffing, stuffed animals, and real animals, to name a few. Millions of dust mites can be present in a typical mattress. The dust mite produces approximately 10 fecal balls each day containing the allergenic proteins.

The physician must be aware that informing a patient about a dust mite allergy may provoke a sensitive issue. It is important to explain to the patient that dust is not dried dirt that has been tracked into the house. Avoidance strategies for dust mites are focused primarily in the bedroom—the “safe haven” for the patient. Clutter should be reduced to provide less surface area for dust mites to adhere to. Bare floors also provide less surface area and are easier to clean. Carpets must be vacuumed twice weekly with special bags to prevent dust from escaping back into the air. Pets should be kept out of the bedroom, and certainly off the bed.

Bed sheets and pillowcases should be washed weekly in hot water. Over 130°F (54.5°C) is recommended but residential homes are limited to 120°F (49°C) to prevent scalding of children. Higher temperatures can be achieved by washing sheets and pillowcases at the Laundromat or by placing them in the sun. Stuffed animals should be put in the dryer on “High” for 15 minutes and then stored in the closet or in a cargo net. Special allergenic barriers should be purchased and placed around the pillows and mattress, underneath the regular bedding.

Animals

In the Western world, approximately 60% of households have at least one pet.⁶ Among these, cat dander is an extremely important allergen and should be included in every testing battery. The majority of the allergen, Fel d 1, comes from the pelt of the animal, but is also seen in urine, sweat, and saliva. Male cats are more allergenic than females. Cat dander is very small (5 µm in diameter) and may remain airborne for long periods of time, which makes it a potential trigger for sensitized patients with asthma. The particles are very “sticky,” and can accumulate in high amounts in carpeting and furniture but also on smooth floors. Because of these qualities, cat dander may be carried by humans into areas where pets are not even present or allowed. More than 90% of homes in the United States have measurable levels of cat and dog dander, whether or not a pet is present, and significant levels of dander are also found in schools, offices, public places, theaters, and airplanes.^{7,8}

Dog dander is generally less allergenic than cat dander, and there is more breed to breed variability in the allergens present. Many patients who claim to be allergic to their dog may actually be allergic to other allergens that accumulate on their pelt, such as pollen, mold, dust, and even cat dander.

Bird feathers are another source of dander, and the amount of dander is related to the size of the bird. Available extracts usually consist of mixtures of chicken, duck, and goose dander. Other household sources of feathers include comforters, pillows, mattresses, and jackets. Many patients who believe that they are allergic to their pet bird may actually be reacting to the mold present at the bottom of the cage.

Without a doubt, the most effective avoidance strategy for pet allergy is to remove the pet from the home environment, but this is a very sensitive area and should be discussed very delicately with the patient. Most pets are considered a part of the family, and if the physician is insistent on breaking up this bond, the entire relationship with that patient may be damaged. Even if a pet is removed from the home, it may take several months for levels of dander to decrease to the point where the patient is no longer symptomatic.

If the animal remains in the home, it is helpful to remove carpeting and place air purifiers in the rooms the animal likes to inhabit. If possible, the pet should be restricted from going into the bedroom and particularly from sitting on the bed. After playing with the pet or sitting on furniture where the pet is present, patients should wash their hands before touching their face to prevent inoculating the dander into their eyes or nose. Washing the animal may reduce dander levels, but this has to be done every few days to be effective.

Cockroach

Cockroaches are very clever scavengers. These creatures tend to cluster around food and water sources, and populations may reach very high levels, particularly in urban settings. Cockroach sensitivity is a major risk factor for early childhood asthma and rhinitis.⁵ The allergy is typically not from the living roach. After they die, their body parts become desiccated and begin to disintegrate. These shed particles are very lightweight and become airborne, where they may spread through the ventilation system of a building. For this reason many homes and buildings with significant levels of cockroach allergen have no visible evidence of infestation.

The most important strategy to prevent cockroach infestation is cleaning up food debris in the home. If roaches are seen, commercially available insecticides or boric acid powder may be used. Roach traps are minimally effective and probably not worth the money spent on them. Caulking every crack in the house might be helpful, but this is extremely difficult to achieve. If the infestation persists, the patient should not hesitate to call a professional exterminator.

Mold

Common indoor molds include *Alternaria alternata*, *Cladosporium herbarum*, *Aspergillus fumigatus*, and *Penicillium notatum*. Mold spores may enter the indoor environment through windows, doors, crawl spaces, and unsealed parts of the foundation. Cracks in the foundation may lead to excessive moisture in the basement with a characteristic odor resulting. Rooms with running water, such as the kitchen, bathrooms, and laundry room, are high-risk areas for mold growth. Other sources of mold include indoor plants, old books, furniture, and piles of newspapers. Many people come in to the office dismayed that they are allergic to their Christmas tree. This "Christmas tree syndrome" is actually caused by mold, which grows on the tree as it lies on the damp ground.

Mold may cause reactions in the body through several mechanisms. The one which is most clearly defined as “allergy” is the classic type I, IgE-mediated hypersensitivity, which is picked up on skin or via blood testing. However, skin testing often produces a delayed reaction to molds, possibly due to a type III or type IV reaction. Many people will be symptomatic because of the odor of molds or because of the direct irritation that mold spores may have on the nasal mucosa. *Stachbotrys chartarum*, a black-colored mold not particularly allergenic to humans, produces a mycotoxin when disturbed. This toxin is often released during the renovation of older structures and may produce symptoms such as congestion, rhinorrhea, and headache.

Similar to outdoor mold avoidance strategies, the quest to decrease mold in the indoor environment begins with a careful survey around the interior of the house. The patient should focus on areas of previous mold growth or water damage. Any visible evidence of mold should be cleaned with a commercially available product or a dilute solution of bleach (1 part bleach to 10 parts water). Water leaks should be fixed and a dehumidifier should be used in damp areas, such as the basement. Attics, kitchens, laundry rooms, bathrooms, and basements should always be equipped with ventilation units and exhaust fans. Indoor sources of mold, including plants, old books, magazines, and firewood should be minimized. If serious water damage is present or cracks in the foundation are discovered, a professional should evaluate the situation and recommend the proper remediation.

NONALLERGIC TRIGGERS

Airborne allergens, which are recognized by the immune system, are common sources of inflammation, but there are many other nonallergic irritants that can stimulate local inflammation without systemic effects, such as tobacco smoke. Despite public awareness of the dangers of cigarette smoking, 20.6% of adults in the United States (18 years and older) continue to smoke.⁹ Exposure to maternal tobacco smoke during pregnancy and infancy is highly associated with asthma prevalence, and second-hand smoke exposure has an adjuvant effect on allergen sensitization during the first 3 years of life.¹⁰ It is recommended that a “no-smoking” policy should be instituted in the household, and this includes the porch and garage. Clothing exposed to tobacco smoke should be put away or washed to prevent the small irritant particles (less than 1 μm) from being circulated into the air.

Chemical irritants are ubiquitous in both the outdoor and indoor living environments. Cleaning products can release high levels of alcohols, aldehydes, and benzene compounds. Likewise, products of combustion, such as carbon monoxide and nitric oxide, as well as carbon dioxide from respiration can reach toxic levels if not properly ventilated. It is important to ensure that all units in the house that use a flame, such as the furnace, stove, and fireplace, are adequately vented. Fans for fresh air ventilation should be installed, and air handlers should be adequate for the size of the house. To save money, patients may opt for a smaller unit, but this can have disastrous results. As already stated, newer homes are not as “leaky” regarding fresh air, and this may allow levels of airborne chemicals to build up very quickly.

Nonallergic stimulators to the respiratory tract may also include extremes of temperature and humidity, or rapid changes in these parameters. Patients who are sensitive to these stimuli may also react adversely to strong odors or be able to sense odors in the air that others are unable to detect. Such patients already know to stay away from the perfume counter at the department store or the scented candle store. From an evolutionary standpoint, this sensitivity probably had a selective advantage for certain humans who were able to detect dangers such as advancing storms or nearby fires.

Even the density of particles in the air can produce respiratory symptoms because of their direct irritating effect on nasal and oropharyngeal membranes. This phenomenon helps explain why patients with no detectable allergies may react on a high pollen day or when dusting the house.

SCHOOL AND WORKPLACE

Up to this point the discussion has focused on environmental control strategies at home, but this is not the only place patients inhabit. It is quite possible that some people actually spend more time in their workplace than at home. However, school and workplace avoidance poses some specific challenges. First of all, the “safe haven” is much more difficult to create, particularly if the patient is working in an open area or a cubicle setting. There may be high levels of allergens from unknown sources. Perhaps the desk is cleaned every night by a maintenance worker who is also a “cat person,” or the building may have high levels of mold from a water leak or recent renovation.

Examples from the real world illustrate the point.

In one instance, several workers were becoming ill with cough and headache, particularly those who were sitting near the ventilation ducts. After an environmental engineer was called in to perform air sampling, it was determined that a maintenance worker was unknowingly storing cleaning chemicals near the air intake system of the office building.

In another instance, a child who is allergic to mold and dust was coming home every day from school with worsening respiratory symptoms and had recently to increase his asthma medication. When his mother went to speak with his teacher, she noticed that the rug on which the children gathered every day for reading time was the same one that was present when she was a student there. When the old rug was finally replaced with foam tiles, her child’s asthma improved.

If a patient is suspicious that the workplace is contributing to symptoms, he or she should be asked to talk with fellow employees to see if others are having similar problems. Inquire with the management about recent problems with the building, although they may be reluctant to share this information. If the ventilation ducts have not been recently cleaned, this may be requested. Small air purifiers can be used near the patient’s desk, and the desk should be kept clean and free of clutter. Have the patient inquire about moving his or her desk to another part of the office, even if the offending allergens have not yet been determined. For schools, parents should also schedule a meeting with the teachers and administrators to discuss the allergic needs of their child.

THE PREVENTION OF ALLERGIES

While environmental control strategies are designed to optimize the management of patients with allergies, do they have any role in the prevention of new sensitizations and the development of allergic disease? Studies have demonstrated an association between high allergen exposure and an increased rate of sensitization, particularly for indoor allergens.¹¹ Cockroaches, dust, and rat dander are early sensitizers, particularly in kids who live in the inner-city areas.¹² Data from the Childhood Asthma Management Plan demonstrated a ninefold increase in dust mite sensitization in children with asthma who lived in homes with detectable dust mite antigen, compared with those with no detectable antigen.¹³ There is a strong, linear relationship between the level of sensitization and the development of asthma, allergic rhinitis, and eczema.¹⁴

If environmental control is used for prevention, when should it be initiated? As early as 22 weeks’ gestation, fetuses of atopic mothers are capable of mounting

a proliferative response to dust mite allergen, directed by maternal IgG.¹⁵ Dust mite-specific IgE has been detected in the cord blood of fetuses whose mothers had high exposure to dust mites.¹⁶ However, high levels of interleukin (IL)-4 and IL-5 in cord blood did not correlate with sensitization later in childhood. Serum elevation of dust mite-induced T-cell cytokines at 6 months, on the other hand, strongly correlated with sensitization by the age of 2 years.¹⁷ This finding suggests that early childhood is a critical period for allergen sensitization.

In the Isle of Wight prevention study, 120 high-risk infants were recruited prenatally and randomized to receive either a hydrolyzed diet along with dust avoidance measures for the first year of life, or standard recommendations. The infants were monitored clinically and skin tested at ages 1, 2, 4, and 8 years. The treatment group demonstrated a significantly lower incidence of allergic rhinitis at 12 and 24 months compared with the control group, along with a reduction in positive skin-prick tests.¹⁸ By the age of 8 years there was also a significantly lower incidence of allergic rhinitis, atopic dermatitis, and asthma in the treatment group than in the control group.¹⁹

The literature is controversial concerning the presence of pets in the household. It has been demonstrated in some studies that increased exposure to cat dander early in life is associated with increased sensitization, but others have failed to demonstrate this.^{20,21} Two prospective studies also failed to demonstrate an association of any kind between animal exposure and the development of asthma.^{20,22} It has been suggested that very high levels of cat dander may actually be protective against later allergen sensitization.²³ In houses with animals, higher levels of endotoxin, a lipopolysaccharide found in the cell wall of gram-negative bacteria, may induce a form of tolerance by producing a modified T-helper cell type 2 response, leading to IgG₄, but not IgE, antibody production. It is reasonable to recommend to expecting parents that they should not acquire new pets, but it is probably not necessary for them to eliminate their existing pets from the home.

PRODUCTS

There are a large number of products available on the market nowadays to “treat” allergies, and it is important for the physician to be knowledgeable about these products. Patients will find information in catalogs and brochures, at the physician’s office, in stores, and over the Internet, but the physician must guide the patient toward the most beneficial products. For a modest-sized residence, it is not unusual to spend more than \$1000 on products designed to reduce a variety of indoor allergens.²⁴

Filters are used to catch allergens, and either prevent them from entering the indoor environment or remove them once they have entered. Some of the less expensive and also less efficient filters, made of such materials as fiberglass or polyester resin, are used in forced-air heating systems and as pre-filters in units containing HEPA filters. HEPA (high-efficiency particulate air) filters were originally developed by the Atomic Energy Commission to clean radioactive dust, and are able to filter 99.97% of particles larger than 0.3 μm . These filters are expensive, but will last approximately 2 to 5 years when used with a pre-filter.

The use of air purifiers increased dramatically during the 1990s. It is best for the physician not to endorse specific products or companies, but rather discuss the pros and cons of different types that are available. Air purifiers are able to decrease the airborne levels of a wide variety of allergens and irritant particles, and the patient should never be discouraged from trying one. The size of the unit purchased should depend on the size of the room in which it is being used. Of course, the patient’s “safe haven” is the best place to put this unit, but multiple units may be used



Fig. 2. Air purifiers using a high-efficiency particulate air (HEPA) filtration system. Different units are available based on the size of the room being treated. The units pictured use a 4-stage filtration process to trap allergens and absorb odors. The 360° intake system draws air in from all sides of the air purifier to trap allergens in 2 pre-filters, followed by a HEPA filter. Odors are absorbed by an activated carbon-zeolite blend. (Courtesy of Allergy Control Products Inc, Danbury, CT; with permission.)

throughout the home. It is best to use an air purifier in a room without carpeting. Many of the units on the market contain carbon/charcoal post-filters to remove odors, as well as ultraviolet radiation to destroy organic material without destroying the occupants or their furnishings.

The two basic types of air purifier are HEPA units and electronic precipitators. Air filters using HEPA filtration are very effective and low-maintenance units. HEPA units



Fig. 3. Mattress encasings are made from cotton fibers that are tightly woven to a 6.8- μm pore size to protect against dust mite allergens. (Courtesy of Allergy Control Products Inc, Danbury, CT; with permission.)

are available as central units and in a variety of room sizes (Fig. 2), are used with a pre-filter, and usually come equipped with a carbon/charcoal post-filter. These purifiers do not produce any ozone. By contrast, electronic precipitators produce a small amount of ozone, as they work by charging the particles in the air and then passing them between 2 magnetic plates. These units require more maintenance because if these plates are not cleaned, their efficiency will drop dramatically. In addition, the charged particles may produce a greasy, dark residue on carpets and furniture.

Vacuum cleaners were introduced to the market in 1935. For the dust-allergic patient, it is important to vacuum carpeting twice weekly, preferably by someone else. If using a vacuum cleaner with bags, a 2- to 3-layer microfiltration bag or HEPA filtration bags should be used because dust can pass easily through the standard, single-layer bags. True HEPA vacuum cleaners are available, but less expensive and less efficient units are also sold under the names "HEPA-like" vacuum cleaners or "allergy vacuums."

Dust mite barriers, available for pillows and mattresses, are designed to entomb dust mites, essentially cutting them off from their food supply (Fig. 3). These barriers are made from the same tightly woven materials used to make surgical gowns and typewriter ribbons, and partial encasements for the mattress are equally as effective as total encasements. Different sizes and textures are available; it is helpful to have samples available for the patient to examine.

Acaricides may also be recommended for patients allergic to dust mites (Fig. 4). Tannic acid, a chemical present in tea which is also used to tan leather, denatures



Fig. 4. Commercially available sprays are designed to neutralize allergens on contact for up to 3 months. The sprays contain tannic acid as the active ingredient, which neutralizes dust mite, pet dander, mold, and pollen allergens that can build up in carpets. (Courtesy of Allergy Control Products Inc, Danbury, CT; with permission.)

the dust mite antigen but does not kill dust mites. Unfortunately, this product needs frequent reapplication and may stain fabrics. Benzyl benzoate is a powder that is able to kill dust mites, but does not denature the antigen already present. The effect of this compound lasts approximately 2 to 6 months.

Table 1 Allergens and environmental control strategies		
Allergens	Typical Conditions	Steps for Prevention or Post Exposure
Outdoor Allergens		
Pollen	• Hot, dry, windy days • Peak: 5–10 AM	• Close windows • Wear a mask when working outdoors • Use air conditioning • Remove exposed clothing • Shower
Mold	• Warmth + Moisture + Organic debris • Damp shady areas • Decaying leaves • Stagnant bodies of water • Peak: after sunset • Seasonal spikes: snow melt, rain	• Remove dense vegetation • Remove dead trees • Store firewood away from house • Divert water from foundation • Fill low-lying areas
Indoor Allergens		
Dust mites	• Above 50% humidity • Temperatures 65°–84°F • Low altitude (below 3500 ft) • Bed sheets, mattresses, pillows, carpets, furniture, animal fur, stuffed animals	• Bare floors less susceptible than carpet • Vacuum carpets twice weekly • Wash bed clothes over 130°F • Use allergen barriers
Animals	• Cat and dog dander • Bird feathers	• No animals in bedroom or bed • Wash hands after touching pet • Avoid down comforters, pillows, jackets
Cockroach	• Dead roach debris, not living roach	• Clean up food debris • Use insecticides or boric acid powder • Caulk house cracks • Exterminator
Mold	• Windows, doors, crawl spaces, unsealed parts of building foundation • Kitchen, bathroom, laundry, basement • Indoor plants • Old books and newspapers • Old furniture	• Clean visible evidence of mold with bleach • Fix water leaks • Use dehumidifier in damp areas • Ventilation units for attics, kitchens, laundry rooms, bathrooms, basements • Minimize indoor plants, old books, magazines, firewood
Nonallergic triggers	• Tobacco smoke • Chemical irritants • Odors	• No smoking in home • Wash clothing exposed to smoke • Fans, ventilation in home • Air purifiers

Dehumidifiers should also be considered for the dust mite–allergic or mold-allergic patient, particularly if there are rooms in the house that exceed 50% relative humidity. Relative humidity is a ratio of the absolute humidity of a space to the highest humidity level that can be achieved in that space, and may be determined with a hygrometer purchased at the local hardware or home store. The efficiency of dehumidifiers will be highest when combined with proper venting of bathroom and laundry rooms. Whole house units may be attached to a central air-conditioning system, but smaller units are also available. Humectants, containing calcium chloride to absorb moisture, can be used in small spaces such as closets.

DISCUSSING ENVIRONMENTAL CONTROL STRATEGIES

It is important to discuss avoidance strategies with the patient (**Table 1**), but the physician should not expect this to be easy and should not expect it to be over in one session. It may take several visits to finish the entire discussion, and the material needs to be repeatedly reviewed as well. Office staff and handouts may be used to help explain important points. The physician should constantly be aware of sensitive issues and avoid giving the patient a large “to do” list. A few key strategies may be chosen during each visit and prioritized for the patient. The discussion should focus on “reducing” rather than “eliminating” allergens from the environment.

The patient should receive the plan in written form and, during follow-up visits, be asked to report on progress. Rather than asking, “Have you tried the strategies we spoke about?” the physician should ask, “What have you tried since our last visit?” Environmental control is a challenging endeavor, particularly when the patient is reacting to multiple allergic and nonallergic agents. It is necessary to educate patients about their condition and encourage them every step of the way. Even if they do not see immediate results from the changes they have made, they should understand that environmental control strategies are one important component of the multimodal-ity treatment plan for allergic disease designed to help them live a symptom-free life.

REFERENCES

1. Sheikh A, Hurwitz B, Nurmatov U, et al. House dust mite avoidance measures for perennial allergic rhinitis. *Cochrane Database Syst Rev* 2010;7:CD001563. Grade A.
2. Morgan WJ, Crain EF, Gruchalla RS, et al. Results of a home-based environmental intervention among urban children with asthma. *N Engl J Med* 2004; 351:1068–80. Grade B.
3. Tsang AM, Klepeis NE. Descriptive Statistics Tables from a Detailed Analysis of the National Human Activity Pattern Survey (NHAPS) Data, Environmental Protection Agency, Washington, DC; 1996.
4. Salo PM, Arbes SJ Jr, Crockett PW, et al. Exposure to multiple indoor allergens in US homes and relationship to asthma. *J Allergy Clin Immunol* 2008;121:678–84. Grade B.
5. Arshad SH. Does exposure to indoor allergens contribute to the development of asthma and allergy? *Curr Allergy Asthma Rep* 2010;10:49–55. Grade B.
6. Erwin EA, Wickens K, Custis NJ, et al. Cat and dust mite sensitivity and tolerance in relation to wheezing among children raised with high exposure to both allergens. *J Allergy Clin Immunol* 2005;115:74–9. Grade B.
7. Arbes SJ, Cohn RD, Yin M, et al. Dog allergen (Can f 1) and cat allergen (Fel d 1) in US homes: results from the National Survey of Lead and Allergens in housing. *J Allergy Clin Immunol* 2004;114:111–7. Grade B.

8. Abramson SL, Turner-Henson A, Anderson L, et al. Allergens in school settings: results of environmental assessments in 3 city school systems. *J Sch Health* 2006;76:246–9. Grade B.
9. CDC. Vital signs: current cigarette smoking among adults aged ≥ 18 years—United States, 2009. *MMWR Morb Mortal Wkly Rep* 2010;59(35):1135–40. Grade A.
10. Raheerison C, Penard-Morand C, Moreau D, et al. Smoking exposure and allergic sensitization in children according to maternal allergies. *Ann Allergy Asthma Immunol* 2008;100:351–7. Grade B.
11. Chew GL, Perzanowski MS, Canfield SM, et al. Cockroach allergen levels and associations with cockroach-specific IgE. *J Allergy Clin Immunol* 2008;121:240–5. Grade B.
12. Alp H, Yu BH, Grant EN, et al. Cockroach allergy appears early in life in inner-city children with recurring wheezing. *Ann Allergy Asthma Immunol* 2001;86:51–4. Grade B.
13. Huss K, Adkinson NF Jr, Eggleston PA, et al. House dust mite and cockroach exposure are strong risk factors for positive allergy skin test responses in the childhood asthma management program. *J Allergy Clin Immunol* 2001;107:48–54. Grade B.
14. Arshad SH, Tariq SM, Matthews SM, et al. Sensitization to common allergens and its association with allergic disorders at age 4 years: a whole population birth cohort study. *Pediatrics* 2001;108:e33. Grade B.
15. Warner JA. Primary sensitization in infants. *Ann Allergy Asthma Immunol* 1999;83(5):426–30. Grade B.
16. Peters JL, Suglia SF, Platts-Mills TAE, et al. Relationships among prenatal aeroallergens exposure and maternal and cord blood IgE: project ACCESS. *J Allergy Clin Immunol* 2009;123:1041–6. Grade B.
17. Rowe J, Kusel M, Barbara BJ, et al. Prenatal versus postnatal sensitization to environmental allergens in a high-risk birth cohort. *J Allergy Clin Immunol* 2007;119:1164–73. Grade B.
18. Hide DW, Matthews S, Matthews L, et al. Effect of allergen avoidance in infancy on allergic manifestations at age two years. *J Allergy Clin Immunol* 1994;93:842–6. Grade B.
19. Arshad SH, Bateman B, Sadeghnejad A, et al. Prevention of allergic disease during childhood by allergen avoidance: the Isle of Wight prevention study. *J Allergy Clin Immunol* 2007;119:307–13. Grade A.
20. Lau S, Illi S, Platts-Mills TAE, et al. Longitudinal study on the relationship between cat allergen and endotoxin exposure, sensitization, cat-specific IgG and development of asthma in childhood—report of the German Multicentre Allergy Study (MAS 90). *Allergy* 2005;60:766–73. Grade B.
21. Tariq S, Matthews S, Stevens M, et al. The prevalence of and risk factors for atopy in early childhood: a whole population birth cohort study. *J Allergy Clin Immunol* 1998;101:587–93. Grade B.
22. Korppi M, Hyvrinen M, Kotaniemi-Syrjnen M, et al. Early exposure and sensitization to cat and dog: different effects on asthma risk after wheezing in infancy. *Pediatr Allergy Immunol* 2008;19:696–701. Grade B.
23. Murray CS, Woodcock A, Custovic A. The role of indoor allergen exposure in the development of sensitization and asthma. *Curr Opin Allergy Clin Immunol* 2001;1:407–12. Grade B.
24. Kattan M, Stearns SC, Crain EF, et al. Cost-effectiveness of a home-based environmental intervention for inner-city children with asthma. *J Allergy Clin Immunol* 2005;116(5):1058–63.