

House Dust Mite and Cockroach Exposure: Risk Factors for Asthma

ROBERT A. WOOD, M.D.

INTRODUCTION

THE INCIDENCE AND PREVALENCE of asthma have risen sharply in the past 20–30 years. This rise in asthma has been particularly prominent in children and even more so in those living in urban environments. This is not unique to the United States but has in fact occurred in developed countries around the world. Current estimates in the United States indicate that the number of children with asthma has increased by at least 100% in the past 20 years. In fact, between 1980 and 1995, the number of children with asthma in the United States rose from 2.3 to 5.5 million.^{1–3} The increase has occurred in both sexes and all ethnic groups, with the sharpest increases occurring in children under the age of 5 years and in urban, predominantly minority populations.⁴

The reasons for this dramatic increase in asthma are not known and there are likely to be multiple contributing factors. Atopy, defined as the tendency to become allergic, is the most important predictor for the development of asthma, so anything that contributes to the development of atopy is also likely to be important to the development of asthma. While atopy is to a large extent genetically determined, genetic changes in a population occur slowly and therefore cannot explain the increases in asthma and atopy. There is evidence that exposure to both allergens and irritants, especially environmental tobacco smoke (ETS), early in life may play a pivotal role in the development of allergy and asthma.

In addition, there is also substantial evidence that other exposures, particularly to infectious

agents, may stimulate the immune system away from the development of allergy and asthma.^{5–7}

This critical role of exposure to infectious agents in early life, or more importantly the lack thereof, has been termed the “hygiene hypothesis.” Simply stated, this hypothesis proposes that the less the immune system is exposed to infectious agents in early life (the first 6–12 months appear to be most important), the more it will (can) focus on allergic responses. The immunologic basis for this hypothesis is that the developing immune system can be directed toward either TH1 lymphocyte predominance, which focuses on response to infections, or a TH2 lymphocyte predominance, which focuses primarily on allergic responses, and that early exposure to infectious agents largely dictates the direction that the immune system will take. This is now widely accepted as a possible explanation for the increases in asthma and allergy in developed countries, where improved hygiene and smaller family size appear to predispose to the development of both allergy and asthma. Whether this is sufficient by itself or whether the immune system is simultaneously driven in the opposite direction (i.e., towards atopy) by exposure to allergens and other factors, will take many years to sort out.

In this delicate balance of genetic predisposition and environmental exposures, several specific allergens appear to be of particular importance. This review will focus on the potential contribution of two of these allergens, dust mites and cockroach, to the development and clinical course of asthma.

Department of Pediatrics, Division of Allergy and Immunology, Johns Hopkins University School of Medicine, Baltimore, Maryland.

ROLE OF ALLERGEN EXPOSURE IN ASTHMA

Dust mites

Dust mites are recognized as the most important indoor allergen on a worldwide basis.⁸⁻¹⁰ Dust mites are microscopic organisms which live in the dust that is found in all dwellings and workplaces. Contrary to popular belief, house dust mites do not bite or sting. They feed on shed human skin scales that collect in the dust on furniture, particularly mattresses, and on carpeting below beds. House dust mites are important medically because they produce allergens in their secretions and excrement. Inhalation of dust containing mite feces and cast skins is a common cause of asthma symptoms in both children and adults. Exposure is virtually ubiquitous, except in areas of the world that are too dry to support their growth.¹¹

There is convincing evidence that dust mite exposure increases the risk of dust mite sensitivity as well as the development of asthma.¹²⁻¹⁷ While the data supporting this relationship are most convincing in early childhood, there is also evidence that mite exposure in adults, especially in populations without significant childhood exposure, can lead to the development of asthma.¹⁸ In addition, there is limited evidence to suggest that measures to reduce mite exposure in early childhood may lead to a reduction in the development of mite sensitivity and asthma.¹⁹

There is also extensive evidence that dust mite exposure contributes to asthma disease activity, asthma medication requirements, and asthma exacerbations.²⁰⁻²³ Just as importantly, there is convincing evidence that dust mite exposure can be reduced with a variety of physical and chemical measures, and that dust mite avoidance can reduce asthma symptoms and disease activity.²⁴⁻²⁹ It should be noted that a meta-analysis on this question published in 1998 concluded that there was not adequate evidence to support this position.³⁰ However, this meta-analysis has come under broad criticism, and its conclusions are not felt to be valid by most experts in this field.¹⁰

There have been no long-term studies on the relationship of allergen exposure or allergen avoidance and the persistence of asthma (for any allergen). While significant improvements in asthma have been demonstrated in some studies of dust mite avoidance, it is not known whether

these improvements might eventually translate into a long-term asthma remission. It is known that the improvements that occur with mite avoidance are lost when dust mite-sensitive asthmatics are returned to a mite-infested environment, which suggests that nothing short of sustained avoidance would be capable of inducing a long-term remission.²⁸

Cockroach allergens

Although the cockroach was first recognized as an allergen capable of causing asthma in the 1970s,³¹⁻³² it was not until the 1990s that it became recognized as a major indoor allergen.^{13,33-35} It is in fact now recognized as the predominant indoor allergen in inner city environments in the United States. While there is convincing evidence that cockroach exposure is related to the development of cockroach sensitivity,³⁶ there is currently no evidence that cockroach allergen exposure in early life is a risk factor for the development of asthma. However, there is strong biological plausibility that this may be the case, especially considering the dramatic rise in asthma prevalence in children in inner-city environments, and final conclusions should be possible with further study.

There is convincing evidence that cockroach allergen exposure is a risk factor for asthma exacerbations.^{13,35} In fact, in a comprehensive study on the factors that contribute to the enormous problem of asthma in inner-city children, the combination of cockroach sensitivity and cockroach exposure was the single greatest risk factor for asthma exacerbations.³⁵ While it has been shown that cockroach allergen levels can be reduced with a combination of cleaning and extermination,^{37,38} there is currently no data on the clinical effects of cockroach avoidance. At least one large study is currently underway that will provide more information on this important question.

CONCLUSION

The relationship of asthma to environmental factors is an area of tremendous importance. Dust mites and cockroaches are widespread indoor allergens that may significantly impact the clinical course of asthma. Most importantly, exposure to these allergens in sensitized patients has been

shown to increase asthma morbidity. Whether these allergens may contribute to the development of asthma is an area of great interest, as is the possibility that allergen avoidance could improve the long-term course of asthma.

However, in addition to allergens, environmental factors need to be considered in a broader sense, including exposure to infectious agents in early life, as well as biologic agents and chemical substances. In the United States, childhood asthma rates increased dramatically over the last 20 years, and a variety of environmental exposures, both alone and in combination, have clearly played a key role in this alarming rise. The picture is extraordinarily complicated, with a variety of environmental exposures interacting with genetically susceptible hosts to induce the disease we call asthma. It is also clear however, that asthma can itself have many faces, ranging from a transient condition of early childhood, related primarily to viral infections, to a life-long disease characterized by chronic airway inflammation and frequent exacerbations. It is clear that environmental factors play a central role in this persistent form of asthma, although it is not clear whether any are truly responsible for this disease, or rather, whether these individuals followed this path for other reasons. Research is clearly needed to sort out these issues.

Asthma is the most common chronic disease of childhood and with it come enormous costs in terms of both monetary expenditures and human suffering. Fortunately, however, the means are now available to control virtually all childhood asthma with treatments that are safe and even convenient. Our preeminent goal now should be to ensure that these therapies are made available to all children with asthma so that the recent increases in asthma morbidity and mortality can be stopped and eventually reversed.

REFERENCES

- Massey, I.T., T.F. Moore, V.L. Parsons, et al. 1989. Design and Estimation for the National Health Interview Survey, 1985–1994. DHHS Publication No. (PHS)89-1384 (Vital and Health Statistics; Series 2; No. 110). Hyattsville, MD: U.S. Department of Health and Human Services, Public Health Service, CDC National Center for Health Statistics.
- Mannino, D.M., D.M. Homa, C.A. Pertowski, et al. 1998. Surveillance for asthma—United States, 1960–1995. *MMWR* 47:1–28.
- Sly, R.M. 1999. Changing prevalence of allergic rhinitis and asthma. *Ann. Allergy Asthma Immunol.* 82:233–298.
- Weiss, K.B., P.J. Gergen, and E.F. Cram. 1992. Inner city asthma. The epidemiology of an emerging U.S. public health concern. *Chest* 101:3625–3675.
- Martinez, F.D. 1995. Viral infections and the development of asthma. *Am. J. Respir. Crit. Care Med.* 151:1644–1648.
- Bodner, C., D. Godden, and A. Seaton. 1998. Family size, childhood infections and atopic diseases. The Aberdeen WHEASE Group. *Thorax* 53:28–32.
- Strannegard, O., and I.-L. Strannegard. 2001. The causes of the increasing prevalence of allergy: is atopy a microbial deprivation disorder? *Allergy* 56:91–102.
- Platts-Mills, T.A.E., and A. De Weck. 1989. Dust mite allergens and asthma—a world-wide problem. *Bull. WHO* 66:769–780.
- Platts-Mills, T.A.E., W.R. Thomas, R.C. Aalberse, et al. 1992. Dust mite allergens and asthma: report of a 2nd international workshop. *J. Allergy Clin. Immunol.* 89:1046–1060.
- Arlian, L.G., and T.A.E. Platts-Mills. 2001. The biology of dust mites and the remediation of mite allergens in allergic disease. *J. Allergy Clin. Immunol.* 107:S406–S413.
- Arlian, L.G. 1989. Biology and ecology of house dust mites. *Dermatophagoides* spp. and *Euroglyphus* spp. *Immunol. Allergy Clin. North Am.* 9:339–356.
- Sporik, R., S.T. Holgate, T.A.E. Platts-Mills, et al. 1990. Exposure to house-dust mite allergen (Der p I) and the development of asthma in childhood. A prospective study. *N. Engl. J. Med.* 323:502–507.
- Call, R.S., T.F. Smith, E. Morris, et al. 1992. Risk factors for asthma in inner city children. *J. Pediatr.* 121:862–866.
- Kueher, J., J. Frischer, R. Meiner, et al. 1994. Mite exposure is a risk factor for the incidence of specific sensitization. *J. Allergy Clin. Immunol.* 94:44–52.
- Lau, S., G. Falkenhorst, A. Weber, et al. 1989. High mite-allergen exposure increases the risk of sensitization in atopic children and young adults. *J. Allergy Clin. Immunol.* 84:718–725.
- Peat, J.K., E. Tovey, C.M. Mellis, et al. 1993. Importance of house dust mite and *Alternaria* allergens in childhood asthma: an epidemiological study in two climatic regions of Australia. *Clin. Exp. Allergy* 23:812–820.
- Peat, J.K., E.R. Tovey, B.G. Toelle, et al. 1996. House-dust mite allergens: a major risk factor for childhood asthma in Australia. *Am. J. Respir. Crit. Care Med.* 153:141–146.
- Dowse, G.K., K.J. Turner, G.A. Stewart, et al. 1985. The association between *Dermatophagoides* mites and the increasing prevalence of asthma in village communities within the Papua New Guinea highlands. *J. Allergy Clin. Immunol.* 75:75–83.
- Hide, D.W., S. Matthews, S. Tariq, et al. 1996. Allergen avoidance in infancy and allergy at 4 years of age. *Allergy* 51:89–93.

20. Pollart, S.M., M.D. Chapman, G.P. Fiocco, et al. 1989. Epidemiology of acute asthma: IgE antibodies to common inhalant allergens as a risk factor for emergency room visits. *J. Allergy Clin. Immunol.* 83:875–882.
21. Vervloet, D., D. Charpin, E. Haddi, et al. 1991. Medication requirements and house dust mite exposure in mite sensitive asthmatics. *Allergy* 46:554–558.
22. Kavity, S., A. Solomon, R. Soferman, et al. 1993. Mite asthma in childhood: a study of the relationship between exposure to house dust mites and disease activity. *J. Allergy Clin. Immunol.* 91:844–849.
23. Custovic, A., S.C.O. Taggart, H.C. Francis, et al. 1996. Exposure to house dust mite allergens and the clinical activity of asthma. *J. Allergy Clin. Immunol.* 98:64–72.
24. Platts-Mills, T.A.E., E.R. Tovey, E.B. Mitchell, et al. 1982. Reduction of bronchial hyperreactivity following prolonged allergen avoidance. *Lancet* 2:675–678.
25. Carswell, F., K. Birmingham, J. Weeks, et al. 1996. The respiratory effects of reduction of mite allergen in bedrooms of asthmatic children—a double-blind controlled trial. *Clin. Exp. Allergy* 26:386–396.
26. Dietemann, A., J.C. Bessot, C. Hoyet, et al. 1993. A double-blind, placebo-controlled trial of solidified benzyl benzoate applied in dwellings of asthmatic patients sensitive to mites: clinical efficacy and effect on mite allergens. *J. Allergy Clin. Immunol.* 91:738–746.
27. Ehnert, B., S. Lau-Schadendorf, A. Weber, et al. 1992. Reducing domestic exposure to dust mite allergen reduces bronchial hyperreactivity in sensitive children with asthma. *J. Allergy Clin. Immunol.* 90:135–138.
28. Peroni, D.G., A.L. Boner, G. Vallone, et al. 1994. Effective allergen avoidance at high altitude reduced allergen-induced bronchial hyperresponsiveness. *Am. J. Respir. Crit. Care Med.* 149:1442–1446.
29. Gillies, D.R.N., J.M. Littlewood, and J.K. Sarsfield. 1987. Controlled trial of house dust mite avoidance in children with mild to moderate asthma. *Clin. Allergy* 22:105–111.
30. Goetsche, P.C., C. Hammarquist, and M. Burr. 1998. House dust mite control measures in the management of asthma: a meta-analysis. *Br. Med. J.* 317:1105–1110.
31. Bernton, H.S., T.F. McMahon, and H. Brown. 1972. Cockroach asthma. *Br. J. Dis. Chest* 66:61–66.
32. Kang, B. 1976. Study on cockroach antigen as a probable causative agent in bronchial asthma. *J. Allergy Clin. Immunol.* 58:357–365.
33. Kang, B.C., J. Johnson, and C. Veres-Thorner. 1993. Atopic profile of inner city asthma with a comparative analysis on the cockroach-sensitive and ragweed-sensitive subgroups. *J. Allergy Clin. Immunol.* 92:802–811.
34. Sarpong, S.B., R.G. Hamilton, P.A. Eggleston, et al. 1996. Socioeconomic status and race as risk factors for cockroach allergen exposure and sensitization in children with asthma. *J. Allergy Clin. Immunol.* 97:1393–1401.
35. Rosenstreich, D.L., P. Eggleston, M. Kattan, et al. 1997. The role of cockroach allergy and exposure to cockroach allergen in causing morbidity among inner-city children with asthma. *N. Engl. J. Med.* 336:1356–1363.
36. Eggleston, P.A., D. Rosenstreich, H. Lynn, et al. 1998. Relationship of indoor allergen exposure to skin test sensitivity in inner-city children with asthma. *J. Allergy Clin. Immunol.* 102:563–570.
37. Eggleston, P.A., R.A. Wood, C. Rand, et al. 1999. Removal of cockroach allergen from inner city homes. *J. Allergy Clin. Immunol.* 104:842–846.
38. Eggleston, P.A., and L.K. Arruda. 2001. Ecology and elimination of cockroaches and allergens in the home. *J. Allergy Clin. Immunol.* 107:S422–S429.

Received on July 2, 2003
in final form, February 9, 2004

Reviewed by:
Richard C. Ahrens, M.D.

Address reprint requests to:
Robert A. Wood, M.D.
CMSC 1102
Johns Hopkins Hospital
600 North Wolfe St.
Baltimore, MD 21287

E-mail: rwood@jhmi.edu

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.