

HOUSE DUST MITES – WHAT IS THE EVIDENCE FOR PROMOTING REDUCTION IN EXPOSURE?

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ABSTRACT

Exposure to allergens is required for the sensitisation and production of abnormal quantities of IgE antibodies that result in symptoms of allergic diseases. House dust mites are the source of the most important allergens in the home environment. Mite prevalence and sensitivity varies geographically, depending on climatic features. In South Africa, mite sensitisation has increased over the last 20 years, especially in African patients in both urban and rural environments.

Mite avoidance is commonly recommended for patients with allergic asthma and allergic rhinoconjunctivitis, but recent meta-analyses have failed to demonstrate a beneficial effect. Despite this, mite avoidance is achievable with the use of allergen-impermeable bedding in addition to other measures. Correct patient selection is necessary if we are to expect beneficial results.

ATOPY

Atopy is a personal and/or familial tendency to become sensitised and produce IgE antibodies

- in greater than normal quantities
- in response to ordinary exposure to allergens
- leading to symptoms of asthma, eczema or rhinoconjunctivitis.¹

The atopic syndrome consists of a number of diseases affecting different organs, e.g. allergic asthma, allergic rhinitis, allergic conjunctivitis and atopic eczema. A person may have one or more of these diseases that may also vary with time, depending partly on exposure to triggers. The atopic phenotype has a strong hereditary component. About 40% of children are born with this hereditary trait, but only about 25% of the population seem to develop symptoms of the atopic syndrome. Appearance and intensity of symptoms depend on length and severity of exposure to triggers, most commonly allergens that may be found in food and air, especially indoor air.

Triggers of symptoms in atopic disease include:

- Infections
- Irritants
- Allergens
- Exercise
- Emotions.

Sensitisation and symptoms both require exposure.

The first step in the development of atopic disease is sensitisation to allergens which may be present in food, or in outdoor or indoor environments. After exposure, atopic individuals produce IgE antibodies to these allergens, yet require re-exposure to develop symptoms. Thus exposure to allergens is required for both 'priming' of the immune system (sensitisation) and response to that 'priming' (elicitation of symptoms on re-exposure).

The most important indoor allergens include droppings of mites (both house dust mites (HDMs) and storage mites), fungal spores and pet dander. Chronic atopic patients also become hyper-responsive to non-allergens such as cigarette smoke, formaldehyde, and various household smells.

PREVALENCE OF SENSITISATION TO MITES

Of these triggers, HDMs are the most important. The prevalence of mite sensitivity varies geographically; e.g. in Europe, the cold Scandinavian countries have low prevalence of sensitisation, as well as very low levels of HDM, compared with warmer, more southern European countries (Table I).

Geographical differences in mite allergy prevalence in selected non-European countries:

- Saudi Arabia³ – coastal: 56.3 %; desert: 12.6 %
- United Arab Emirates⁴ – desert: 9.5 %
- Thailand⁵ (children) – 67 %
- India⁶ (dust-sensitive) – 83 %

In non-European countries, the prevalence of sensitisation also seems to depend upon climate.

Table I. Prevalence of mites in Europe²

	Prevalence (%)			
	Scandinavia	United Kingdom	The Netherlands	Mediterranean
Allergen source				
House dust mites	2 - 30	80	80	15 - 50
Storage mites	40 - 45	> 30	65 - 70	10

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Table II. Phylum Arthropods

Phylum Arthropods
Subphylum Uniramia
Class Insecta (insects)
Class Myriapoda (centipedes, millipedes)
Subphylum Crustacea
Class Malacostraca (crayfish, lobsters, crabs)
Class Maxillopoda (copepods)
Subphylum Chelicerata (Cheliceriformes)
Class Merostomata (horseshoe crabs)
Class Pycnogonida (sea spiders)
Class Arachnida
Order Aranea (spiders)
Order Opiliones (daddy longlegs)
Order Scorpiones
Order Pseudoscorpiones
Order Solifugae (whipscorpions)
Order Acari
Suborder Mesostigmata (free-living, predator and parasitic mites)
Suborder Prostigmata (chiggers, follicle mites)
Suborder Metastigmata (ticks)
Suborder Oribatids (soil mites)
Suborder Astigmata (house dust, storage & scabies mites)

Prevalence of sensitisation to mites in South Africa:

- 1979⁷ – rural Xhosa asthmatics: nil; urban black asthmatics: 3%; urban white asthmatics: 65%
- 1995⁸ – urban black asthmatics: 44.2%
- 1990 – rural black asthmatics: 14.2% (J Vermeulen – SATS meeting 1990, Sun City)
- 2000⁹ – rural Xhosa positive BHR: 37.5%; urban white positive BHR: 64%; urban Xhosa positive BHR: 37.9%

Why are there such differences between different countries, different regions within countries, and different populations within a country? The prevalence of sensitisation to dust mites is directly related to magnitude of exposure in a population as well as individual differences. Therefore in areas where dust mites are not encountered (Scandinavian countries, Saudi Arabian deserts) the prevalence of sensitisation is very low. Similarly in houses which are less conducive to HDMs, and there is less exposure (depending on rural or urban location, or socio-economic factors), there is a

lower prevalence of sensitisation. Environmental changes rather than genetic differences may explain some of the changes seen in different race groups over time in the South African data.

WHAT ARE HOUSE DUST MITES AND HOW DO THEY PROLIFERATE?

Mites (Acari) are microscopic members of the phylum Arthropods (Table II). They are a member of the sub-phylum Chelicerata, class Arachnida, and are thus closely related to spiders, but not insects.

The Astigmatic mites are unusual organisms! They have no distinct head: the body appears as an oval structure with legs and mouthparts extruding. Mites have neither eyes, nor ears, as we know them. Some parts of the body are light sensitive to distinguish between day and night. Sense organs for hearing, tasting and heat perception are located in special hairs (called solenidia) present on legs and mouth parts. There are no special structures for gas exchange. Oxygen, carbon dioxide and water vapour pass through the chitinous skin, which also serves as mite skeleton. They partly regulate water vapour loss by secreting an oily liquid and spreading it over the skin.

Within the mite, the free-flowing blood transports gases, nutrients and waste products. Mites excrete nitrogenous waste in the form of guanine in faeces and under the skin to be removed during moulting together with the old skin. Mite allergens are commonly digestive enzymes used by the mite to digest its food.

The Astigmatic mites contain 3 main families. The HDMs (Pyroglyphidae) contain about 16 genera and 46 species.¹⁰ The other major families are the storage mites and scabies mite families.

Of all the allergic and irritant triggers, HDMs are the major problem because in addition to the high rates of sensitisation, very high concentrations of mite allergens are found within many homes. Table III shows the relationship between sensitisation and exposure.

In urban houses, the two main mite categories (house-dust and storage) inhabit different niches. Fabrics and textiles soiled with human skin scales and other organic material are the home of the house-dust ecosystem with pyroglyphid mites and xerophilic fungi as the most abundant inhabitants of the community. Xerophilic fungi are fungi or moulds that do not require free water, but can grow if the air is above 60-65% relative humidity. Mite levels are high in bedding, upholstery and carpets in bedrooms and living rooms. Concentrations on walls and smooth floor coverings are low. Other niches found infested with HDMs include air-conditioning systems, children's soft toys, clothing and footwear.

There is a second indoor ecosystem on humid smooth surfaces such as walls, room partitions, ceilings and smooth floors. This mite ecosystem comprises storage mites, dust lice, and various species of mould and fungi. Occasionally the storage mite ecosystem is visible to the naked eye due to the brilliant colours of the mould. On other occasions the almost colourless and transparent mites have completely grazed off the mould leaving no visible material damage.

Both mite ecosystems depend for energy and nutrients on organic soiling. The protein content of carpet dust is sometimes so low as to limit the growth of HDMs,

Table III. Sensitisation and hyper-reactivity among allergic patients, and exposure in the domestic environment²

Allergen / Irritant Source	Sensitisation / hyperreactivity in patients	Noxious concentrations in dwellings
Airborne dust	> 50%	62%
Cigarette smoke	> 50%	58%
Fungi	45%	20%
Insects	10 - 55%	5 - 20%
Irritant gases	> 50%	10 - 90%
Mites	65 - 80%	20 - 95%
Pets	75 - 80%	85%
Pest rodents	10 - 15%	10%

but for limiting conditions of existence, such as light, temperature, water, nutrition and a place to live, the availability of water (in the form of vapour) is most relevant. A large range of temperature and humidity are suitable for HDM proliferation, but a fairly narrow, high humidity range is required for optimal growth (Fig. 1).

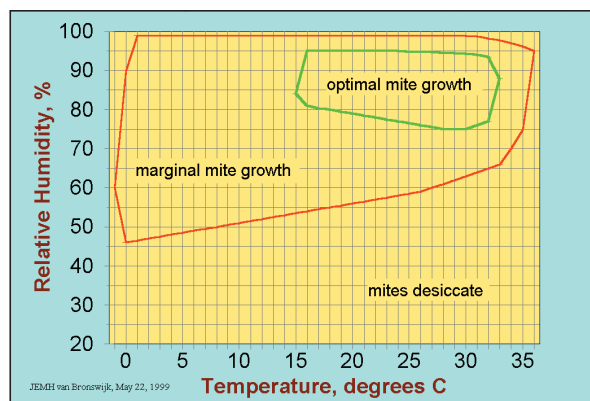


Fig. 1. Development of house dust mites.²

Bedding, upholstered furniture and even smooth surfaces, have a far higher humidity than that found in ambient air, and the presence of mould serves as a co-factor for mite colonisation by helping local humidity to increase, and providing a nutritional substrate.

HOW WE CAN USE LIMITING FACTORS FOR LONG-TERM DECREASE OF POPULATION GROWTH AND ALLERGEN EXPOSURE?

- Killing mites with chemicals is effective, but exposes people to the chemicals, and does not remove the allergen from the environment.
- Changing the humidity and temperature is the basis for a number of long-term mite avoidance procedures. Dehumidifiers and heaters alter air conditions. Removing mould and repairing damp areas changes the humidity at textile surface level.
- Vacuuming and air filtration remove not only viable mites but also mite allergen as well as fungi and protein-containing dust, the main substrates for mite nutrition. Even a hot wash in the domestic washing machine successfully exterminates a mite colony. Vacuuming however may in many cases simply displace HDMs and their allergen from the carpets into the air, resulting in continued exposure to the allergens. This has been reported with normal vacuum cleaners, wet cleaners and cleaners with HEPA filters (high efficiency particulate arrestance filter down to 0.3 microns).
- Removal of niches where mites live is a possibility. For storage mites this means the use of fungi-resistant finishing materials. For HDMs, removal of all textiles is a theoretical possibility. However, bedding is considered essential for healthy life, while upholstered furnishings and carpet products increase comfort in indoor environments for most of us. In fact the total removal of textiles such as all carpets may be unrealistic.

HISTORY OF ALLERGEN AVOIDANCE

Allergen avoidance has a long history. In 1552 the Italian physician Girolamo Cardano visited the Archbishop of Edinburgh, John Hamilton. The archbishop had been an asthma patient for years and the thera-

py of his own doctors had been of no avail. Cardano observed the patient for 40 days. He then advised the archbishop to leave out some foods and to change his indoor environment. He advocated avoiding feather beds and down covers, and provided the archbishop with a new pillow with a new filling. The patient improved dramatically.

Dust in the home has been studied in Germany and The Netherlands since the seventeenth century when Antonie van Leeuwenhoek started his observations on fleas and mites in his own dwelling. In the 1930s physicians would treat their lung and skin patients by avoiding contact with mites and fungi in the home environment.

The role of HDMs as a cause for skin and chest allergies was first suggested in 1964 by Voorhorst and co-workers¹¹ in The Netherlands. Prior to 1970, dozens of articles had identified *Dermatophagoides pteronyssinus* as responsible for the major allergenicity of house dust.

In 1968 IgE was characterised by Ishizaka. In the 1970s skin-prick testing was developed, trials were correlating airway hyper-reactivity, skin-prick tests and specific IgE levels, subcutaneous immunotherapy was being conducted with crude soluble dust-mite extracts and early trials were examining the effects of mite reduction.

In 1979, Daniel Vervloet,¹² a French allergist, reported on 42 asthmatic children with positive skin tests to *D. pteronyssinus* and domestic dust, and raised total and specific IgE. After prolonged (9 months) stay at high altitude (Briançon 1300 m), total IgE dropped to 40% of prior levels, with less marked decreases in specific IgE to *Dermatophagoides*, domestic dust and grass pollen. Clinical improvement of asthma was observed after the first week of stay and was maintained without drugs during all the 9 months at altitude. These improvements were ascribed to the removal of subjects from antigenic provocation into a hypoallergenic atmosphere.

Since then, standard recommendations have been to reduce HDM exposure in all mite-sensitive asthmatics. Recent evidence has, however, failed to consistently show benefit. In this era of evidence-based medicine, we need to ask ourselves whether the interventions we recommend actually work.

KEY QUESTIONS

- 1) Is it possible to substantially reduce mite allergen exposure?
- 2) Is mite allergen avoidance as a single intervention effective in the management of adult or childhood asthma?

Is mite avoidance achievable?

HDM allergen levels are commonly measured by monoclonal antibody assays. It is important to measure levels in reservoir dust rather than airborne allergen as the latter is too unreliable.¹³ Results have been expressed in a plethora of units such as unit weight (concentration) as well as per unit area. Exposure to >2 µg/g is considered a risk factor for sensitisation and asthma in susceptible kids, with a linear relationship between exposure level and sensitisation. No threshold level for provocation of symptoms or asthma severity has been defined because of many confounding factors.

In most studies HDMs 'overshadow' other allergens, even cat, dog, pollens and cockroach. Data show that in tropical and warmer areas *Blomia tropicalis* is an additional major allergenic dust mite species in addition to *D. pteronyssinus* and *D. farinae*. This is a distinct species with low to moderate cross-reactivity to *Dermatophagoides* species¹⁴ and therefore should be included in diagnostic IgE and skin-prick test panels.

In the most recent Cochrane review,¹⁵ only 7 of 29 studies demonstrated significant reduction in mite allergen levels (Table IV). HDM allergen reduction was unsuccessful in 15 studies. Most studies where reduction was successful included allergen-impermeable bed covers and reduced antigen levels to <1 µg/g of dust. No studies where chemical methods alone were used demonstrated successful reduction in HDM allergen levels.

Table IV. Review of HDM allergen reduction in 29 studies¹⁵

	Successful	Unsuccessful	Unreported
Total	7	15	7
Air/cleaning only	2	3	4
Chemical only	0	8	1
Barrier only	3	2	2
Barrier and chemical	2	2	0

Conclusions from current studies are that recommendations for scrubbing and cleaning alone are ineffective. Even vacuum cleaners with HEPA filters may increase airborne allergen exposure during cleaning¹⁶ and there is no evidence to show they reduce exposure. Chemical methods may kill mites but do not remove mite allergen.

Thus efforts to reduce the reservoir are currently the focus: specifically replacing carpets with impervious flooring and the encouragement of mite- and mite-allergen-proof bedding.

Is mite-allergen avoidance effective in the management of adult or childhood asthma?

The Cochrane review commented that the quality of data is very poor. The review included 29 studies, 9 of chemical methods only, 7 of barrier methods only and 13 of cleaning or various combinations. Although all subjects were sensitive to HDMs, very few studies confined their patient group to monosensitive patients. Thus the effects of reduction of exposure to dust mites may have been masked by continued exposure to other allergens that the patients were allergic to. The length of interventions ranged from 2 weeks to 1 year.

Results of this meta-analysis seem disappointing. Overall there was no difference in asthma symptom scores, medication use or morning peak expiratory flow rates. When analysed for chemical methods alone there was a significant adverse effect on symptoms, while analysis of physical methods alone showed a significant beneficial effect on symptoms. Although this seems to suggest that the use of physical barriers may lead to an improvement in symptoms, because of the large number of tests done, two statistically significant results were expected by chance. When studies were analysed only for those with successful mite reduction, the results were very similar.

Three recent studies have failed to demonstrate any significant benefit of HDM reduction using bed covers. Again, the quality of the data may have prevented these studies from showing beneficial effects. One study achieved reduction in allergen levels but looked at only 30 subjects.¹⁷ Another study of 55 monosensitive individuals¹⁸ achieved an initial significant reduction in exposure, but this was not sustained. A large study of 1122 subjects by Woodcock *et al.*¹⁹ achieved reduced Der P exposure at 6 months (0.58 µg/g vs 1.71 µg/g) but not at 12 months (1.05 µg/g vs 1.64 µg/g). In this study there was no difference in symptoms, peak flow rate, quality of life and the proportion of patients weaned off inhaled corticosteroids (ICS). About half of the subjects were sensitive to HDMs but no mention is

made of what proportion were monosensitive.

One study after the Cochrane review reported a positive result. This study by Halcken *et al.*²⁰ was a small (47 subjects) double-blinded placebo-controlled study in mite-sensitive children. Mite-proof bed covers were used with no other intervention, and reduction in exposure to house dust allergen levels was sustained to the end of the study. Active reduction of ICS therapy depended on normal lung function, peak expiratory flow rate variability of <20% and symptoms less than twice weekly. A significant reduction of ICS dosages was achieved, averaging 200 µg/day, in the active group, but no reduction was achieved in the placebo group.

There are many anecdotal reports that house dust reduction measures have been clearly beneficial in selected patients. What then are the possible reasons for the studies not consistently showing this effect? Several explanations have been proposed.

We know that in many studies, measures did not reduce HDM levels significantly (to < 1 µg/g). This may be because the measures recommended were not adhered to, or because the measures applied were ineffective or incomplete. Measures that are thorough and practical should be recommended, including mattress, pillow, duvet and blanket coverage, with or without the addition of additional measures. There may well be a difference in efficacy of reducing HDM levels between the interventions, and studies that combine different methods of reducing antigen make delineation of effective strategies very difficult. Another possibility is that initial mite antigen levels were too low in these studies. To show a difference, baseline mite antigen levels should be high, greater than 2 µg/g and preferably >10 µg/g. This explanation is unlikely as HDM is such a prevalent allergen.

A further explanation is that the numbers are simply too small to test the hypothesis. Although this may be the case, some confidence intervals in the Cochrane review were very small. Patient selection may be a problem, with most patients not being mite monosensitive. In addition, little regard is given to the level of severity of asthma in these studies, making it likely that very mild asthmatics were included in whom one would not expect to see any benefit. Finally it is to be expected that children, rather than adults, should be a major focus as their immune systems have not yet become resistant to change, and their lungs may not yet have undergone the airway re-modelling that occurs with prolonged inflammation.

Another possible, but unlikely, explanation is that reducing mite allergen has no beneficial effect on asthma. The Cochrane review sums up, 'It seems implausible to suggest the complete removal of a major provoking agent would be ineffective. The HDM is the allergen to which asthmatics are most frequently sensitive, and the acute effects of exposure on the symptoms of asthma are well established. Even so, it is important to remember that mite-sensitive asthmatic patients are usually sensitive to other allergens, so successful elimination of only one allergen may have limited benefit.'

RECOMMENDATIONS

- Children and adults with asthma should avoid areas with high concentrations of dust mites.
- Atopic sensitisation should be tested in all children and adults with persistent asthma.

- All mite-monosensitive patients with asthma should use mite-impermeable covers and, if possible, institute additional measures such as the removal of carpets in the bedroom.
- Subjects who are sensitive to HDMs and other allergens should avoid additional triggers, and if asthma is 'moderate persistent' or 'severe persistent' should institute full HDM avoidance. Interventions in the home should have three interrelated goals: to reduce live mite populations; reduce mite allergen levels; and reduce human exposure to both. Theoretically different approaches are possible: mite-proof dwelling construction, management of indoor humidity in existing homes, and intensive special cleaning or removal of infested textiles and finishing material. Since effective mite avoidance is usually a lifelong project, dwellers favour procedures with minimal costs in time and money. These are the long-lasting measures, frequently associated with changes in characteristics of building construction, the design of heating and ventilation of the dwelling and reducing the major reservoirs of HDMs.

For existing homes, practical measures that may be of benefit include:

- Avoiding smoking in the house.
- Removal of pets.
- The use of dust-mite-proof mattress, duvet and pillow covers, and the purchase of new pillows. Ensure that HDM covers really are impermeable to mites and their allergen, and that they are accredited by a standards organisation. They will also need to be washed at 60°C and tumble-dried on a hot setting regularly, and should have demonstrated their durability to this treatment.
- Washing, removal or freezing of children's soft toys.
- Vacuuming once a week. Advise patients to get the best vacuum cleaner they can realistically afford, preferably with a HEPA filter. It may seem obvious, but someone other than the allergy sufferer should empty the bag. All surfaces should be damp dusted.
- Regular turning (and vacuuming) of the mattress.
- Removal of fabric curtains and furnishings.
- Removal of carpets in the bedroom.

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