

Childhood Asthma and Indoor Allergens: The Classroom May Be a Culprit

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ABSTRACT: Asthma has become the most common chronic illness among children. Indoor environments appear to play a substantial role in the development of asthma. Recent studies indicate strong evidence of a causal relationship between exposure to certain indoor environmental pollutants and development and/or exacerbation of asthma in susceptible individuals. Allergens of concern include those produced by dust mites, cockroaches, cats, dogs, and molds. It is important to better understand this relationship and take preventive and corrective steps to reduce or eliminate these sources in schools, homes, and day care centers. Measures include tracking of asthma and allergic response incidents; monitoring for the presence of allergens and molds; effective cleaning procedures; prompt repair of water leaks and/or moisture problems; control of indoor relative humidity; and proper operation of heating, ventilation, and air conditioning (HVAC) systems.

KEY WORDS: allergens, asthma, cockroaches, dust mites, indoor air quality, molds, pets

INTRODUCTION

Asthma has become the most common chronic illness among children, and indoor environments appear to play a substantial role in its development. The escalation of allergies and asthma among children has become a national crisis, with asthma being a major contributor to school absenteeism (Pew Environmental Health Commission, 2000). An Executive Order from President Clinton, *Protection of Children from Environmental Health Risks and Safety Risks* (Executive Order 13045, 1997), addressed this concern and the need to reduce the associated risks. The U.S. Environmental Protection Agency (USEPA) responded by establishing the Office of Children's Health Protection and addressing health and safety risks to children and asthmatics when issuing new air-quality standards. The impact of

the relationship between asthma and indoor air quality (IAQ) has also led to coordinated efforts of the Department of Health and Human Services (DHHS), USEPA, and the Centers for Disease Control and Prevention (CDC). These efforts include educational and media campaigns to promote healthier home and school environments.

Health effects from exposure to indoor pollutants, including those that trigger asthmatic and allergic responses, are of particular concern in schools. Children are more vulnerable to exposure to pollutants and face greater environmental health risks than do adults for a number of reasons. Children's immune and neurological systems are still developing, and because of their lower body weight, they breathe a relatively larger volume of air as compared with adults. In addition, because young children play closer to the ground, they are more likely to come into contact with contaminated dust on indoor floor surfaces. These factors result in a higher body burden of air pollutants than that experienced by adults having the same exposure (USEPA, 1997).

Common indoor pollutants include molds, allergens from pets and insects, particles and fibers, ozone, environmental tobacco smoke, and volatile organic chemicals. Allergens of particular concern in schools

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and homes are those that originate from furry pets such as cats and dogs, dust mites, cockroaches, and molds.

WHY THE CONCERN ABOUT THE INDOOR ENVIRONMENT?

Outdoor air pollution has been shown to worsen asthma. Curiously, however, there has been a general improvement in outdoor pollution levels over the last 20 years. At the same time, many schools, offices, and homes have become much tighter buildings with minimal fresh air flow. As a result, pollutants are being retained in buildings at greater levels. Further, adults and children spend more time indoors than they did in the past; therefore, the duration of exposure to indoor pollutants has increased (USEPA, 1995).

These factors have led public and environmental health professionals and IAQ specialists to consider the indoor environment as a potential contributor to the increase in asthma. Recent studies demonstrate a relationship between exposure to certain indoor environmental pollutants and the development and/or exacerbation of asthma in susceptible children (Platts-Mills, Thomas, Aalberse, Vervloet, & Chapman, 1992). The National Academies Institute of Medicine's Committee on the Assessment of Asthma and Indoor Air (National Academies Institute of Medicine, 2000) found sufficient evidence that exposures to allergens produced by dust mites and cockroaches, as well as those from cats, dogs, and molds, can aggravate and/or actually trigger asthmatic symptoms in IgE-sensitized individuals.

Budget constraints or older or poorly maintained equipment may limit schools' abilities to effectively control humidity and temperature levels. Structural defects; roof leaks; and heating, ventilation, and air conditioning (HVAC) systems with insufficient capacities or poor maintenance and operation have led to excessive dirt (from outdoor air and building dust) and moisture in many schools. These conditions encourage the growth of molds and dust mites, thereby contributing to the increased risk of developing allergies and asthma.

Asthma may be aggravated by numerous factors. For example, studies have shown that in many children and young adults with asthma, allergic reactions are often an important part of their asthma attack (Platts-Mills & Carter, 1997). In a landmark study, Rosenstreich, Eggleston, and Kattan (1997) reported that cockroach allergen exposure causes asthma-related conditions in inner-city children. Almqvist et al. (1999) found that children are exposed to significant amounts of cat allergen in schools. The National Heart, Lung, and Blood Institute's 1997 revised guidelines for asthma management recommended that asthma sufferers be tested for sensitivity to dust mites, cats, cockroaches, and various molds (National Insti-

tutes of Health [NIH], 1997). There is a growing belief that more aggressive measures should be taken to address asthma and allergies from both an environmental and medical point of view (Shapiro et al., 1999).

ASSESSMENT OF INDOOR POLLUTANTS

Increasingly, IAQ investigators are monitoring for environmental allergens and molds in buildings. Sampling and analysis of dust reservoirs in a building provide information on the types and amounts of biocontaminants present. The school nurse can use this information to help identify potential sources so that action can be taken to reduce pollutant levels that may trigger adverse health effects.

Allergens and molds can be evaluated by collecting samples of dust from surfaces such as flooring, upholstered furniture (chairs, bedding), and other furnishings (cabinet tops, shelving). Settled dust samples can provide a "fingerprint" of these biocontaminants in a building. Sample results provide a means of assessing exposure risk so that the need for corrective or avoidance measures can be determined.

The sampling procedure is simple. One can use a filter cassette and a vacuum pump or a special dust collection bag that fits into the hose attachment of a standard household vacuum cleaner. It is important to collect a sufficient quantity of dust. A teaspoonful is recommended as a minimum. Dust samples are analyzed for indoor allergens by a qualified laboratory using an antibody assay called enzyme-linked immunosorbent assay (ELISA). Results can be compared with risk factor ranges (threshold values associated with an increased risk of sensitization) to help determine the need for protective remedial actions and/or avoidance measures (Hamilton, Chapman, Platts-Mills, & Adkinson, 1992). Table 1 presents the levels at which current research indicates there is an increased risk of sensitization. Allergen concentrations typically are expressed as micrograms of allergen per gram of dust (ug/g) or allergen units per gram of dust (U/g).

Molds should be analyzed by a qualified laboratory accredited by the American Industrial Hygiene Association (AIHA) in its Environmental Microbiology Laboratory Accreditation Program (EMLAP). The lab selected should have expertise in identifying environmental fungi. The analysis of molds in dust is usually performed using culture-based techniques, with agar media that are favorable for the recovery of environmental fungi. The laboratory should be able to speciate the types of molds present to better distinguish atypical and/or potentially toxic molds from those considered more normal or typical in the environment. Species-level mold identification also enables a more detailed comparison of indoor and outdoor air samples and provides a better tool for linking sources and related exposures. Mold results can indicate whether there are common molds present merely

Table 1. Indoor Allergens: Levels of Concern for Increased Risk of Sensitization

Source	Allergen ^a	Level of Concern
Dust mite	<i>Dermatophagoides pteronyssinus</i> 1 (Der p 1)	2 µg/g ^b (Dreborg, 1998)
Dust mite	<i>Dermatophagoides farinae</i> 1 (Der f 1)	2 µg/g (Dreborg, 1998)
Cat	<i>Felis domesticus</i> (Fel d 1)	8 µg/g (Chapman, 1995)
Dog	<i>Canis familiaris</i> (Can f 1)	10 µg/g (Chapman, 1995)
Cockroach	<i>Blattella germanica</i> (Bla g 1)	2 U/g ^c (Rosenstreich et al., 1997)

^a Allergen abbreviations indicate major allergen measured for each source.

^b µg/g = micrograms of allergen per gram of dust.

^c U/g = allergen units per gram of dust.

from settling out of the air or whether more atypical molds are present and/or have colonized on indoor surfaces (Morey, Horner, Epstien, Worthan, & Black, 2000).

Cat Allergens

Many children are allergic to furry pets and must avoid direct contact. Sensitization to cat dander and other domestic animals is not uncommon. Research indicates in some areas of the world as many as 50–70% of children with asthma are sensitized to furry pets (Almqvist et al., 1999). Awareness of the risk factor from exposure to pet allergens triggering and/or aggravating asthmatic symptoms and allergic reactions has led a number of school districts to establish policies restricting pets in the classroom. In doing so, these school officials recognize that children are more susceptible to pollutants and/or pathogens than are adults and should be protected accordingly (G. Jefferis, personal communication, June 2, 1999).

Building evaluations and sample analysis conducted by Air Quality Sciences, Inc., frequently have identified cat allergens in schools (Epstien, 1999). In the absence of pets in the classroom, schools still can be a source of indirect exposure to pet allergens. Interestingly, recent research has shown that even people who are not pet owners can become sensitized to pet allergens from indirect or “second-hand” exposure. Cat owners’ clothing has been suggested as the major source of the allergen in the classroom. Classroom levels of the cat allergen, *Felis domesticus* 1 (Fel d 1), can be sufficient to contribute to allergic responses in cat-allergic children. Further, Fel d 1 was transferred from cat owners’ clothing to non-cat owners’ clothes and was subsequently carried home. Levels of Fel d 1 were detected in cat-free homes (Almqvist et al., 1999).

Dust Mites

Dust mites are ubiquitous in indoor environments and share with molds an affinity for moisture. The major dust mite allergens are *Dermatophagoides pteronyssinus* and *Dermatophagoides farinae*. Dust mites are able to extract moisture from the air and can obtain enough moisture in this manner to thrive as long as the relative humidity remains above 60% for at least

a few hours per day. Their major food source is skin scales, a major component of indoor dust.

Dust mites accumulate primarily in upholstered furniture, floor dust, and other fleecy or porous materials. In homes, mattresses are the major reservoir for mite allergens. Control measures such as regular dusting with a slightly damp cloth and vacuuming using a vacuum cleaner equipped with a high-efficiency particulate air (HEPA) filter can be beneficial for reducing the amount of allergens in the indoor environment.

Molds

Molds are fungi. There are thousands of different types of fungi, including molds, yeasts, and mushrooms. The term mold refers to the colored or pigmented body and spore mass of a microscopic fungus. Attention to molds is important when addressing environmental biocontaminants. Many molds can trigger allergic responses in sensitive individuals. In addition, some molds can be pathogenic or toxic. Mold spores are abundant in the outdoors, and their presence indoors is expected. Normally, outdoor air should be the source of indoor molds. The mixture of airborne spores indoors should reflect those found in outdoor air. In mechanically ventilated buildings, the overall number of spores should be lower.

No building surfaces are sterile. Scattered spores will almost always be present on surfaces and in dust indoors; this is consistent with deposition from the air and is unremarkable. However, extensive visible mold inside a building is not acceptable. Visible mold growth often appears as discoloration on a building material or surface and may range in color from white to orange or from green to brown or black. Removal of visible mold growth should be done in such a manner as to restrict dispersal of spores into clean areas. During mold removal, personal protective equipment and/or work area isolation or containment may be necessary.

The growth of molds and fungi indoors is not normal or desirable and when found should receive prompt attention. In air samples, a mold problem may be indicated when a comparison of the indoor and outdoor air shows the mixtures to be disproportionate. In dust samples, an abundance of one or two spe-

cies of molds, rather than a more widely dispersed mixture, may indicate colonization or growth of molds in the building (Morey et al., 2000). Problems arise when a building has a moisture problem from leaks or other sources of water or moisture intrusion or from consistently high indoor relative humidity. Moisture control is the key to preventing mold problems. Schools are constantly addressing such preventive and corrective maintenance issues.

IMPLICATIONS FOR SCHOOL NURSING PRACTICE

Efforts should continue toward resolving these health risks for children. Suggested proactive measures that can be taken by schools are listed below and include some items that can be performed by a school nurse and others that require facilities personnel knowledgeable in the building systems' operation and maintenance. Many of these suggestions can be implemented at little or no cost. Good communication and coordination among all school staff members are essential for successful execution of these measures. The school health professional, as well as school management, administrative, and facilities personnel, will find practical guidance in the USEPA's *Indoor Air Quality Tools for Schools* (USEPA, 1995), which reminds the user that the costs and efforts required for preventive actions are usually much less than those encountered when attempting to resolve problems after they develop. Useful information also can be found at <http://www.aerias.org>, a Web site devoted entirely to health issues related to IAQ. The following steps are recommended:

- Consider establishing a school policy to control the presence of pets and animals in the classroom.
- Periodically (such as 2 to 4 times per year) monitor for the presence of allergens and molds in building dust. Use a qualified laboratory with professional scientists experienced in addressing IAQ issues.
- Ensure effectiveness of cleaning procedures through regular visual inspection; be sure to check hard-to-reach places and include food service areas, as well as classrooms and other common areas.
- Repair all water leaks promptly and remove and replace wet or damp materials.
- Minimize damp conditions and moisture in buildings and maintain relative humidity at less than 60–65%. Relative humidities near building surfaces should be maintained below the dew point. Watch for condensation on window surfaces.
- To the extent feasible, ensure that HVAC design and operation complies with American Society of Heating, Refrigeration, and Air-conditioning Engineers (ASHRAE) standards, such as the 62

series (ASHRAE, 1989, 1999). Provide an adequate amount of clean, controlled outdoor air. ASHRAE recommends approximately 15 to 20 cubic feet per minute (CFM) of outdoor air with adequate control of indoor contaminants.

An important tool for the school nurse in assessing IAQ conditions and the potential for asthma and allergy problems are health records and records of health-related complaints (USEPA, 1995). The school nurse can play a key role in monitoring and recognizing trends in reported illnesses. Specifically, track incidents of asthma attacks and allergic reactions and look for patterns in time(s) and locations(s) of their occurrence. For example, are these incidents or complaints occurring at particular times of the day or week? Are certain areas of the school building more affected than others? Are these health complaints occurring more at school or away from school? Noting such patterns can help to identify likely sources and thereby help facilitate reducing associated health problems.

SUMMARY

In response to the alarming increase in asthma and allergies among school children, the national health budget provides for additional efforts, including an outreach program focusing on asthma awareness and education and the promotion of healthier home and school environments. Efforts are also being directed toward developing a better understanding of the link between the indoor environment and asthma and allergens, particularly in schools, homes, and day care centers. Monitoring potential pollutant sources and reducing the levels of pollutants that increase asthma and allergic responses in children will help provide healthier indoor environments. The goal is to reduce or eliminate harmful indoor exposures to allergens and molds, thereby mitigating the frequency and severity of these health problems in school-age children.

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