



Spectrum of Noninfectious Health Effects From Molds

Committee on Environmental Health

Organizational Principles to Guide and Define the Child Health Care System and/or Improve the Health of All Children

ABSTRACT

Molds are eukaryotic (possessing a true nucleus) nonphotosynthetic organisms that flourish both indoors and outdoors. For humans, the link between mold exposure and asthma exacerbations, allergic rhinitis, infections, and toxicities from ingestion of mycotoxin-contaminated foods are well known. However, the cause-and-effect relationship between inhalational exposure to mold and other untoward health effects (eg, acute idiopathic pulmonary hemorrhage in infants and other illnesses and health complaints) requires additional investigation. Pediatricians play an important role in the education of families about mold, its adverse health effects, exposure prevention, and remediation procedures.

BACKGROUND

Outdoors, fungi break down organic matter such as fallen leaves and dead trees and are ecologically beneficial. The most common outdoor molds are *Cladosporium* species, *Aspergillus* species, *Penicillium* species, *Alternaria* species, *Candida* species, *Botrytis* species, and *Helminthosporium* species. The most prevalent indoor molds in nonproblem homes are *Cladosporium* species, *Penicillium* species, *Alternaria* species, *Streptomyces* species, *Epicoccum* species, and *Aspergillus* species.¹ Indoors, molds usually are not a problem unless the spores encounter persistently humid or wet areas, at which point colonies begin to grow. Household areas such as air conditioners, basements, bathrooms, crawl spaces, pillows, refrigerator seals, sinks, shower grout, windowsills, and other places where standing water occurs are potential problem areas. Leaks in roofs, water-damaged walls, potted plants, or even pet urine can contribute to mold growth. Carpeting, ceilings, paneled or hollow walls, and wicker or straw baskets are other potential reservoirs if moisture accumulates.

Exposures to mold vary, reflecting regional differences, local climate (humidity and wind), home construction, use of varying heating and cooling systems, humidifiers, dehumidifiers, and air-filtering devices. Outdoor factors such as shade, organic debris near the home, and landscape maintenance also influence indoor mold concentrations. Air filters and dust control can decrease airborne concentrations of molds in the indoor environment.

Molds have the potential to cause a variety of adverse health effects. They affect health by both immune- and non-immune-related mechanisms. Immunologically, molds produce allergens that may lead to immunoglobulin E-mediated responses such as allergic rhinitis/conjunctivitis and asthma. Less common responses include allergic bronchopulmonary aspergillosis, allergic fungal sinusitis, and hypersensitivity pneumonitis. Nonimmune effects include infection, irritation

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Key Words

mold exposure, health effects, allergies, hypersensitivity pneumonitis, mycotoxins, hemosiderosis, water damage, remediation, prevention

Abbreviations

ALPH—acute idiopathic pulmonary hemorrhage
IOM—Institute of Medicine
CDC—Centers for Disease Control and Prevention
EPA—Environmental Protection Agency
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of mucous membranes, and reactions from toxins (mycotoxins). When mycotoxin-producing molds contaminate food products, the ingested mycotoxins can adversely affect specific target organs including the central nervous system, the gastrointestinal tract, and the kidneys. Certain mycotoxins have also been associated with hepatocellular carcinoma in persons infected with hepatitis B virus. Serious health problems from mold ingestion are very rare and tend to occur mainly in the agricultural setting.

Inhaled mycotoxins have been linked with acute idiopathic pulmonary hemorrhage (AIPH) in infants. The first report suggesting a relationship between AIPH and the mold *Stachybotrys* species came from Cleveland, Ohio, in the 1990s.² The Institute of Medicine (IOM) conducted a comprehensive review of the literature on the adverse health effects of mold.³ The authors concluded that there was insufficient evidence to determine if mold exposure to *Stachybotrys* species was associated with AIPH in part because of problems with data collection and lack of available, standardized tools for exposure assessment. The IOM recommended further surveillance and additional research. Although the causal association between AIPH in infants has not been firmly established, the Cleveland study, additional case series, case reports from independent sources, and basic scientific studies in animal models have provided some evidence of plausibility. Epidemiologic studies suggest that exposure to secondhand cigarette smoke may be an additional risk factor. Ongoing work in toxicology and epidemiology will provide further insight into these issues in the future. The Centers for Disease Control and Prevention (CDC) is continuing surveillance for AIPH in metropolitan areas in states with the highest prevalence. Several systematic reviews are available,³⁻⁵ and the accompanying technical report⁶ (available online) describes mold-related clinical effects in more detail.

In addition to the adverse health effects associated with exposures to mold, there are health risks associated with living in damp indoor environments.⁷⁻¹¹ These risks include respiratory symptoms such as wheezing, coughing, and hay fever. The IOM study found sufficient evidence of an association between mold and other agents in damp indoor environments and upper and lower respiratory tract symptoms, as well as asthma symptoms in sensitized persons. However, there was insufficient information to determine if mold exposure was associated with the development of asthma. Similarly, no conclusions could be drawn for an association with neuropsychiatric symptoms, skin rashes, or rheumatologic illnesses.

PREVENTION/REMEDICATION

Mold spores are ubiquitous in the environment, and it is impossible to keep mold spores completely out of the house. The challenge is to keep the spores from coloniz-

ing and growing. Therefore, the key to mold control is moisture control. The aforementioned water-prone household areas should be kept as dry as possible. Actions that will help reduce indoor air humidity and prevent condensation include venting appliances that produce moisture (clothes dryers and stoves) to the outside and using a bathroom fan or opening a window when showering or bathing. When there is inadequate bathroom ventilation, using a towel to wipe shower walls and using a fan or space heater for a short period of time may diminish excessive moisture accumulation. Dehumidifiers can be used to reduce humidity to a target level of less than 50%. Bathrooms and basements should be left uncarpeted. Organic materials kept indoors, such as plants, wood, or paper products, can accumulate excess moisture and can serve as potential reservoirs of mold growth. Because outdoor molds are easily tracked inside, leaves should be discarded. Parents should be aware that playing on or near piles of leaves exposes their children to increased levels of mold spores. This increased exposure could contribute to increased symptoms among children with asthma/allergies. Condensation on pipes and ductwork within interior and exterior structure walls are other potential problem areas. Insulating cold water pipes and increasing the air temperature may help.

Remediation of water-damaged items from previous flooding or rainwater is needed to prevent mold amplification and its potential effects of upper respiratory irritation, allergic sensitization, and/or exacerbation of underlying mold allergy; remediation will also reduce the risk of structural damage to the building. Timely (within 24 hours) water cleanup and removal of water-damaged items after a flood are important.

Currently, there is insufficient information to reliably state what levels of mold exposure can result in adverse health effects and to specify what levels constitute a "dampness problem." Additional research is needed in this area to find a dose-response relationship that can help predict what the adverse health consequences of mold are. Environmental sampling may be useful to identify the source if there is a suspicion of mold (eg, musty odor) but no visible mold growth. It may also be necessary for diagnosis and treatment of mold-related illnesses, insurance purposes, or litigation. Consultation with pediatric experts in pulmonary medicine, allergy/immunology, environmental health, or physicians with expertise in occupational environmental health may be helpful in the interpretation of such environmental data.

If environmental sampling for mold is done, it should be performed by professionals, such as industrial hygienists or indoor environmental quality consultants, who have expertise in evaluating indoor mold/dampness problems. Although no formal certification process for mold evaluation exists, guidelines are available.¹²⁻¹⁴

Reliable air sampling can be expensive and requires

expertise and specialized equipment. If air sampling is conducted, an outdoor air sample should be collected at the same time for comparison. In general, the levels and types of molds should be similar indoors (in nonproblem buildings) and outdoors. Higher indoor concentrations of mold, a predominance of one type, or a difference in types of molds found indoors versus outdoors suggest an indoor mold problem.

Assays to detect mycotoxins and microbial volatile organic compounds in environmental samples and blood have been developed and can serve as important tools for researchers studying pathogenesis of disease. However, the tests, including immunoassays for mold, have not been standardized for clinical use, and it is not clear what levels are associated with health effects.¹⁵

The US Environmental Protection Agency (EPA) and the CDC offer practical guidelines for mold control and cleanup in the home setting (available at www.cdc.gov/health/mold.html or by calling 800-438-4318). According to current EPA guidelines, individuals can usually clean up mold-contaminated areas less than 10 ft.² If there has been extensive water damage, mold growth covers more than 10 ft.² the heating, ventilating, and air conditioning (HVAC) system is involved, or the water and/or mold damage was caused by sewage or flood water, consider hiring a professional and consulting the EPA guide "Mold Remediation in Schools and Commercial Buildings."¹⁶

Mold abatement can be difficult, and use of biocides, such as sodium hypochlorite (eg, household bleach), is controversial. Some experts believe that bleach merely decolorizes mold and that dead mold is still allergenic. However, recent evidence suggests that there is loss of skin-test reactivity to the treated mold in some sensitized individuals.¹⁷ The CDC recommends removal of mold growth from hard surfaces with commercial products, soap and water, or a bleach solution of 1 cup of bleach to 1 gallon of water.¹⁸ This approach is recommended for use on nonporous materials such as tile floors, countertops, metal objects, plastic, glass, and other hard nonabsorbent materials. Concrete and brick surfaces may also be cleaned this way. In general, mold may be difficult to remove from porous materials such as carpet, drywall, or wood products, and bleach (and other cleaning products) may affect the structural integrity of the material. With extensive water and mold damage, porous materials are best discarded. When deciding to use bleach for mold remediation, its accessibility and affordability must also be taken into account. If bleach is used, it should not be combined with ammonia or other household cleaning products, and the area should be well ventilated during use. Guidelines are also available from the CDC (1600 Clifton Rd, Atlanta, GA 30333 or online at the aforementioned Web address). More detailed information on mold cleanup after flooding is also available.¹⁹

HUMIDIFIERS

Many parents use cool mist humidifiers or vaporizers when children have colds or when the air is dry in winter. These devices, if not properly cleaned, can serve as reservoirs for mold growth. In addition, increased humidity can contribute to increased dust mite populations and mold in the indoor environment. A systematic review in the *Cochrane Database of Systematic Reviews* assessed the effects of inhaling heated water vapor in the treatment of the common cold by comparing symptoms, viral shedding, and nasal resistance after a naturally or experimentally induced common cold.²⁰ Three of the 6 identified trials showed slight benefit on the symptoms of the common cold; however, neither viral shedding nor viral titers decreased. Therefore, the benefit in symptoms must be balanced with the risk of increased growth and exposure to house dust mites and mold with increased humidity. If used, they should be used for a limited period of time, and they must be cleaned frequently to prevent mold growth and according to the manufacturers' instructions.

AIR CLEANERS

People with allergies and asthma may use air cleaners to decrease concentrations of mold spores in the air. Different air-filtration systems are available that remove particles (including mold spores) from the air, including electrostatic filters/precipitators, and high-efficiency particulate air (HEPA) filters.²¹ Certain air cleaners, often called "air purifiers," emit large amounts of ozone and should be avoided. These ozone generators, often advertised as purifiers that cleanse the air of microbes, can produce high concentrations of ozone in an indoor environment, and the EPA and other regulatory agencies have cautioned against their use.^{22,23} Filters on central forced-air systems and furnaces should be changed periodically according to the manufacturers' recommendations. Upgrading to a medium-efficiency filter (rated at 20%–50% efficiency at removing particles between 0.3 and 10 μm) will improve air quality and is economical. Electrostatic filters/precipitators in central furnace and air conditioning systems may be beneficial for airborne particles but are only effective when turned on. Room HEPA filters are also beneficial. However, they only work in a single room, and the noise generated may not be acceptable.

RECOMMENDATIONS TO PEDIATRICIANS

1. Because there are established health hazards, inquire about the presence of mold as part of a "healthy-home" inventory. Questions about a child's environment are basic to a comprehensive pediatric health history.²⁴ Questions can be incorporated during visits for health supervision or sick visits. Asking about a child's environment should be routine for children

- with common illnesses, such as allergic rhinitis/conjunctivitis and asthma, as well as for those with less common illnesses, such as hypersensitivity pneumonitis.
2. Provide guidance to parents of all children about:
 - a. the adverse health effects of mold exposure, especially the causal relationship between mold and allergic illness and respiratory symptoms; and
 - b. preventing and reducing mold exposure in the immediate indoor and outdoor environments.
 3. Educate families on mold remediation. Visible signs of mold growth (eg, discolored patches or cottony or speckled growth on walls or furniture, evidence of dampness or water damage or an earthy musty odor in a particular area) suggest a damp environment and mold growth. In areas where flooding has occurred, prompt cleaning (within 24 hours) of walls and other flood-damaged items is necessary to prevent mold growth. Testing the environment for specific molds is usually not necessary. In general, individuals can perform mold cleanup for areas less than 10 ft.²
 4. When treating an infant with AIPH, inquire about mold and water damage in the home. Report cases of AIPH to state health departments. Although a causal relationship between AIPH and damp, moldy indoor environments has not been firmly established, the knowledge is incomplete at this time. Therefore, it is prudent to recommend that parents of infants with AIPH try to find and eliminate sources of chronic moisture and mold growth before the child returns to the home. Avoidance of exposure to secondhand cigarette smoke is always recommended, but especially in cases of AIPH.
 5. Be aware that there are no uniformly accepted, valid, quantitative environmental sampling methods or serologic tests to assess exposures to mold and other agents associated with damp indoor environments. There are also no accepted valid airborne levels of mold that predict adverse health effects.
 6. Be aware that there is currently no method to test humans for toxigenic mold exposure.²⁵
 7. Be aware that mold-contaminated foods (especially grains) can contain harmful amounts of mycotoxins. The US Department of Agriculture has set allowable limits in certain food items and has some routine monitoring in place to prevent harmful ingestion of mycotoxin-contaminated foods. Inquire about dietary history if a mycotoxin-induced illness is suspected.
 - a. ongoing surveillance of the prevalence of AIPH in infants; and
 - b. longitudinal studies on the effects of indoor mold exposure in early childhood on the development of asthma and other respiratory illnesses.
 2. Support research to improve methods for quantitative assessment of exposures to indoor molds for use in further epidemiologic studies. Promote research in investigating links between exposures to indoor molds and adverse health effects.
 3. Support research to determine fungal biological markers in diagnostic tests.
 4. Recommend that remediation of water damage in homes and other buildings be performed promptly. Educate landlords and individuals responsible for building maintenance that damp buildings are unhealthy. They should not wait for medical complaints before starting remediation.
 5. Routinely test and publish toxin limits in food and beverages.
 6. The CDC, EPA, and building-management-related government agencies should continue to develop and promote education and training programs to improve efforts to avoid or reduce dampness and dampness-related health risks. Targeted programs should be developed for the general public, health professionals, and people involved in design, construction, management, and building maintenance.
 7. Outdoor air mold and pollen concentrations should be monitored more extensively and added to the Air Quality Index (<http://airnow.gov>). The government should encourage and support programs such as the National Allergy Bureau, which monitors and reports outdoor mold and pollen counts (www.aaaai.org/nab).
 8. Promote lay public education programs that properly inform US citizens about what the proven and, more importantly, unproven health effects of mold exposure are.

COMMITTEE ON ENVIRONMENTAL HEALTH, 2005–2006

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 *Janice J. Kim, MD, PhD, MPH
 *Lynnette J. Mazur, MD, MPH
 James R. Roberts, MD, MPH

LIAISONS

- Elizabeth Blackburn, RN
 US Environmental Protection Agency

RECOMMENDATIONS TO GOVERNMENT

1. Support research to determine the effects of molds on human health, such as:

Mark Anderson, MD
Centers for Disease Control and Prevention/National
Center for Environmental Health
Martha Linet, MD
National Cancer Institute
Walter Rogan, MD
National Institute of Environmental Health Sciences

STAFF

Paul Spire

*Lead authors

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