Mechanisms of allergic diseases

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Indoor allergens in school and day care environments

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Overall Purpose/Goal: To provide excellent reviews on key aspects of allergic disease to those who research, treat, or manage allergic disease.

Target Audience: Physicians and researchers within the field of allergic disease.

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Activity Objectives

1. To recognize factors that influence pet and dust mite allergen levels in schools and day care centers and the evidence supporting various methods of intervention.
2. To identify the levels of environmental allergen that have been associated with allergic sensitization.
3. To become familiar with studies examining the association between asthma and pet allergen exposure in schools.
4. To understand the limitations of the assessment of fungal allergen exposure and the hypothesized underlying mechanisms of the observed health effects.

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Most studies that have examined exposure to indoor allergens have focused on home environments. However, allergen exposures can be encountered in environments other than the home. For example, many children spend a large part of their time in schools and day care facilities. Over the past 2 decades, a large number of studies have been conducted in school and day care environments. However, the role of indoor exposures in allergy and asthma development or morbidity in these settings is not well characterized. The purpose of this review is to evaluate the importance of indoor allergen exposures in school and day care settings. We summarize the key findings from recent scientific literature, describe exposure characteristics, discuss the role of these exposures in relation to asthma and allergy symptoms, and provide information on the effectiveness of published interventions. (J Allergy Clin Immunol 2009;124:185-92.)

Key words: *Allergen, indoor, exposure, asthma, allergy, school, day care*

Exposure and sensitization to indoor allergens are important risk factors for asthma and allergic respiratory diseases.[1] Although the role of indoor allergen exposure in the development of allergic sensitization and asthma remains subject to debate, there is strong evidence that indoor allergens play a key role in triggering and exacerbating allergy and asthma symptoms.[2]

Most studies of indoor allergens have targeted home environments because homes are often considered the primary sites of exposure. Over the past decades, the importance of nonresidential indoor environments has also been recognized.[3] For example, in schools and day care facilities, allergen and other indoor exposures can affect children's health because children spend a large part of their childhood and adolescent years in these environments.

This review focuses on the importance of indoor allergen exposures in day care and school environments. The purpose of this article is to summarize key findings from the scientific literature and to identify future research needs. Studies for this review were searched by using the following databases: PubMed, Embase, Web of Science, Scopus, and Education Resources Information Center. Although inhalation of food allergens might

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Terms in boldface and italics are defined in the glossary on page 186.

Abbreviation used
MUP: Mouse urinary protein (mouse allergen)

induce allergic reactions in sensitive individuals, food allergens, which can constitute an important part of allergen exposures in day care and school settings, are beyond the scope of this review. Furthermore, the relevance of exposures other than aeroallergens (eg, environmental tobacco smoke, endotoxin, ***volatile organic compounds***, and other irritants) will not be discussed, although these exposures might also affect indoor air quality and occupants' health status.

EXPOSURE TO INDOOR ALLERGENS IN DAY CARE AND SCHOOL ENVIRONMENTS

Study designs and exposure assessment

Indoor allergen exposures in schools and day care centers have been an area of continuing research interest. Studies have been conducted worldwide,[4-15] but the research has been most active in the United States and Scandinavian countries.[16-35] Although most studies have targeted school environments, the number of studies that have assessed allergen levels in day care centers has increased over the past decade.[7,9,11,15,19,22,24,28] To date, studies have mainly been ***cross-sectional*** in design. Some studies, however, have examined seasonal variation in allergen levels.[16,20]

Cat (Fel d 1), dog (Can f 1), dust mite (Der f 1 and Der p 1), cockroach (Bla g 1 and Bla g 2), and mouse (Mus m 1 and mouse urinary protein [MUP]) allergens and molds have been the most frequently studied allergens. Although sampling and analytic procedures used in the studies vary considerably, allergen concentrations are usually quantified by using antibody-based ***ELISAs***.[36] However, methodological differences can contribute to the variability of the findings and complicate comparisons between studies. For example, differences in sampling equipments (eg, flow rate, vacuum power, and collection devices), sampling locations, and used metrics can make comparisons difficult.[36] In general, correlations between different sampling methods have been poor.[37] In most studies allergen levels have been assessed in settled dust samples collected from various indoor sites. ***Air sampling*** techniques have been primarily used for pet allergens (eg, Fel d 1), which are carried on aerodynamically smaller-sized particles and remain airborne for longer periods of time. Studies that have assessed allergen levels on the surface of clothing have also used ***tape sampling***.[38]

Allergen levels and exposure characteristics

Tables E1 to E5 in this article's Online Repository at www.jacionline.org summarize the main findings on cat, dog, dust mite, cockroach, and mouse allergen levels from published studies that have examined indoor allergen exposures in day care and school environments in the past 2 decades.

Exposure to cat and dog allergens. Numerous studies have shown that animal allergens can be present in environments in which no animals reside.[3,4] In schools and day care centers, cat (Fel d 1) and dog (Can f 1) allergens are frequently detected, but the levels of exposure vary greatly. In general, these common aeroallergens are found at low levels (see Tables E1 and E2) in these settings. Nonetheless, although the magnitude of exposure tends to be low, studies have demonstrated that allergen levels in educational facilities can be higher than in homes where no pets are present.[21,29]

Cat and dog allergen levels have generally been found in higher levels in carpeted and upholstered areas.[4,10,18,19,23,26] Levels in

GLOSSARY

AIR SAMPLING: There are multiple methods to sample aeroallergens, including sedimentation/gravity sampling (nonquantitative), rotating arm impactors, suction impactors, centrifugal sampling, and filtration sampling. The selection of the method/device depends on several factors, including the characteristics of the aeroallergen(s) (eg, particle size), sampling conditions and time, and analytical techniques used for quantification.

AMBIENT RELATIVE HUMIDITY: Relative humidity is calculated as the amount of moisture in the air divided by the maximum amount of moisture possible in the air at a specified temperature. Dust mites thrive in environment with temperatures of 70°F to 80°F and greater than 55% relative humidity.

β-1,3 GLUCAN AND ADJUVANT: β-1,3 Glucans are glucose polymers in the cell walls of plants and fungi. Exposure to elevated levels of this glucose polymer has been associated with increased atopy, increased conjunctival/respiratory symptoms, and decreased FEV_1. In addition, β-1,3 glucans can act as adjuvants to increase antigen-specific IgE levels in animal models.

CROSS-SECTIONAL: A cross-sectional analysis examines relationships or associations at a single point in time (as opposed to a prospective cohort study, which looks at a sample population over time). In a cross-sectional study, disease prevalence can be determined, but due to the single time point, a causal relationship between a risk factor and disease cannot be established.

ELISA: An ELISA uses a color detection system to quantify the amount of a protein of interest (antibody or antigen). In a sandwich ELISA a capture antibody is coupled to a solid phase followed by incubation with a biologic fluid (eg, serum, dust extract) and detection of the antigen by a second antibody.

LARGE-SIZED PARTICLE: Only particles of 5 μm or less reach the lower airway. For example, intact pollen grains (15-75 μm) have the greatest effects on the upper airway and conjunctiva because of their size and subsequent trapping before reaching the lower airways.

LOW INCOME: The definition of a low-income family is one in which the income from the preceding year does not exceed 150% of the poverty line income. In 2009, the low-income threshold for the 48 contiguous states was defined as $33,075 for a family of 4 (poverty level of $22,050 for a family of 4).

TAPE SAMPLING: A hand-held roller with adhesive tape can be used to collect samples from clothing. Rolled tape samples are immunostained to detect allergen.

VOLATILE ORGANIC COMPOUNDS: Volitile organic compounds include a variety of organic chemicals that are emitted as gases from certain solids and liquids. Many household products, such as paints, cleaning supplies, pesticides, printers, glues, adhesives, and permanent markers are sources of volitile organic compounds in indoor environments. Volatile organic compounds can be up to 10 times more concentrated in indoor air compared with those in outdoor air.

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