PREVENTION AND EXTERMINATION STRATEGIES FOR HOUSE DUST MITES AND THEIR ALLERGENS IN HOME TEXTILES

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Abstract—Preventing and exterminating clinically relevant concentrations of house dust mite allergen in the urban environment is one of the more interesting challenges for architects and building engineers, pest control contractors, cleaning services, and sanitary biologists.

When this challenge is not met, up to 40% or more of the human population may be affected by allergic symptoms such as conjunctivitis, rhinitis, asthma or eczema. The actual size of the problem in any given area depends on the massiveness and length of exposure to mite allergens arising from home textiles.

Within Europe the sensitization rate for house dust mites ranges from 5% to 25%, depending on the success of house dust mites (Pyroglyphidae) in dwellings. Yearly cost of allergy in the European Community amount to 9 milliard ECU, half of which is preventable by adequate avoidance measures.

In this report a strategy will be outlined that enables engineers, patients, doctors and nurses to take their part in preventing and clearing allergic symptoms caused by indoor factors. Starting from hygienic limits for allergen exposure, the different effective avoidance measures are systematized and discussed in the context of the technical or clinical discipline concerned.

A step-wise approach is used for every patient: 1. Establishing sensitizations present; 2. Assessing actual exposure; and 3. Preparation and Execution of the Avoidance Plan.

In low risk areas (such as Denmark) introducing only a higher level of ventilation proved successful in diminishing house dust mite allergen exposure to below clinically relevant levels. In high risk areas (such as the Netherlands) strategies advocated by the treating physician include cleaning, (re)furnishing and ventilation.

Clinical results of general advice (handing out pamphlets) are presently so poor that drug treatment of patients has taken preference, and the source of the trouble (allergen exposure) is left untouched. There exists an increasing concern among family physicians, district nurses, economists as well as the general population.

In these high-risk areas isolation and ventilation schemes should be combined with cleaning technologies fitting to the individual household. Parts of this extermination and prevention strategy were tested in (prospective) patient populations, showing a 50% or more reduction of clinical symptoms or disease.

INTRODUCTION

Preventing and exterminating clinically relevant concentrations of house dust mite allergen in the urban environment is a challenge for architects and building engineers, pest control contractors, cleaning services, and sanitary biologists, as well as patients and physicians. Diminishing (water availability) in home textiles by increasing air-exchange rates and thermal insulation of floors, and special cleaning of home textiles involving killing mites and removing allergenic dirt, are effective approaches (Kniest, 1990; Schober, 1991; Harving *et al.*, 1993).

Energy conservation strategies have led to a decrease in ventilation and an increase in indoor humidity, mite concentration and allergen contamination (Harving *et al.*, 1993). Since this increased indoor pollution was not matched with the overall acceptance of more efficient and innovative pest control and cleaning procedures, it is not surprising that the prevalence of atopic disease in Europe has risen from 6–11% of the population in the time period from 1925–1958 (Fuchs, 1967), to 25–37% nowadays (Kjellman & Croner, 1984; Croner & Kjellman, 1990; Åberg 1989). Affected persons may show symptoms of conjunctivitis, rhinitis, asthma or eczema.

Current yearly costs of allergic disease in the European Community at large can be computed from published figures for the Netherlands and Germany, and amount to 9 milliard ECU (Mölken et al. 1989; Deutscher Bundestag 1990).

In this report a strategy will be outlined for preventing and clearing of allergic symptoms caused by indoor factors (Figure 1). Starting from the individual sensitization situation and hygienic limits for allergen exposure, the different effective avoidance measures are systematized and discussed.

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Table 1: Indoor allergen sources present in 75% or more of Dutch dwellings. CAP-codes of allergen preparations as used by Pharmacia (1992), are added to facilitate the communication between technologists and clinicians (after: Bronswijk and Schober, 1993)

Allergen Source	CAP-code
FUNGI	mx1 (partly)
Aspergillus glaucus group	not available, *
A. restrictus group	not available, *
Cladosporium	m2
Penicillium chrysogenum series	m1
P. frequentans series	not available, *
Phoma	m13
Wallemia	not available, *
INSECTS	
Blattella germanica	
— German cockroach	i6
Lepismatidae	
— Silverfish	not available, *
Psocoptera	
— Dust lice	not available, *
MAMMALS	
Canis familiaris	
— Dog	e2
Felis catus	
— Domestic cat	e1
Mus musculus	e88
— House mouse	(or:e71 + e72)
Rattus norvegicus	e87
— Brown rat	(or:e73 + e74 + e75)
MITES	
Acaridae	
— Storage mites	d70, d72
Glycyphagidae	
— Storage mites	d71, d73
Pyroglyphidae	
— House dust mites	d1, d2, d3, d74
Tarsonemidae	
— Fungal mites	not available, *

*sensitization occurs (Bronswijk, 1981; Bronswijk *et al.*, 1986) but is not tested routinely.

STEP 1: Offending Allergens

House dust mite allergens occur in the midst of an almost endless list of possiblE occurring allergens indoors. In the Netherlands about 18 different biological taxa serve as abundant sources, present in at least 75% of the dwellings (Table 1). Not all atopic persons are exposed to the same degree and for the same length of time to all allergens included. Judging from the percentage of patients sensitized, exposure to pets and house dust mites are most common in this part of Europe (Bronswijk et al., 1992). With the rising trend in allergies, a new market may develop for pest control and cleaning contractors specialized in house dust allergen reduction.

In individual cases, all relevant allergens should be assessed for possible sensitization by a physician before measuring exposure, and the development of an individual allergen avoidance plan. When an allergy for house dust mites is present, other allergens associated with humid indoor conditions should not be forgotten in sensitization testing (Kort, 1993). Unfortunately diagnostic preparations are not available for all relevant indoor allergens.

It is the responsibility of the patient to forward the details of his complete sensitization range to his allergen avoidance consultant—the district nurse, pest control contractor or specialized cleaning firm. In fact, the preventive measures that can be taken in the dwelling environment are not of a medical nature, but belong to the domain of housekeeping or building engineering.

The remaining part of this report will be restricted to one allergen source: house dust mites.

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Table 2: Numbers of Pyroglyphids collected by vacuumcleaner (1 min vacuuming / m^2) from surfaces in 20 homes from the environs of Utrecht (the Netherlands) inhabited by house-dust-mite-allergic rhinitis patients in June 1988 (Kniest, 1990; Kniest unpublished; Kort et al. 1989; Kort 1990).
Within rows, same letters denote no difference (Mann Whitney U Test, 5% confidence limit)

Habitat	Median (& Maximum) /m^2			/g dust		
MATTRESS (n=60)	12	(209)	a	30	(450)	a
UPHOLSTERED FURNITURE						
Bedroom (n=29)	8	(835)	a	40	(555)	a
Living Room (n=28)	9	(167)	a	34	(500)	a
Other Spaces (n=6)	13	(31)	a	33	(177)	a
CARPETING						
Bedroom (n=42)	10	(331)	a	9	(64)	b
Living Room (n=25)	7	(228)	a	8	(280)	b
Other Spaces (n=6)	2	(777)	a/b	5	(92)	b/c
NON-TEXTILE FLOOR COVERING						
Bedroom (n=15)	0.1	(2.1)	c	1	(17)	b/c
Living Room (n=8)	0.4	(0.9)	c	1	(3)	b/c
Other Spaces (n=26)	0.0	(4.9)	c	0	(3)	c
WALLS & ROOM PARTITIONS						
Bedroom (n=34)	0.0	(11)	c	0	(196)	c
Living Room (n=37)	0.0	(0.5)	c/d	0	(19)	c
Other Spaces (n=8)	0.0	(0.5)	c/e	0	(125)	c

STEP 2: Assessing Exposure

The actual size of the house dust mite problem in any given area depends on the massiveness and length of exposure to mite allergens arising from home textiles. Mite concentrations differ by geographical area, as does the relative importance of carpeting, padded furniture and bedding (Bronswijk & Schober, 1993; Nes *et al.*, 1993).

Quantitative differences among homes in a climatically homogeneous area are still extensive, depending on the choice of furnishings and type of cleaning performed and the ventilation characteristics and thermal insolation situation of the particular dwelling. Also, within a home, not all surfaces are polluted to the same extent. Expressed as mites collected per surface area there is usually no difference between mattresses, padded furniture and carpeting, indicating that the mite exposure derived from these textiles is probably proportional to their surface area (Table 2).

Mattresses and upholstered furniture have a higher mite load by dust weight than carpeting (Table 2). In this study the median values for mattress and upholstered furniture are all well above the hygienic limit of 10 mites / g dust. In case of carpeting this is the case for the maximum values. This could indicate that bedding and furniture cause a more relevant exposure than carpeting. However, the 'per surface area' figures show a greater uniformity. Based on the 'per gram' figures, walls and room partitions contribute significantly to the allergen exposure in some dwellings (Kort, 1993b).

It is not possible to assess with the naked eye the mite allergen load of any home textile. In fact 'blind' avoidance actions consisting of the removal of (part of the) home textiles is only effective in about half of the cases (Kniest *et al.* 1992).

Therefore, a survey of actual exposure should precede any mite avoidance procedure. To this end, the members of the household are asked to draw maps of all dwelling floors while indicating the type and location of all home textiles. With the aid of the domestic vacuum cleaner two dust samples are taken from each room, one from carpeting (if present), and one from padded furniture and/or mattress, pillow, quilts, blankets and hairy toys. Allergenic products of mites are measured in an indirect way by quantifying the presence of guanine with the ACAREX test (Allergopharma, Reinbeck, Germany). Only a negative ACAREX-value lays below the hygienic limit (Bronswijk *et al.*, 1988).

Effective Mite Avoidance

Step 1. (Possible) Sensitisation
- — Prevention of symptoms
- — Prevention of sensitisation

Step 2. Assessment of actual Exposure
- — Inspection round
- — House-dust sampling and analysis
- — Wall sampling and analysis

Step 3. Avoidance Plan
- — Care for hard floor coverings
- — Carpet care
- — Care for furniture and remaining furnishings
- — Care for walls and ceilings
- — 'Allergen-proof' (re)furnishing

Figure 1: Overview of an effective mite avoidance system as tested in a multidisciplinary environment in the Netherlands

The ACAREX-values are noted on the dwelling maps. A clear picture of the actual problem is the result. Priorities may now be established and the actual avoidance procedures planned.

STEP 3: Exterminating Sources and Removing Reservoirs

As far as the living mites are concerned, allergens are nothing other than digestive enzymes that are accidentally excreted with the fæces. The mite allergens show a great stability. In one experiment dust was heated at 60°C and stored under simulated domestic conditions for 4 years without losing a significant part of its allergenicity (Kort, 1993a). Allergen avoidance in problem dwellings consists of two parts: exterminating mites and removing allergenic dust.

Short-term measures may be taken at short notice and give positive results within weeks or months. Special types of cleaning and removing strong sources of allergenic dust belong to this group. These procedures have to be repeated regularly, since living requirements of the mites are still met.

Long term measures such as drying out the dwelling are more effective in the long run than acariciadal cleaning, but their effect may not be visible untill 2 heating seasons later. Drying of a humid home is a slow process.

In more or less dry, low risk areas introducing a higher level of ventilation only proved successful in diminishing house dust mite allergen exposure to below clinically relevant levels. A Danish initiative improved the allergen-situation by changing the building design of the dwelling. In Denmark about 100 different building projects of 'Anti-Allergy-Dwellings' have been completed on the bais of selection of finishing materials and a relative indoor humidity of 45% or less. Under Danish winter conditions such a humnidity can be realized by the installation of a ventilation system with at least 1 complete air change/hour during 24 hours/day. Recently such building projects have started in Germany (Duisburg, Düsseldorf, Gerresheim). Building costs are about 10–15% higher than in case of a conventional design (Mies, 1988; Schober, 1991; Anonymous, 1993).

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It is not feasable to tear down all existing humid homes, nor will it be possible to build all new buildings 'Allergy-free'. Especially in moist, high risk areas, short-term measures should be taken in addition to building changes.

In high risk areas (such as the Netherlands) strategies currently advocated by the treating physician include cleaning, (re)furnishing and ventilation. Clinical results of this general advice are presently so poor that drug treatment of patients has taken preference. The source of the trouble (allergen exposure) is left untouched. There exists an increasing concern about this phenomenon among family physicians, district nurses, economists as well as the general population.

In these high-risk areas isolation and ventilation schemes should be combined with cleaning technologies, involving the destruction of the mite population. Recently a laboratory model has been developped that enables the researcher to compare the anti-mite effects of different household procedures or special avoidance products (Schober, 1991; Koren 1993).

Parts of this extermination and prevention strategy were tested in (prospective) patient populations, showing a 50% or more reduction of clinical symptoms or disease (Kniest, 1990).

Life-long monitoring of allergen exposure

There does not exist any medicament or avoidance procedure that can really heal an allergy. Therefore allergic patients will have to be on the watch for allergen exposure during the rest of their lifes. It is not sufficient to have one great avoidance endeavour, not even when it includes the refinishing and refurbishing of the complete home.

Mites will be brought in by guests and inhabitants. As long as humid pockets are available, new populations will develop. Therefore a monitoring system should be installed, e.g. on the basis of half-yearly guanin measurements of house dust (Kniest 1990). An assesssment set being on the market, the actual assessment can be made by the inhabitants or users of the building. It is also conceivable that this becomes an extra service of cleaning or pest control firms. 'Anti-Allergy' cleaning and pest control could be a new and growing market in the European Communities.

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REFERENCES

Åberg, N. (1989). Asthma and allergic rhinitis in Swedish conscripts. *Clin. Exp. Allergy* 19:59-63.

Anonymous 1993. Ein 'milbenfreies Haus für Allergiker geplant'. Rheinische Post, 22. Januar 1993.

Bronswijk, J.E.M.H. van (1981). House dust biology for allergists, acarologists and mycologists. NIB, Zeist. ISBN 90 275 3501 9.

Bronswijk, J.E.M.H. van; Rijckaert G.; Lustgraaf, B. van de (1986). Indoor fungi, distribution and allergenicity. *Acta Botanica Neerlandica* 35:329-345.

Bronswijk (1988). J. Medical Entomology 26(1):55-59

Bronswijk, J.E.M.H. van; Nes, A.M.T. van; Baart de la Faille, H. (1992). Dietary measures—Allergen avoidance. pp. 59-68, in: D. van Moerbeke, S. Mariz, eds. Allergy Manual. UCB, Braine-l'Alleud. ISBN 2-87301-001-0

Bronswijk, J.E.M.H. van; Schober, G. (1993). Geoklimatische Verteilung von Innenraumallergenen. *Mönchengladbacher Allergie-Seminar,* 5:69-84

Croner, S., Kjellman, N.-I. M. (1990). Development of atopic disease in relation to family history and cord blood IgE levels. *Pediatric Allergy Immunol.* 1:14-20.

Deutscher Bundestag 1990. Asthma und Allergie: Öffentliche Anhörung des Ausschusses für Jugend, Familie, Frauen und Gesundheit des Deutschen Bundestages am 26.April 1989 (Referat ffentlichkeitsarbeit). ISBN 3-924521-34-4

Fuchs, E. (1967). Sozialhygienische Bedeutung der allergischen Krankheiten. pp. 544-552, in: K. Hansen, M. Werner, eds., Lehrbuch der klinischen Allergie. Thieme, Stuttgart.

Harving, H.; Korsgaard, J.; Dahl, R. (1993). House-dust mites and associated environmental conditions in Danish homes. Allergy 48:106-109

Kjellman, N.-I. M., Croner, S. (1984). Cord blood IgE determination for allergy prediction—a follow-up to seven years of age in 1,651 children. *Annals Allergy* 53:167-171

Koren, L.G.H. (1993). Long-term efficacy of acaricides against house dust mites (*Dermatophagoides pteronyssinus)* in a semi-natural test system. Proceedings of 1st International Conference on Insect Pests in the Urban Environment, Cambridge. in press.

Kort, H.S.M.; Bronswijk, J.E.M.H. van; Schober, G. (1989). Moulds, mites and moisture, a prelimminary report on six cases of fungal damage in dwellings. Pp. 389-393, in: C.J. Bieva, Y. Courtois, M. Govaerts, eds., Proceedings 'Present and future of indoor air quality'. Excerpta Medica, Amsterdam. ISBN 0 444 81134 6

Kort, H.S.M. (1990). Mites, dust lice, fungi and their interrelations on damp walls and room partitions, pp. 63-68, in: M.J. Sommeijer, J. van der Blom, eds., Proceedings 'Experimental and Applied Entomology', a symposium of the Netherlands Entomological Society, December 15, 1989. Nederlandse Entomologische Vereniging, Amsterdam.

Kort, H.S.M. (1993a). Stability . . . Allergy (in press)

Kort, H.S.M. (1993b). Allergenic mites on mineral walls and in textiles. Proceedings of 1st International Conference on Insect Pests in the Urban Environment, Cambridge. in press.

Kniest, F.M. (1990). The management of dust allergens. Ph.D.-thesis, Catholic University of Nijmegen, Nijmegen, the Netherlands.

Kniest, F.M.; Wolfs, B.J.; Vos, H.; Ducheine, B.O.I.; Chayk-Bakker, M.J. van; Lange, P.J.P. de; Vos, E.M.P.; Bronswijk, J.E.M.H. van (1992). Mechanisms and patient compliance of dust-mite avoidance regimens in dwellings of mite-allergic rhinitic patients. Clinical and Experimental Allergy 22:681-689

Mies, J. (1988). In Duisburg werden die ersten Anti-Allergie-Häusern gebaut. Lästige Milben haben in der trockenen Luft keine Chance. Rheinische Post, 27. August 1988.

Mölken, M.P.M.H. van; Doorslaer, E.K.A.; Rutten, F.F.H. (1989). CARA in cijfers. Verslag van een pilot-studie. Institute for Medical Technology Assessment, Limburg State University, Maastricht, the Netherlands.

Nes, A.M.T. van; Boven, F.E. van; Pernot, C.E.E., Schellen, H.L.; Bronswijk, J.E.M.H. van (1993). Abundance of house dust mites (Pyroglyphidae) in different home textiles, in relation to ventilation and outdoor climates in Europe. Proceedings of 1st International Conference on Insect Pests in the Urban Environment, Cambridge. in press.

Pharmacia (1992). RAST/Pharmacia Allergenpanel / CAP-RAST. Pharmacia, Geschftsbereich Diagnostik, Freiburg.

Schober G. (1991). Control of allergenic mites and fungi in house dust. Ph.D.-thesis, Utrecht State University, Utrecht, the Netherlands