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School exposure and asthma

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Key Messages

- The indoor school environment is a significant reservoir of allergens, molds, pollutants, and endotoxin.
- There is an association between school exposure and pediatric asthma morbidity.
- School-based interventions have the potential for substantial individual, community, and public health benefit.
- Ongoing research is needed to study the health effects associated with school exposures and assess cost-effectiveness of multifaceted school-based interventions.

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ABSTRACT

Objective: To provide a comprehensive overview of common school exposures and the association between school exposures and pediatric asthma morbidity.
Data Sources: A comprehensive literature review was performed using PubMed.
Study Selections: Full-length, peer-reviewed studies published in English were considered for review. In vivo, in vitro, and animal studies were excluded. Studies of school exposure to cockroach, mouse, dust mite, dog, cat, molds, pollution, and endotoxin associated with asthma and asthma morbidity were considered.
Results: The current literature establishes an association between school exposure and pediatric asthma morbidity. There is a need for ongoing research to evaluate the effects of school-based environmental interventions on asthma morbidity.
Conclusion: It is evident that the indoor school environment is a significant reservoir of allergens, molds, pollutants, and endotoxin and that there is an association between school exposure and pediatric asthma morbidity. School-based interventions have the potential for substantial individual, community, and public health benefit. It is important that researchers continue to study the health effects associated with school exposures and assess cost-effectiveness of multifaceted school-based interventions.

Introduction

Asthma is one of the most common chronic conditions seen in pediatrics, affecting more than 6 million children in the United States.[1] Asthma prevalence is higher among pediatric patients and minority and low-income groups.[1] Asthma significantly affects patients' health and quality of life and comes with a substantial economic burden.[2] Children with asthma have higher health care use, including higher rates of emergency department visits, hospitalizations, outpatient visits, and prescription drugs, compared with school-aged children without asthma.[3]

Exposure to indoor allergens and pollutants plays a role in the development of atopic diseases, including asthma, allergic rhinitis, and atopic dermatitis. This exposure and subsequent sensitization to indoor allergens are risk factors for asthma control.[4] Previous studies have found that more than 80% of school-aged children with asthma are sensitized to at least one indoor allergen and that sensitization is a predictor of asthma persistence in later life.[5,6] The timing of sensitization is an important factor because a recent study found that younger aeroallergen sensitization was associated with increased asthma risk in later childhood.[7] The location of exposure is also an important factor. Early research in this field focused on the home environment and asthma and found an association

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between environmental exposures in the inner-city home environment and childhood asthma morbidity.[8] In recent years, research has expanded to consider exposure in schools and day care centers because children spend 7 to 12 hours per day in this setting.[9–11] The classroom represents an occupational model for children, and exposures in this environment have significant health effects.

In this article, we discuss common school exposures and the association between exposures and pediatric asthma morbidity. A comprehensive literature review was performed in PubMed assessing school exposure and asthma. Full-length, peer-reviewed studies published in English were considered for review. In vivo, in vitro, and animal studies were excluded. Exposures of interest for the review included cockroach, mouse, dust mite, dog, cat, molds, pollution, and endotoxin.

The School Environment

Cockroach

Cockroach is an important indoor allergen, especially in urban areas. The major cockroach allergens are Bla g 1 and Bla g 2. Rosenstreich et al,[8] in a landmark study, found that children sensitized and exposed to high levels of cockroach in inner-city homes had increased asthma morbidity. Furthermore, Amr et al[12] documented a significant positive correlation between cockroach exposure in the school and asthma prevalence. In the urban school setting in the United States, the prevalence of cockroach allergen has differed across studies. A group of early studies found a high prevalence of cockroach allergen in schools[9,12,13] and reported that 66% to 71% of dust samples from classrooms had detectable cockroach allergen.[9,12] The highest levels of cockroach allergens were in teachers' lounges, cafeterias, second grade classrooms, and kindergarten classrooms.[12] Although cockroach allergen was detected in schools, the median or mean concentrations were below the defined threshold effect associated with asthma symptoms (8 U/g).[8]

In contrast to these early studies, more recent studies in urban schools have found low to undetectable cockroach levels. The School Inner-City Asthma Study (SICAS 1) was a National Institute of Allergy and Infectious Diseases–funded, comprehensive, prospective study of classroom- and school-specific exposures and asthma morbidity among students in urban schools in the Northeast, adjusting for exposure in the home.[14] In this study, measured levels of cockroach allergen (Bla g 2) were found to be undetectable to very low in the dust samples from both schools and homes.[10] For those schools with detectable levels, the mean concentration of Bla g 2 did not exceed the threshold level associated with asthma.[10] The finding of low cockroach levels in urban schools has been consistent in multiple SICAS studies.[10,15,16] In addition, a study that assessed early childhood education centers in Arkansas reported undetectable levels of cockroach allergen (Bla g 1 or Bla g 2) in classrooms.[17] The differences in cockroach allergen levels in schools may be because allergens levels vary by location even within a city, by race/ethnicity, and by gradation in poverty levels.[10] Despite these differences, no study has identified median or mean concentrations above the defined threshold effect associated with asthma symptoms.[8]

Mouse

Mouse allergen exposure is also an important indoor allergen in urban areas. The major mouse allergens identified are Mus m 1 and Mus m 2. Mouse allergen exposure in the inner-city home environment has been linked to higher asthma morbidity.[18,19] Recent studies have focused on the school environment given the significant amount of time children spend in the school setting. These studies have found that mouse allergen, not cockroach allergen, was the primary school-based allergen.[10,15,20] Studies by the SICAS research team have consistently detected higher levels of mouse allergen in schools compared with levels in the same students' home environment[10,14,15] and that levels of mouse allergen in the school setting were similar to those seen in occupational laboratory animal settings.[10,21] Mouse allergen levels in inner-city schools were higher when mouse droppings were seen in the classroom and lower in classrooms where there was no evidence of mice.[22] That said, even within classrooms with no evidence of mice, there was still evidence of significant mouse allergen exposure that exceeded the level linked to an increase in asthma symptoms and health care use.[22] A recent study by Sheehan et al[23] found that exposure to mouse allergen in schools is associated with increased asthma symptoms and decreased lung function in inner-city children with asthma. Given the prevalence of mouse exposure in the school setting and its association with asthma morbidity, additional research is needed to determine whether reducing allergen exposure in mouse sensitized children results in improvements in asthma morbidity. The School Inner-City Asthma Intervention Study (SICAS 2), a National Institute of Allergy and Infectious Diseases randomized clinical trial that used environmental interventions modeled from successful home-based interventions, is currently under way, with health outcomes results pending.[24]

Dust Mite

Dust mite allergens (Der f 1, Der p 1) are microscopic arthropods found in dust and products with woven material and have the propensity to thrive in humid, warm environments.[25] The suggested threshold level for sensitization to dust mite allergen is more than 2 μg/g and for asthma symptoms is more than 10 μg/g.[4,25] There is debate about whether dust mite allergen exposure is associated with asthma development because some studies have found an association[5,26] and others have not.[27,28] However, for children sensitized to dust mites, there is sufficient evidence of a causal relationship between exposure to dust mite allergen and exacerbations of asthma.[29]

Dust mite levels in the school setting are similar or slightly lower than the corresponding levels in the home environment.[30] There is wide variation in dust mite allergen levels in the school setting, with the highest levels in the day care center found in carpeted areas during the day when the center was occupied.[31] However, the mean or median concentrations of dust mite allergens levels in school have not exceeded the previously determined threshold level associated with asthma symptoms.[10,11,15,16,25] A direct association of dust mite allergen exposure in the school setting and asthma morbidity has not yet been identified.

Dog and Cat

Dogs and cats are the most common animals kept as domestic pets and often thought of as a member of the family. Can f 1 is the major dog allergen, and Fel d 1 is the major cat allergen. These allergens can be carried on small airborne particles and adhere well to clothing and upholstery. The threshold allergen levels associated with sensitization are more than 1 μg/g for cat and more than 2 μg/g for dog, and the threshold levels associated with asthma symptoms in sensitized individuals are more than 8 μg/g for cat and more than 10 μg/g for dog.[32,33] Pet ownership is of considerable interest at this time given its unclear role in the pathogenesis of asthma, with many factors to consider, including the age at exposure, amount of allergen exposure, and sensitization status. However, for individuals already sensitized, exposure to cat and dog allergens is of significant concern and associated with asthma morbidity.[29,34]

Exposure to Can f 1 and Fel d 1 can occur in the home, school, and public spaces.[32,33,35] Multiple studies have detected cat and dog allergens in the school and day care settings. Within these studies,