

Review article

Effects of damp and mould in the home on respiratory health: a review of the literature

Peat JK, Dickerson J, Li J. Effects of damp and mould in the home on respiratory health: a review of the literature.
Allergy 1998; 53: 120–128. © Munksgaard 1998.

This review examines whether there is a direct or indirect relation between damp or mould in the home and respiratory health. Home dampness is thought to have health consequences because it has the potential to increase the proliferation of house-dust mites and moulds, both of which are allergenic. The results from the many studies conducted to investigate whether damp and mould are associated with health outcomes are difficult to compare because the methods of measuring exposures and health outcomes have not been standardized. However, the studies that have been conducted in children are probably the most reliable because the confounding effects of active smoking or occupational exposures are absent, and because the presence of symptoms of cough and wheeze have been consistently investigated in many studies. The increased risk of children having these symptoms if the home has damp or mould is fairly small with an odds ratio that is generally in the range 1.5–3.5, these estimates being statistically significant when the sample size has been large enough. This range is consistent with the measured effects of other environmental exposures which are considered important to health, such as environmental tobacco smoke or outdoor air pollutants. The potential benefits of reducing mould in the home have not been investigated, and the few studies that have investigated health improvements as a result of increasing ventilation or reducing damp in order to reduce house-dust mite levels suggest that this intervention is expensive, requires a large commitment, and is unlikely to be successful in the long term. This implies that houses need to be specifically designed for primary prevention of respiratory problems associated with indoor allergen proliferation rather than using post hoc procedures to improve indoor climate and reduce allergen load as a secondary or tertiary preventive strategy.

J. K. Peat¹, J. Dickerson², J. Li¹

¹Department of Medicine, University of Sydney, Sydney; ²Institute of Respiratory Medicine, University of Sydney, Sydney, NSW 2006, Australia

Dr Jennifer K. Peat
Sydney University Department of
Pediatrics and Child Health
Clinical Epidemiology Unit
New Children's Hospital
Westmead NSW 2145
Australia

Accepted for publication 24 September 1997

Damp in the home may have health consequences because of its action in increasing the proliferation of house-dust mites and moulds, both of which are allergenic. However, it is difficult to collect direct evidence that building design influences the indoor environment and, in turn, allergen levels and respiratory health. In practice, it is not possible to monitor closely indoor microclimates, which are complex and are influenced by many factors, including building materials, ventilation, water content, and the effects of heating and cooling; therefore, the factors which influence exposure to indoor allergens have not been accurately identified.

Moreover, there are inherent limitations in the design of the studies which can be used to investigate whether there is a relation between indoor exposure and clinical outcome. Because cohort studies are constrained by the financial and practical problems of measuring exposure over extended periods, the studies from which there is evidence have been cross-sectional or case-control in design, because these provide more immediate results, but there are obvious problems in using their results to infer direct causal effects.

This review summarizes the literature which has investigated respiratory health outcomes in rela-

Table 1. Associations between house-dust mite levels and housing characteristics that have been reported

Authors	Study design	Effect
Cabrera et al. (1995) (64)	Der p 1 levels in beds of asthmatic patients in 10 homes in Spain	Der p 1 levels were 4–8-fold lower in homes where dehumidifier was used
Chan-Yeung et al. (1995) (13)	Der p 1 levels in beds and floors of asthmatics in 57 homes in Vancouver and 63 in Winnipeg	Der p 1 levels related to age of home, storey, type of heating, and number of occupants
Colloff (1992) (58)	House-dust mite numbers in beds of 23 people with atopic dermatitis in UK	House-dust mite numbers slightly higher in mattresses in damp homes
Dornelas de Andrade et al. (1995) (65)	Der p 1 levels from cross-section of 108 homes in France	Der p 1 levels lower in homes with low relative humidity but no relation to presence of mechanical ventilation, water vapour, heating, or air vents or to use of humidifiers
Dotterud et al. (1995) (66)	House-dust mite numbers in beds of 19 atopic and 19 nonatopic children in Norway	House-dust mite numbers slightly higher in homes with poor ventilation, increased humidity, and water leaks
Fletcher et al. (1996) (23)	Der p 1 levels in beds and floors of nine homes with mechanical ventilation heat recovery units and nine control homes in UK	Der p 1 levels not significantly lower in homes with mechanical ventilation heat recovery units
Harving et al. (1993) (19)	House-dust mite numbers in 96 homes of asthmatics in Denmark	House-dust mite numbers related to indoor humidity and air-exchange rates
Kalra et al. (1992) (16)	Der p 1 levels in beds and floors of homes of 40 asthmatic patients in UK	No correlation between Der p 1 levels and house type, ventilation, or presence of double glazing
Kuehr et al. (1994) (67)	Der p 1 levels in beds of cohort of 1291 children in Germany	Der p 1 levels higher in rooms with damp spots, higher relative humidity, and low storey level, and lower in homes with underfloor heating
Lintner & Brame (1993) (11)	Der p 1 levels in beds or carpets in 424 homes in USA	Der p 1 levels lower in homes with air-conditioning, especially in summer months
Malainual et al. (1995) (68)	Der p 1 levels in beds in 630 buildings in Thailand	Der p 1 levels not different between regions or building types (single house, shop, slum house, and hotels)
Munir et al. (1995) (69)	Der p 1 levels in beds and floors of 130 homes of asthmatic children in three regions of Sweden	Der p 1 levels higher in homes with dampness problems and in homes without basement; also higher in homes with higher relative humidity and poor ventilation
Plácido et al. (1996) (70)	Der p 1 levels in floors of 59 asthmatics, 36 house-dust-mite-sensitized subjects, and 23 controls in Portugal	Higher Der p 1 levels associated with older homes, signs of dampness, and presence of carpets
Sundell et al. (1995) (71)	Der p 1 levels in beds and floors from 30 homes with levels above 2 mg/ml and 30 homes with levels below 1 mg/ml in Stockholm	High Der p 1 levels associated with high indoor compared to outdoor humidity and with low air-exchange rates in home
Tovey et al. (1996) (72)	Der p 1 levels in beds and floors of over 600 randomly selected children in nine regions of Australia	No difference in Der p 1 levels between storey, wall construction, age of home, carpeting, presence of mould, or ventilation type
van Strien et al. (1994) (20)	Der p 1 levels from 516 houses in The Netherlands; relative humidity measured in 19 homes	Der p 1 levels higher in homes with observed signs of dampness (total sample) and higher absolute humidity (subsample)
van Strien et al. (1995) (73)	Der p 1 levels from beds of 46 "high-risk" infants (with atopic mothers) and 56 "low risk" infants in The Netherlands	Der p 1 levels lower in beds of infants with new mattresses or blankets and top plastic sheeting over mattresses
Wickman et al. (1993) (74)	House-dust mite numbers in dust from 65 homes of house-dust-mite-sensitized children in Sweden	House-dust mite numbers higher in mattresses in basement and ground floor bedrooms and in tight or damp homes
Wickman et al. (1994) (75)	Der p 1 levels in mattresses from 70 houses in Sweden	Der p 1 levels lower in homes with natural ventilation and presence of basement
Zock et al. (1994) (76)	Der p 1 levels from homes of 228 asthmatic children in The Netherlands	Der p 1 levels lower in homes with carpet compared to hard floors

tion to housing characteristics or the presence of damp or mould in the home. All of the papers from the last 15 years which could be accessed via MEDLINE are included.

Housing characteristics associated with house-dust mite proliferation

Indoor humidity is thought to have a major controlling influence on house-dust mite populations.

In clinical terms, this is important because house-dust mite exposure is one of the best documented environmental causes of asthma (1–4). Because very low house-dust mite allergen (Der p 1) exposure levels have been associated with sensitization and symptoms (5), no safe threshold of exposure to Der p 1 has been confirmed.

Levels of Der p 1 are almost certainly influenced by local conditions because much higher levels are found in humid regions (3, 6–8) and because levels

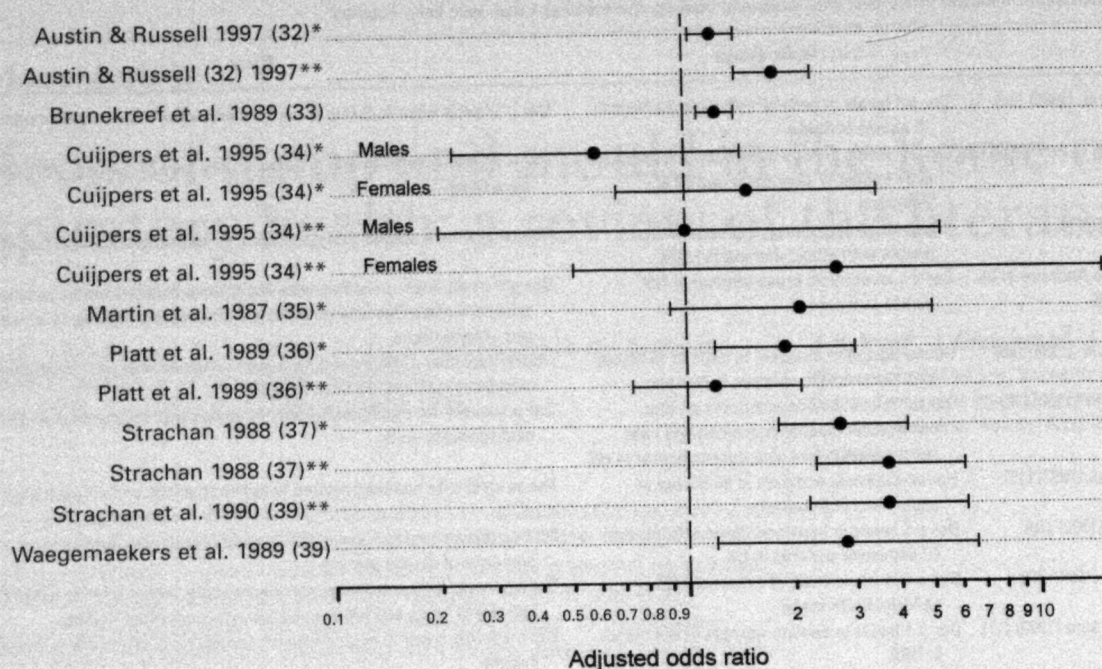


Fig. 1. Reported associations between wheeze in children and damp or mould in home. Data shown are odds ratios and their 95% confidence interval. Associations with damp are indicated by * and with mould by **. In studies where both mould and damp have been combined, no annotation is shown.

undergo spontaneous seasonal changes (9–15), although such changes have sometimes been small (16) and have not always been demonstrated (17). The vast range of Der p 1 levels in homes within the same climate (3, 8, 13, 18) also supports the hypothesis that indoor microclimate has a large influence. A relationship between measurements of indoor relative humidity and Der p 1 levels in homes has been established in some studies (8, 16, 19, 20), but not others (13).

The literature which has associated Der p 1 levels with specific home characteristics has been reviewed (21). Table 1 shows that housing characteristics which can be assumed to increase indoor humidity have been associated with higher house-dust mite numbers or with higher allergen levels in some, but not all, studies. It has been suggested that mechanical ventilation may have a major effect on indoor climate in cold regions but is unlikely to be effective in regions which have a humid outdoor climate for a significant part of the year (22, 23). The finding that beds have higher Der p 1 levels than floors (12, 24) and that bed, but not floor, levels are associated with the severity of airway hyperresponsiveness (3) suggests that the microclimate that influences allergen exposure from beds may be more relevant to respiratory health than that which influences exposure from floors.

There is some evidence that post hoc modifications to the home environment can reduce allergen

levels. In the USA, the use of air-conditioning to modify indoor climates reduced house-dust mite populations and subsequent allergen production (11), and, in Denmark, modest reductions in house-dust mite counts were monitored after increased indoor air-exchange rates to reduce humidity (19, 25), but the counts were low at the onset of the trial, and the changes achieved were too small to have clinical importance. In the UK, acaricide treatment of beds and floors has been shown to reduce allergen exposure significantly (26) and to improve airway responsiveness marginally in house-dust-mite-sensitized asthmatic children (27).

Association between indoor damp or mould growth and health

In the USA, exposure to *Alternaria* from outdoor sources has been associated with asthma exacerbations (28), and, in Australia, we found an important association between allergic sensitization to *Alternaria* and childhood asthma in inland regions where *Alternaria* levels are thought to be high as a result of farming practices and/or climatic conditions (29). Although children in Australia and New Zealand become sensitized to other moulds such as *Cladosporium*, *Penicillium*, and *Aspergillus*, this does not appear to have clinical importance in terms of being a risk factor for the development of asthma (30, 31). This suggests that levels of expo-

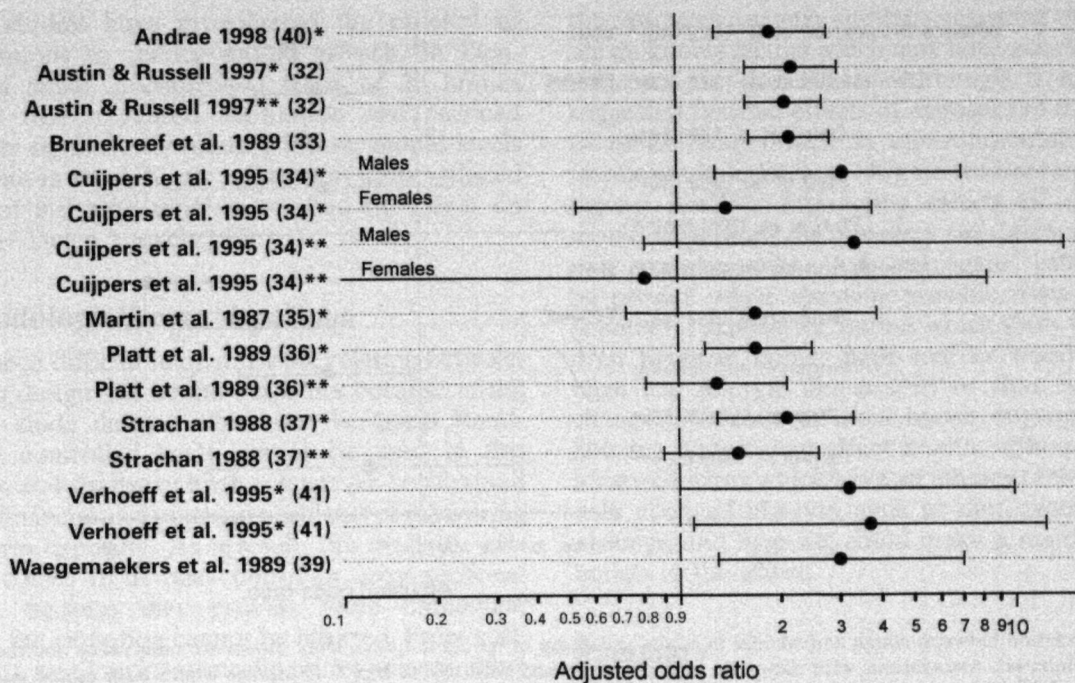


Fig. 2. Association between cough in children and damp or mould in home. Data shown are odds ratios and their 95% confidence interval. Associations with damp are indicated by * and with mould by **. In studies where both mould and damp have been combined, no annotation is shown.

sure to these moulds may be above the threshold needed to cause sensitization but below that which promotes airway inflammation, or that these particular moulds are less potent than *Alternaria* in causing airway abnormalities.

The two symptoms which have been investigated most often in relation to the home environment are cough and wheeze. Fig. 1 shows the odds ratios from the studies which have investigated an association between damp or mould in the home and wheeze in children (32–39), and Fig. 2 shows the odds ratios for cough (32–41). One study which did not find a significant effect between damp and respiratory symptoms but which yielded insufficient information to compute an odds ratio (42) is excluded.

Fig. 3 shows the odds ratios for cough and wheeze in adults associated with damp and mould in the home (36, 43–45), and Fig. 4 shows the odds ratios for asthma in both children and adults (33, 39–41, 43–50). Approximately half of the studies show a significant association between respiratory symptoms and the presence of damp and mould. The odds ratios from almost all studies are greater than unity, although the estimates from studies with a small sample size are not statistically significant. The only study which has examined the relation between the severity of asthma and the amount of damp in the home was a case-control study of asthmatic and nonasthmatic subjects in which a

modest correlation between a damp score and an asthma severity score was found (50).

Housing characteristics associated with mould growth

There are no practical and accurate methods with which to monitor mould exposure. Objective methods such as air sampling, weight gain of wood blocks, or cultivation of spores from dust have been tested (36, 38, 49, 51–54), but only a modest agreement between objective sampling methods and questionnaires has been found (39, 49, 50). Most epidemiologic studies have relied on questionnaires completed by occupants to measure the presence of damp or mould, but evidence from two studies suggests that occupants are more likely to report their homes as having damp or mould than are research investigators, with as much as 30% disagreement (36, 41), and a recent study suggests the opposite – that is, that occupants are less likely to report homes as being damp (50).

Only a small number of studies have investigated the indoor factors that increase mould levels or the influence of outdoor mould levels on indoor levels. As with house-dust mite levels, the wide variations in mould levels between homes (38) suggests that indoor microclimate is also an important determinant of mould exposure. In Sweden, moulds present in winter were associated with housing

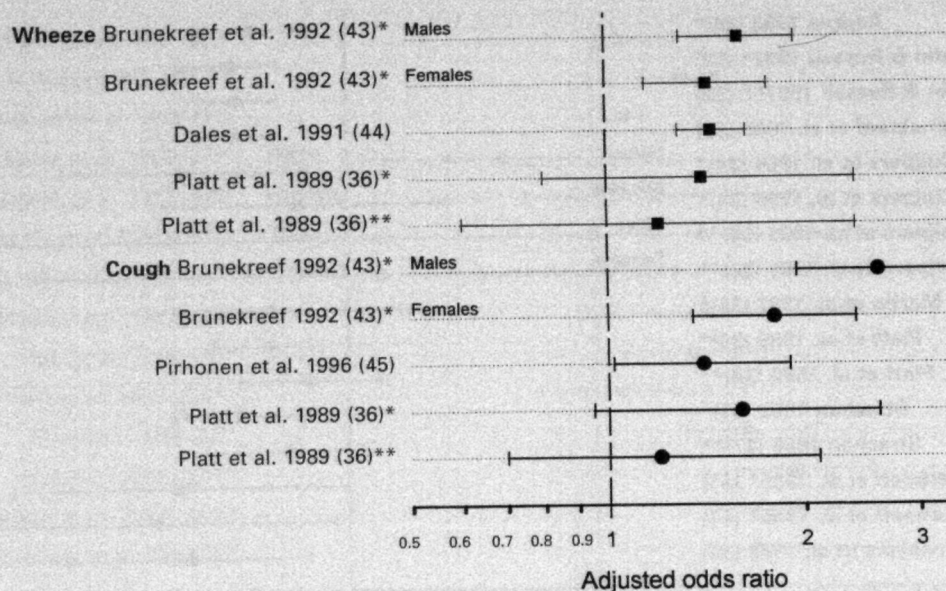


Fig. 3. Association between cough and wheeze in adults and damp or mould in home. Data shown are odds ratios and their 95% confidence interval. Associations with damp are indicated by * and with mould by **. In studies where both mould and damp have been combined, no annotation is shown.

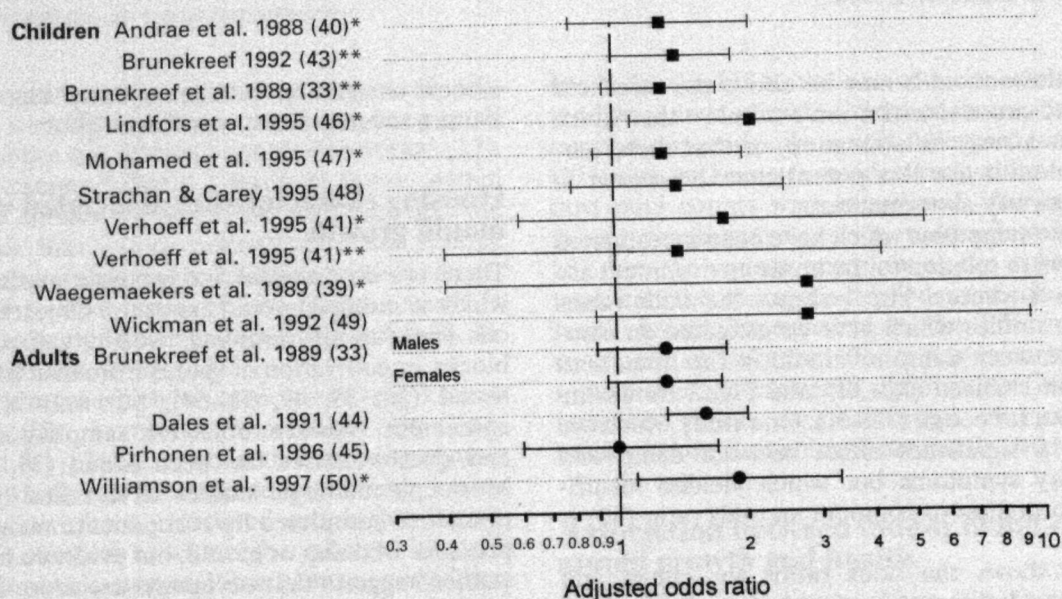


Fig. 4. Association between asthma in children and adults and damp or mould in home. Data shown are odds ratios and their 95% confidence interval. Associations with damp are indicated by * and with mould by **. In studies where both mould and damp have been combined, no annotation is shown.

characteristics (*Alternaria* with thermal insulation, *Aspergillus* with homes rather than units and with wall-to-wall carpets, and *Cladosporium* with concrete slab ground floors), and there was a marginal association between mould levels and length of time spent showering or visible condensation on window panes (49), although only a small number of homes were studied, so that the findings may

not be generalizable. In The Netherlands, indoor mould levels were found to be only weakly related to outdoor levels, to damp in the home, or to home characteristics such as relative indoor humidity (54, 55), and, in San Francisco, outdoor mould levels were higher than indoor levels in new occupancy units (53), and the indoor and outdoor species were very different (54, 56).

Few studies have investigated the efficacy of interventions to reduce mould growth. In Denmark, a small, uncontrolled study of 23 homes showed that increased ventilation and reduced humidity significantly reduced indoor mould levels (56), and, in the UK, air infiltration units reduced levels of airborne moulds but had no effect on airborne Der p 1 levels (57).

Methodological considerations

It has been difficult to quantify the relation between housing design and health outcomes because of the limited study designs which can be used. Randomized controlled trials cannot be used in this context, and studies of birth cohorts are constrained by the financial and practical problems of measuring long-term exposure. As a result, the available evidence comes from case-control or cross-sectional studies, because they provide more immediate results, but causation cannot be inferred. From such studies, a small and statistically nonsignificant effect would be expected if the real effect is small and therefore difficult to quantify, if only a minority of the sample are susceptible to the effects of exposure, or if there is misclassification bias in either the outcome or the exposure variables. On the other hand, the effect will be overestimated in studies in which the subjects associate home dampness with symptom outcomes; for example, the study which was undertaken in response to concerns about damp (39), or in which subjects living in dry or nonmouldy homes have a less accurate recall of symptoms. Such misclassification bias may explain why symptoms have been associated with visual signs of dampness or mould growth but not with air spore counts (36), and with mould growth but not with an objective test of exercise-induced lability (37).

More certainty can be attributed to findings from studies of children because the confounding effects of cigarette smoking and occupational exposures are absent. It is also important to consider that some groups, such as subjects with specific allergies, may be at greater risk of having symptoms if they live in a home with damp or mould present. Thus, it is important to test the hypothesis that sensitized subjects experience more respiratory problems if their home presents high levels of exposure to the allergen to which they are sensitized. Because none of the reported studies have adopted this approach, the effects of damp or mould in the home on susceptible subjects may have been underestimated. This notion of susceptibility is supported by the few studies which have demonstrated larger effects of damp or mould housing in atopic subjects (41, 49, 58).

In the four studies which have presented unadjusted and adjusted odds ratios (39, 41, 43, 44),

the estimates are very similar, suggesting that there are no known factors which may have a confounding influence on the effects. Although it has been suggested that the effects of exposure to damp and to other factors such as environmental tobacco smoke are independent (40), no studies have investigated possible interacting effects of damp or mould with other documented risk factors.

It is also possible that "surrogate" effects may be present when assessing possible roles of environmental exposures. Studies which show that children living in homes with coal or wood heating have less allergic illness (59) or that symptoms change when children move house (60) suggest that housing design may affect health, although other lifestyle factors which have an inherent relationship with changed lifestyle, such as diet, types of furnishings, and hygiene, could make a major contribution to the effect.

Summary

Clearly, most people are exposed to house-dust mites and to a wide range of mould spores in their home, but whether certain home characteristics lead to increased allergen exposure and, as a consequence, to respiratory health effects remains unclear. The symptoms for which there is most evidence, because they have been monitored most consistently, are wheeze and chronic cough. The increased risk of having these symptoms if the home is damp or mouldy is fairly small, with an odds ratio that is generally in the range 1.5–3.5, and may be statistically significant depending on sample size. This range is consistent with the measured effects of other exposures which are considered important such as environmental tobacco smoke or outdoor air pollution.

It is difficult to judge whether housing design, per se, leads to health problems. It is thought that the major sources of *Alternaria* are outdoors, whereas the sources of *Aspergillus* and *Cladosporium* are typically indoors. However, indoor exposures are likely to be a mixture of spores from indoor and outdoor sources and are likely to present more constant exposure levels than outdoor levels, which undergo large, intermittent fluctuations. Thus, tight or poorly ventilated homes may increase exposure to indoor allergens, whereas well-ventilated homes may increase intermittent exposures to outdoor moulds.

Future directions

In the future, studies with large sample sizes will be needed to measure whether intermittent peak exposures or low cumulative exposures to indoor

allergens pose a clinically important risk. The design of such studies will need to take account of problems such as variability in assessing exposures and notions of individual susceptibility. It is also important to determine whether living in a home with high house-dust mite or mould exposure as a result of dampness or poor ventilation increases the severity of existing airway disease or has a more profound effect of initiating respiratory illness in previously disease-free subjects.

Despite the problems in demonstrating a cause-and-effect relation between environmental exposure and health effects, it is essential to initiate strategies to prevent respiratory disease, because symptoms of asthma, wheezing, and cough impose a high social burden and cost on society, especially for children (61–63). Because people spend most of their time indoors, it is important that the home environment does not contribute to poor health. Although standards for outdoor air quality and for indoor air quality in public buildings are now in place, no standards have yet been developed to maintain air quality in the home. In practice, it may be more cost-effective to design houses that prevent indoor allergen proliferation and the onset of related illnesses rather than to invest in expensive post hoc procedures to improve homes with established allergen colonies. The collective evidence is beginning to suggest that homes which are specifically designed to minimize indoor humidity may make an important contribution to the respiratory health of both children and adults who have an allergic disposition.

References

1. Platts-Mills TAE, Thomas WR, Aalberse RC, Vervloet D, Chapman MD. Dust mite allergens and asthma – a world-wide problem. Report of a second international workshop. *J Allergy Clin Immunol* 1992;89:1046–60.
2. Sporik R, Chapman MD, Platts-Mills TAE. House dust mite exposure as a cause of asthma. *Clin Exp Allergy* 1992;22:897–906.
3. 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.
4. 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* 1995;98:64–72.
5. Kuehr J, Frischer T, Meinert R, et al. Mite allergen exposure is a risk for the incidence of specific sensitization. *J Allergy Clin Immunol* 1994;94:44–52.
6. Charpin D, Birnbaum J, Haddi E, et al. Altitude and allergy to house-dust mites. A paradigm of the influence of environmental exposure on allergic sensitization. *Am Rev Respir Dis* 1991;143:983–6.
7. Peroni DG, Boner AL, Vallone G, Antolini I, Warner JO. Effective allergen avoidance at high altitude reduces allergen induced bronchial hyperresponsiveness. *Am J Respir Crit Care Med* 1994;149:1442–6.
8. Dornelas de Andrade A, Bartal M, Birnbaum J, Lanteaume A, Charpin D, Vervloet D. House dust mite allergen content in two areas with large differences in relative humidity. *Ann Allergy Asthma Immunol* 1995;74:314–16.
9. Platts-Mills TAE, Hayden ML, Chapman MD, Wilkins SR. Seasonal variation in dust mite and grass-pollen allergens in dust from the houses of patients with asthma. *J Allergy Clin Immunol* 1987;79:781–91.
10. van der Heide S, de Monchy JGR, de Vries K, Bruggink TM, Kauffman HF. 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.
11. Lintner TJ, Brame KA. The effects of season, climate, and air-conditioning on the prevalence of *Dermatophagoides* mite allergens in household dust. *J Allergy Clin Immunol* 1993;91:862–7.
12. Li C-S, Wan G-H, Hsieh K-H, Chua K-Y, Lin R-H. Seasonal variation of house dust mite allergen (*Der p 1*) in a subtropical climate. *J Allergy Clin Immunol* 1994;94:131–4.
13. Chan-Yeung M, Becker A, Lam J, et al. House dust mite allergen levels in two cities in Canada: effects of season, humidity, city and home characteristics. *Clin Exp Allergy* 1995;25:240–6.
14. Meijer GG, Postma S, van der Heide S, et al. Seasonal variations in house dust mite influence the circadian peak expiratory flow amplitude. *Am J Respir Crit Care Med* 1996;154:881–4.
15. Nagakura T, Yasueda H, Obata T, et al. Major *Dermatophagoides* mite allergen, *Der 1*, in soft toys. *Clin Exp Allergy* 1996;26:585–9.
16. Kalra S, Crank P, Hepworth J, Pickering CAC, Woodcock AA. Absence of seasonal variation in concentrations of the house dust mite allergen *Der p 1* in South Manchester homes. *Thorax* 1992;47:928–31.
17. Marks GB, Tovey ER, Green W, Shearer M, Salome CM, Woolcock AJ. The effect of changes in house dust mite allergen exposure on the severity of asthma. *Clin Exp Allergy* 1995;25:114–18.
18. Custovic A, Taggart SCO, Woodcock A. House dust mite and cat allergen in different indoor environments. *Clin Exp Allergy* 1994;24:1164–8.
19. Harving H, Korsgaard J, Dahl R. House-dust mites and associated environmental conditions in Danish homes. *Allergy* 1993;48:106–9.
20. van Strien RT, Verhoeff AP, Brunekreef B, van Wijnen JH. Mite antigen in house dust: relationship with different housing characteristics in The Netherlands. *Clin Exp Allergy* 1994;24:843–53.
21. Tovey ER. Environmental control. In: Barnes P, Grunstein MM, Leff A, Woolcock AJ, editors. *Asthma*. Philadelphia: Lippincott-Raven, 1997.
22. Colloff MJ. Dust mite control and mechanical ventilation: when the climate is right. *Clin Exp Allergy* 1994;24:94–6.
23. Fletcher AM, Pickering CAC, Custovic A, Simpson J, Kennaugh J, Woodcock A. Reduction in humidity as a method of controlling mites and mite allergens: the use of mechanical ventilation in British domestic dwellings. *Clin Exp Allergy* 1996;26:1051–6.
24. Arruda LK, Rizzo MC, Chapman MD, et al. Exposure and sensitization to dust mite allergens among asthmatic children in São Paulo, Brazil. *Clin Exp Allergy* 1991;21:433–9.
25. Harving H, Korsgaard J, Dahl R. House-dust mite exposure reduction in specially designed, mechanically ventilated “healthy” homes. *Allergy* 1994;49:713–18.
26. Weeks J, Oliver J, Birmingham K, Crewes A, Carswell F.

- A combined approach to reduce mite allergen in the bedroom. *Clin Exp Allergy* 1995;25:1179-83.
27. Carswell F, Birmingham K, Oliver J, Crewes A, Weeks J. The respiratory effects of reduction of mite allergen in the bedrooms of asthmatic children - a double-blind controlled trial. *Clin Exp Allergy* 1996;26:386-96.
 28. O'Hollaren MT, Yunginger JW, Offord KP, et al. Exposure to an aeroallergen as a possible precipitating factor in respiratory arrest in young patients with asthma. *N Engl J Med* 1991;324:359-63.
 29. Peat JK, Tovey E, Mellis CM, Leeder SR, Woolcock AJ. Importance of house dust mite and *Alternaria* allergens in childhood asthma: an epidemiological study in two climatic regions of Australia. *Clin Exp Allergy* 1993;23:812-20.
 30. Peat JK, Woolcock AJ. Sensitivity to common allergens: relation to respiratory symptoms and bronchial hyper-responsiveness in children from three different climatic areas of Australia. *Clin Exp Allergy* 1991;21:573-81.
 31. Sears MR, Herbison GP, Holdaway MD, Hewitt CJ, Flannery EM, Silva PA. The relative risks of sensitivity to grass pollen, house dust mite and cat dander in the development of childhood asthma. *Clin Exp Allergy* 1989;19:419-24.
 32. Austin JB, Russell G. Wheeze, cough, atopy, and indoor environment in the Scottish Highlands. *Arch Dis Child* 1997;76:22-6.
 33. Brunekreef B, Dockery DW, Speizer FE, Ware JH, Spengler JD, Ferris BG. Home dampness and respiratory morbidity in children. *Am Rev Respir Dis* 1989;140:1363-7.
 34. Cuijpers CEJ, Swaen GMH, Wesseling G, Sturmans F, Wouters EFM. Adverse effects of the indoor environment on respiratory health in primary school children. *Environ Res* 1995;68:11-23.
 35. Martin CJ, Platt SD, Hunt SM. Housing conditions and ill health. *BMJ* 1987;294:1125-7.
 36. Platt SD, Martin CJ, Hunt SM, Lewis CW. Damp housing, mould growth, and symptomatic health state. *BMJ* 1989;298:1673-8.
 37. Strachan DP. Damp housing and childhood asthma: validation of reporting of symptoms. *BMJ* 1988;297:1223-6.
 38. Strachan DP, Flannigan B, McCabe EM, McGarry F. Quantification of airborne moulds in the homes of children with and without wheeze. *Thorax* 1990;45:382-7.
 39. Waegemaekers M, van Wageningen N, Brunekreef B, Boeleij JSM. Respiratory symptoms in damp homes. *Allergy* 1989;44:192-8.
 40. Andrae S, Axelson O, Björksson B, Fredriksson M, Kjellman N-IM. Symptoms of bronchial hyperreactivity and asthma in relation to environmental factors. *Arch Dis Child* 1988;63:473-8.
 41. Verhoeff AP, van Strien RT, van Wijnen JH, Brunekreef B. Damp housing and childhood respiratory symptoms: the role of sensitization to dust mites and molds. *Am J Epidemiol* 1995;141:103-10.
 42. Gustafsson D, Andersson K, Fagerlund I, Kjellman N-IM. Significance of indoor environment for the development of allergic symptoms in children followed up to 18 months of age. *Allergy* 1996;51:789-96.
 43. Brunekreef B. Damp housing and adult respiratory symptoms. *Allergy* 1992;47:498-502.
 44. Dales RE, Burnett R, Zwaneburg H. Adverse health effects among adults exposed to home dampness and molds. *Am Rev Respir Dis* 1991;143:505-9.
 45. Pirhonen I, Nevalainen A, Husman T, Pekkanen J. Home dampness, moulds and their influence on respiratory infections and symptoms in adults in Finland. *Eur Respir J* 1996;9:2618-22.
 46. Lindfors A, Wickman M, Hedlin G, Pershagen G, Rietz H, Nordvall SL. Indoor environmental risk factors in young asthmatics: a case-control study. *Arch Dis Child* 1995;73:408-12.
 47. Mohamed N, Ng'ang'a L, Odhiambo J, Nyamwaya J, Menzies R. Home environment and asthma in Kenyan schoolchildren: a case-control study. *Thorax* 1995;50:74-8.
 48. Strachan DP, Carey IM. Home environment and severe asthma in adolescence: a population based case-control study. *BMJ* 1995;311:1053-6.
 49. Wickman M, Gravesen S, Nordvall SL, Pershagen G, Sundell J. Indoor viable dust-bound microfungi in relation to residential characteristics, living habits, and symptoms in atopic and control children. *J Allergy Clin Immunol* 1992;89:752-9.
 50. Williamson IJ, Martin CJ, McGill G, Monie RDH, Fennerty AG. Damp housing and asthma: a case control study. *Thorax* 1997;52:229-34.
 51. Strachan DP, Sanders CH. Damp housing and childhood asthma; respiratory effects of indoor air temperature and relative humidity. *J Epidemiol Community Health* 1989;43:7-14.
 52. Hyndman SJ. Housing dampness and health amongst British Bengalis in East London. *Soc Sci Med* 1990;30:131-41.
 53. Macher JM, Huang F-Y, Flores M. A two-year study of microbiological indoor air quality in a new apartment. *Arch Environ Health* 1991;46:25-9.
 54. Verhoeff AP, van Wijnen JH, Brunekreef B, Fischer P, van Reenen-Hoekstra ES, Samson RA. Presence of viable mould propagules in indoor air in relation to house damp and outdoor air. *Allergy* 1992;47:83-91.
 55. Verhoeff AP, van Wijnen JH, van Reenen-Hoekstra ES, Samson RA, van Strien RT, Brunekreef B. Fungal propagules in house dust. II. Relation with residential characteristics and respiratory symptoms. *Allergy* 1994;49:540-7.
 56. Prah P. Reduction of indoor airborne mould spores. *Allergy* 1992;47:362-5.
 57. Warburton CJ, Niven RM, Pickering CAC, Fletcher AM, Hepworth J, Francis HC. Domiciliary air filtration units, symptoms and lung function in atopic asthmatics. *Respir Med* 1994;88:771-6.
 58. Colloff MJ. Exposure to house dust mite in homes of people with atopic dermatitis. *Br J Dermatol* 1992;127:322-7.
 59. von Mutius E, Illi S, Nicolai T, Martinez FD. Relation of indoor heating with asthma, allergic sensitization, and bronchial responsiveness: survey of children in south Bavaria. *BMJ* 1996;312:1448-50.
 60. Hughes CH, Baumer JH. Moving house: a risk factor for the development of childhood asthma. *BMJ* 1995;311:1069-70.
 61. Mellis CM, Peat JK, Bauman A, Woolcock AJ. The cost of asthma in New South Wales. *Med J Aust* 1991;155:522-8.
 62. Toelle BG, Peat JK, Mellis CM, Woolcock AJ. The cost of childhood asthma to Australian families. *Pediatr Pulmonol* 1995;19:330-5.
 63. Weiss KB. An overview of recent trends in asthma epidemiology. *Eur Respir Rev* 1996;6:101-4.
 64. Cabrera P, Julia-Serda G, Rodríguez de Castro F, Caminero J, Barber D, Carrillo T. Reduction of house dust mite allergens after dehumidifier use. *J Allergy Clin Immunol* 1995;95:635-6.
 65. Dornelas de Andrade A, Birnbaum J, Lanteaume A, et al. Housing and house-dust mites. *Allergy* 1995;50:142-6.
 66. Dotterud LK, Korsgaard J, Falk ES. House-dust mite content in mattresses in relation to residential characteristics and symptoms in atopic and nonatopic children living in northern Norway. *Allergy* 1995;50:788-93.

67. Kuehr J, Frischer T, Karmaus W, et al. Natural variation in mite antigen density in house dust and relationship to residential factors. *Clin Exp Allergy* 1994;24:229-37.
68. Malainual N, Vichyanond P, Phan-Urai P. House dust mite fauna in Thailand. *Clin Exp Allergy* 1995;25:554-60.
69. Munir AKM, Björkstén B, Einarsson R, et al. Mite allergens in relation to home conditions and sensitization of asthmatic children from three climatic regions. *Allergy* 1995;50:55-64.
70. Plácido JL, Cuesta C, Delgado L, et al. Indoor mite allergens in patients with respiratory allergy living in Porto, Portugal. *Allergy* 1996;51:633-9.
71. Sundell J, Wickman M, Pershagen G, Nordvall SL. Ventilation in homes infested by house-dust mites. *Allergy* 1995;50:106-12.
72. Tovey ER, Mahmic A. Special problems in cooling climates. In: van Bronswijk JEMH, Pauli G, editors. An update on long-lasting mite avoidance. European Respiration Society, 1996:32-42.
73. van Strien RT, Verhoeff AP, van Wijnen JH, Doekes G, De Meer GEA, Brunekreef B. Der p 1 concentrations in mattress surface and floor dust collected from infants' bedrooms. *Clin Exp Allergy* 1995;25:1184-9.
74. Wickman M, Nordvall SL, Pershagen G, Korsgaard J, Johansen N. Sensitization to domestic mites in a cold temperate region. *Am Rev Respir Dis* 1993;148:58-62.
75. Wickman M, Emenius G, Egmar A-C, Axelsson G, Pershagen G. Reduced mite allergen levels in dwellings with mechanical exhaust and supply ventilation. *Clin Exp Allergy* 1994;24:109-14.
76. Zock JP, Brunekreef B, Hazebrook-Kampschreur AAJM, Roosjen CW. House dust mite allergen in bedroom floor dust and respiratory health of children with asthmatic symptoms. *Eur Respir J* 1994;7:1254-9.

This document is a scanned copy of a printed document. No warranty is given about the accuracy of the copy. Users should refer to the original published version of the material.