

EDITORIAL

Pillow talk: have we made the wrong beds for our patients to lie in?

For many years patients with asthma and perennial rhinitis have been advised to avoid feather pillows and duvets and, in recent decades, to replace these with 'hypo-allergenic' synthetic-filled pillows and bedding. Is it possible that the advice to avoid feathers in bedding is unnecessary, incorrect or even harmful? Recent studies suggest that it is timely at least to review relevant evidence.

Allergy to feathers

Advice to avoid the use of feather pillows and bedding seems likely to have arisen from clinical experience where patients may have complained of allergic or asthmatic symptoms related to exposure to dust from feather bedding, and also from the early recognition that many patients with symptoms associated with house dust exposure showed positive skin tests to feather extracts [1]. 'Feather allergy' has been, in the past, a common diagnosis. It has been known for some time, however, that allergy to feathers themselves might be only one of the causes of symptoms related to feather bedding, and that the content of other allergens might be important [2].

For those exposed to birds such as pigeons and budgerigars, allergens from feathers are derived, potentially, from two sources: those produced by the bird itself — its secretions and excretions — and those derived from the living inhabitants of the feathers. Feather mites, for example, make up 0.1–10% of the weight of each feather [3].

Extrinsic allergic alveolitis is associated with IgG antibodies against avian serum/faecal globulin and albumin and/or other components of faeces. Other patients have IgE-mediated asthma or rhinitis with exposure to birds. IgE antibodies reactive with extracts of budgerigar and/or canary feathers have been demonstrated in about 20% of budgerigar and canary fanciers with symptoms of atopic disease [4]. In some of these patients with high exposures to feathers, it seems likely that feather mites are an important source of clinically relevant allergens [3]. RAST inhibition data strongly suggested that while some feather mite allergens showed species specificity, others were cross-reactive with *Dermatophagoides pteronyssinus*-derived allergens. Thus existing sensitivity to house dust mites (HDMs) could potentially sensitize an individual for symptoms related to feather mite exposure.

A recent study of patients with allergic cutaneous or respiratory symptoms from Finland confirmed that IgE-

mediated sensitivity to feathers themselves was rare. Although 9% of the group (14% of those with other inhalant sensitivities) reacted to commercial feather extracts, these extracts were shown to contain house dust mite allergens and it seemed probable that most of the positive skin reactions to feather extracts were caused by the mite allergens present in feathers [5]. Earlier studies had also suggested this likely contamination [6]. Whether this contamination is primarily with *D. pteronyssinus*, or with feather mites showing cross-reactivity with *D. pteronyssinus*, is less clear. Although mite contamination of unprocessed feather was found to be common, manufacturers processing (washing and hot drying) appeared to remove this allergen from feathers [7]. It seems, therefore that, in mite-sensitive individuals, many IgE-mediated symptoms associated with exposure to feathers may result from mite exposure.

A third type of 'feather-related' allergens, in addition to those from feathers themselves and from their biological fauna, are allergens which have accumulated in feathers which are in use in a domestic setting, most commonly in bedding. These could potentially include all domestic allergens, including those derived from house dust and storage mites, cats, dogs, other domestic pets and animals including rodents and cockroaches, moulds and pollens. Contamination of the feathers could occur by direct infestation, by contact or by airborne particle deposition.

Bedding

While there are large numbers of studies from many countries of indoor allergen levels in mattress dust there are surprisingly few studies which have examined allergen levels in different types of bedding, or even in bedding rather than mattress dust. Dust from pillows and upper bedding might be expected to be more representative of patient exposure, given the more intimate, prolonged and regular relationship between pillows and upper bedding, and the airway.

There is increasing evidence that the bedroom is the major site of mite exposure. Sakaguchi and colleagues, for example, identified by air sampling that the bedroom is the major site of exposure to house dust mite allergens [8]. In that study it was reported that airborne mite allergen levels during sleep were about 10-fold higher than during usual domestic life in the living rooms of the same houses. The same group have shown, with the use of personal air

samplers in the domestic environment, and an extremely sensitive allergen assay, that the introduction of new mite-free bedding (futons) resulted in a substantial reduction in personal mite exposure [9]. While air sampling was used in these studies, the majority of domestic allergen-related studies have sampled settled reservoir dust as a surrogate. Mite and cockroach allergens, in particular, are present on relatively large particles and settle quickly. This is less true of the major cat allergen Fel d 1, which is also present on fine particles which remain airborne for much longer periods of time.

Sensitization

The relationships between allergen exposure and specific allergen sensitization, the development of allergic symptoms, and the severity of such symptoms are distinct relationships, all subject to ongoing study. There is now increasingly strong epidemiological evidence for an association between allergen exposure and specific allergen sensitization, with longitudinal studies showing a clear dose-response relationship for both mite and cat allergens [10,11], with an additional positive effect from the family history of atopy. The large prospective study by Wahn and colleagues [10] in Germany, for example, using mixed floor dust from child's bedroom, parents bedroom and living room, showed clear dose-response relationships for sensitization to both HDM and cat allergens, during the first three years of life. This study also demonstrated higher percentage sensitization, at any exposure concentration, for those with a positive family history of atopic disease. No threshold value was identified below which sensitization did not occur. A similar result, with no minimum threshold identifiable, and sensitization occurring at low exposure levels, has also been reported from Sweden [12], although this smaller study did not identify a direct relationship between exposure and sensitization. An earlier report from German and Austrian centres [11] examined the incidence of sensitization to *D. pteronyssinus* in over 1000 primary school children (mean age: 7.3 years). An increased risk for sensitization was identified for bed Der p 1 levels of $>2 \mu\text{g/g}$ dust, in those with pre-existing sensitization to other inhalant allergens, while for other children, without pre-existing sensitization, the level associated with risk was substantially higher ($>80 \mu\text{g/g}$). Thus for these primary school children the risk of new sensitization remains present, and is related both to the level of exposure of Der p 1 in the bed, and to the atopic diathesis.

Recently a similar relationship between exposure and sensitization has now been shown for the cockroach allergen Bla g 1, in inner-city children with asthma, aged 4–9 years, in the USA. Interestingly, although the highest concentrations of this allergen are found in kitchens, the strongest relationship between exposure and sensitization was seen for bedroom

dust, taken as a mixed sample from floor and bed. This study also confirmed an independent effect of atopy on sensitization. The authors discuss the possibility that these results may suggest a dynamic process in relation to sensitization [13].

Symptom severity

It has been more difficult to elucidate the relationships between current mite exposure and the development of allergic disease, and also between current mite exposure and allergic symptom severity. However, several cross-sectional and longitudinal studies provide support for recognition of a relationship between mite concentrations in the home and asthma symptom severity. Once again, the importance of the bed and bedroom as a source of mites is suggested by several of these studies. A cross-sectional studies in mite-sensitized adult asthmatics found a modest but significant relationship between the concentrations of Der p 1 and Der p 2 in the bed and several indices of asthma severity, including nonspecific bronchial hyperreactivity (BHR), FEV₁ and peak expiratory flow rate variability [14]. Interestingly, in this study, in which Der p 1 and Der p 2 were measured in the mattress, upper bedding and bedroom carpet, the relationship of exposure level to symptom severity was most strong with bed allergen levels, optimally with whichever was highest of mattress or bedding. Overall geometric means were upper bedding $4.4 \mu\text{g/g}$, mattresses $3.6 \mu\text{g/g}$, bedroom floor $1.2 \mu\text{g/g}$. There was no significant relationship of symptom activity with floor allergen levels.

In children, a relationship of HDM exposure with BHR has been shown in cross-sectional [15] and longitudinal [16] studies. The Australian study revealed a dose-response relationship between Der p 1 exposure and increased risk of current asthma in mite-sensitized children. Risk doubled for every doubling of Der p 1 level. A modest correlation between airway responsiveness and Der p 1 levels was identified for beds, but not for the bedroom or living room floors. These results have been extended with a further Australian study showing a significant association between minimum morning peak flow rate and bed Der p 1 (a composite sample from mattress and upper bedding), in mite-sensitive children [17]. Results suggested that an increase of one natural log concentration of Der p 1 would lead to an $\approx 15 \text{ L/min}$ decrease in peak expiratory flow rate, approximately equivalent to a 6% fall from baseline. These results show some similarity to those of Chan-Yeung and colleagues [18] who identified mite allergen levels in the mattress to be a more important determinant of asthma severity in children with house dust mite allergy, than levels in floor samples.

Thus there is an increasing body of evidence suggesting the importance of the bed as major site of exposure of mite allergens, and, possibly, also of cockroach allergens. High concentrations of cat allergen have also been identified in

the beds of infants [19] and adults [20], although living room floor and furnishings often show higher concentrations, and it is likely that both living room and bedroom are important exposure sources for cat allergen.

Bedding materials

There are few studies of allergen within the different components of the bed (mattress, sheets, duvets, blankets, etc.) or of bedding made of different materials, although different mite allergen concentrations have been identified in different types of mattress. Different types of clothing have been shown to contain different concentrations and total quantities of mite [21] and cat [22] allergens. These amounts may result from different frequency of laundry since both allergens are readily removed by washing, or may, in part, reflect other differences between the materials.

A surprising difference has been identified between synthetic and feather pillows, in terms of their mite allergen content [23]. This initial finding showed, to our considerable surprise, that the Der p 1 content of synthetic pillows was approximately eightfold greater than that in feather pillows. This finding was extended in a subsequent study of new synthetic and feather pillows, with Der p 1 accumulation on new synthetic pillows being substantially greater than that on feather pillows, during a one-year study [24].

Recent studies have identified the use of nonfeather pillows as a possible risk factor in both prevalence of wheeze, and the presence of severe wheeze, data which was also discussed in a recent editorial in this journal [25]. In a questionnaire-based case control study of 11–16-year-old children in Sheffield [26], an increased risk of severe wheeze associated with nonfeather pillows was identified, with the estimation that if the association with nonfeather pillows was causal, it would account for 53% of the severe asthma in this population. While the authors attempted to control for deliberate bedding changes, made because of the presence of asthma, it is difficult to totally exclude this possible explanation for the findings. It was suggested that synthetic bedding may be the source of volatile chemicals, which might influence the airways and play a role in the causation of asthma. Further evidence for this hypothesis is awaited. Ownership of furred pets, either at birth or currently, was also found to be an independent risk factor for the more severe forms of wheeze in adolescence.

In a comparison of two population-based case-control studies in eight-year-old Croydon (UK) children, carried out in 1978/9 and 1991/2 the use of nonfeather pillows was the only domestic indoor exposure which appeared to explain a modest rise in prevalence of wheeze [27]. Again, it was not possible to completely exclude a bias arising from lifelong avoidance of feather bedding in atopic families. There had been a small reduction in furred pet ownership between

these two studies, thus pet ownership did not appear to explain the 20% increase in the population prevalence odds of wheeze. In a comparative study of asthma and allergies among children in West and East Germany, feather bedding was also negatively associated with asthma, allergic rhinitis and eczema, an effect which persisted after attempts to control for parental atopy and for indicators of allergen avoidance [28].

In this issue Frosch and colleagues [29] report a survey of a large group of friends and relatives accompanying persons attending an outpatient department at a large London hospital. A strong association was found between non-feather pillow use and both seasonal and perennial rhinitis, an association which remained significant for perennial rhinitis after exclusion of all those who had changed pillow type. Adjusting the data to the extreme situation where all previous pillow use had been feather, the apparent risk fell to approximately one, thus giving no support for any risk associated with feather pillow use. While the methodology of this study can be criticized, it provides some further evidence that feather bedding does not, in fact, constitute a risk for atopic disease.

If the increased risk of severe wheeze, and of rhinitis, associated with synthetic pillows is caused by the higher house dust mite allergen content, rather than volatile chemicals, then it is likely that this increased risk is largely an effect of the pillow covering material, rather than the filling, although this has yet to be proven experimentally [24]. Advice to patients should probably be to cover the mattress, duvets and pillows with mite-impermeable covers, whatever the filler material. Unfortunately covers are expensive and many patients are unable to purchase them. Large, controlled trial results are needed, to clarify the clinical and cost-effectiveness of effective mite control measures. If such studies showed cost-effectiveness, then allergen-control bedding could possibly be subsidized within health service provisions. The inadequacy of many mite avoidance studies was suggested in a recent meta-analysis, with many studies failing to show efficacy in actual mite allergen reduction [30]. Given the epidemiological data, it is important to further clarify the role of individual bedding materials and asthma risk, and to encourage manufacturers to review their products and their labelling. It seems unlikely that feather bedding *per se* represents a risk to the atopic, while synthetic pillows and bedding may do so, perhaps related to their higher mite allergen content. Responsible manufacturers have the opportunity to produce genuinely 'hypo-allergenic' bedding, with integral mite impermeable coverings.

References

- 1 Berens L. On the composition of feather extracts used in allergy practice. *Int Arch Allergy Immunol* 1968; 34:81–94.

- 2 Voorhorst R, Spijksma FThM, Varekamp H. House-dust atopy and the house-dust mite *Dermatophagoides pteronyssinus* (Trouessart 1897). Leiden: Stafleu, 1969.
- 3 Colloff MJ, Merrett TG, Merrett J, McSharrt C, Boyd G. Feather mites are potentially an important source of allergens for pigeon and budgerigar keepers. *Clin Exp Allergy* 1997; 27:60–7.
- 4 van Toorenenbergen AW, van Wijk G, van Dooremalen G, Dieges PH. Immunoglobulin E antibodies against budgerigar and canary feathers. *Int Arch Allergy Appl Immunol* 1985; 77:433–7.
- 5 Kilpio K, Makinen-Kiljunen S, Haahtela T, Hannuksela M. Allergy to feathers. *Allergy* 1998; 53:159–64.
- 6 Wormald PJ. Cross reactions in skin tests between house dust mite extract and feather extract. *Clin Allergy* 1971; 1:291–3.
- 7 Dryer AL, Hamilton RG, Chandler MJ. Dust mite contamination of unwashed commercial feathers. *J Allergy Clin Immunol* 1998; 101 (1, Part 2):S29.
- 8 Sakaguchi M, Inouye S, Yasueda H, Shida T. Concentration of airborne mite allergens (Der I and Der II) during sleep. *Allergy* 1992; 47:55–7.
- 9 Sakaguchi M, Inouye S, Sasaki R, Hashimoto M, Kobayashi C, Yasueda H. Measurement of airborne mite allergen exposure in individual subjects. *J Allergy Clin Immunol* 1996; 97:1040–4.
- 10 Wahn U, Lau S, Bergmann R et al. Indoor allergen exposure is a risk factor for sensitisation during the first three years of life. *J Allergy Clin Immunol* 1997; 99:763–9.
- 11 Kuehr J, Frischer T, Meinert R et al. Mite exposure is a risk for the incidence of specific sensitisation. *J Allergy Clin Immunol* 1994; 94:44–52.
- 12 Munir AKM, Kjellman NIM, Bjorksten B. Exposure to indoor allergens in early infancy and sensitisation. *J Allergy Clin Immunol* 1997; 100:177–81.
- 13 Egglestone PA, Rosenstreich D, Lynn H et al. Relationship of indoor allergen exposure to skin test sensitivity in inner-city children with asthma. *J Allergy Clin Immunol* 1998; 102:563–70.
- 14 Custovic A, Taggart SCO, Francis HC, Chapman MD, Woodcock A. Exposure to house dust mite allergens and the clinical activity of asthma. *J Allergy Clin Immunol* 1996; 98:64–72.
- 15 Peat JK, Tovey ER, Toelle BG et al. House dust mite allergens: a major risk factor for childhood asthma in Australia. *Am J Respir Crit Care Med* 1996; 153:141–6.
- 16 van der Heide S, de Monchy JGR, de Vries K, Bruggink TM, Kauffman HK. Seasonal variation in airway hyperresponsiveness and natural exposure to house dust mite allergens in patients with asthma. *J Allergy Clin Immunol* 1994; 93:470–5.
- 17 Jalaludin B, Wei XA, Mahmic A et al. Association between Der p 1 concentration and peak expiratory flow rate in children with wheeze: a longitudinal analysis. *J Allergy Clin Immunol* 1998; 102:382–6.
- 18 Chan-Yeung M, Manfreda J, Dimich-Ward H et al. *Am J Respir Crit Care Med* 1995; 152:1805–11.
- 19 Sawyer G, Kemp T, Shaw R et al. Biologic pollution in infant bedding in New Zealand: High allergen exposure during a vulnerable period. *J Allergy Clin Immunol* 1998; 102:765–70.
- 20 Custovic A, Simpson A, Padhi H et al. Distribution, aerodynamic characteristics, and removal of the major cat allergen Fel d 1 in British homes. *Thorax* 1998; 53:63–72.
- 21 Siebers RW, Patchett K, Fitzharris P, Crane J. Mite allergen (Der p 1) on childrens clothing. *J Allergy Clin Immunol* 1996; 98:853–4.
- 22 Patchett K, Lewis S, Crane J, Fitzharris P. Cat allergen (Fel d 1) levels on school childrens clothing and in primary school classrooms in Wellington, New Zealand. *J Allergy Clin Immunol* 1997; 100:755–9.
- 23 Kemp TJ, Siebers RW, Fishwick D, OGrady GB, Fitzharris P, Crane J. House dust mite allergen in pillows. *Br Med J* 1996; 313:916.
- 24 Rains N, Siebers R, Crane J, Fitzharris P. House dust mite allergen (Der p 1) accumulation on new synthetic and feather pillows. *Clin Exp Allergy* 1999; 29:182–5.
- 25 Custovic A, Woodcock A. Feather or synthetic? That is the question. *Clin Exp Allergy* 1999; 29:144–7.
- 26 Strachan DP, Carey IM. Home environment and severe asthma in adolescence: a population based case-control study. *Br Med J* 1995; 311:1053–6.
- 27 Butland BK, Strachan DP, Anderson HR. The home environment and asthma symptoms in childhood: two population based case-control studies 13 years apart. *Thorax* 1997; 52:618–24.
- 28 Duhme H, Weiland SK, Rudolph P, Wienke A, Kramer A, Keil U. Asthma and allergies among children in West and East Germany: a comparison between Munster and Greifswald using the ISAAC phase I protocol. *Eur Respir J* 1998; 11:840–7.
- 29 Frosch AC, Sandhu G, Joyce R, Strachan DP. Prevalence of rhinitis, pillow type and past and present ownership of furred pets. *Clin Exp Allergy* 1999; 29:457–60.
- 30 Gotzsche PC, Hammarquist C, Burr M. House dust mite control measures in the management of asthma: meta-analysis. *Br Med J* 1998; 317:1105–10.

P. FITZHARRIS
R. SIEBERS
J. CRANE

*Department of Medicine
Wellington School of Medicine
Wellington
New Zealand*