

## ACOEM EVIDENCE-BASED STATEMENT

# Adverse Human Health Effects Associated with Molds in the Indoor Environment

In recent years, the growth of molds in home, school, and office environments has been cited as the cause of a wide variety of human ailments and disabilities. So-called “toxic mold” has become a prominent topic in the lay press and is increasingly the basis for litigation when individuals, families, or building occupants believe they have been harmed by exposure to indoor molds. This evidence-based statement from the American College of Occupational and Environmental Medicine (ACOEM) discusses the state of scientific knowledge as to the nature of fungal-related illnesses while emphasizing the possible relationships to indoor environments. Particular attention is given to the possible health effects of mycotoxins, which give rise to much of the concern and controversy surrounding indoor molds. Food-borne exposures, methods of exposure assessment, and mold remediation procedures are beyond the scope of this statement.

Fungi are eukaryotic unicellular or multicellular organisms that, because they lack chlorophyll, are dependent upon external food sources. Fungi are ubiquitous in all environments and play a vital role in the Earth's ecology by decomposing organic matter. Familiar fungi include yeasts, rusts, smuts, mushrooms, puffballs, and bracket fungi. Many species of fungi live as commensal organisms in or on the surface of the human body. “Mold” is the common term for multicellular fungi that grow as a mat of intertwined microscopic filaments (hyphae). Exposure to molds and other fungi and their spores is unavoidable except when the most stringent of air filtration, isolation,

and environmental sanitation measures are observed, for example, in organ transplant isolation units.

Molds and other fungi may adversely affect human health through three processes: 1) allergy; 2) infection; and 3) toxicity. One can estimate that about 10% of the population has allergic antibodies to fungal antigens. Only half of these, or 5%, would be expected to show clinical illness. Furthermore, outdoor molds are generally more abundant and important in airway allergic disease than indoor molds, leaving the latter with an important but minor overall role in allergic airway disease. Allergic responses are most commonly experienced as allergic asthma or allergic rhinitis (“hay fever”). A rare, but much more serious immune-related condition, hypersensitivity pneumonitis (HP), may follow exposure (usually occupational) to very high concentrations of fungal (and other microbial) proteins.

Most fungi generally are not pathogenic to healthy humans. A number of fungi commonly cause superficial infections involving the feet (*tinea pedis*), groin (*tinea cruris*), dry body skin (*tinea corporis*), or nails (*tinea onychomycosis*). A very limited number of pathogenic fungi, such as *Blastomyces*, *Coccidioides*, *Cryptococcus*, and *Histoplasma*, infect nonimmunocompromised individuals. In contrast, persons with severely impaired immune function, for example, cancer patients receiving chemotherapy, organ transplant patients receiving immunosuppressive drugs, AIDS patients, and patients with uncontrolled diabetes, are at significant risk for more severe opportunistic fungal infection.

Some species of fungi, including some molds, are known to be capable of producing secondary metabolites, or mycotoxins, some of which find a valuable clinical use, for example, penicillin and cyclosporine. Serious veterinary and human mycotoxicoses have been documented after ingestion of foods heavily overgrown with molds. In agricultural settings, inhalation exposure to high concentrations of mixed organic dusts, which include bacteria, fungi, endotoxins, glucans, and mycotoxins, is associated with organic dust toxic syndrome, an acute febrile illness. The present alarm over human exposure to molds in the indoor environment derives from a belief that inhalation exposures to mycotoxins cause numerous and varied, but generally nonspecific, symptoms. Current scientific evidence does not support the proposition that human health has been adversely affected by inhaled mycotoxins in the home, school, or office environment.

## Allergy and Other Hypersensitivity Reactions

Allergic responses to indoor molds may be immunoglobulin E (IgE) or immunoglobulin G (IgG) mediated, and both types of response are associated with exposure to indoor molds. Uncommon allergic syndromes, allergic bronchopulmonary aspergillosis (ABPA) and allergic fungal sinusitis (AFS), are briefly discussed for completeness, although indoor mold has not been suggested as a particular risk factor in the etiology of either.

siderations suggest that delivery by the inhalation route of a toxic dose of mycotoxins in the indoor environment is highly unlikely at best, even for the hypothetically most vulnerable subpopulations.

Mold spores are present in all indoor environments and cannot be eliminated from them. Normal building materials and furnishings provide ample nutrition for many species of molds, but they can grow and amplify indoors only when there is an adequate supply of moisture. Where mold grows indoors there is an inappropriate source of water that must be corrected before remediation of the mold colonization can succeed. Mold growth in the home, school, or office environment should not be tolerated because mold physically destroys the building materials on which it grows, mold growth is unsightly and may produce offensive odors, and mold is likely to sensitize and produce allergic responses in allergic individuals. Except for persons with severely impaired immune systems, indoor mold is not a source of fungal infections. Current scientific evidence does not support the proposition that human health has been adversely affected by inhaled mycotoxins in home, school, or office environments.

## Acknowledgment

This ACOEM statement was prepared by Bryan D. Hardin, PhD, Bruce J. Kelman, PhD, DABT, and Andrew Saxon, MD, under the auspices of the ACOEM Council on Scientific Affairs. It was peer-reviewed by the council and its committees, and was approved by the ACOEM Board of Directors on October 27, 2002.

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### Allergy and other hypersensitivity reactions

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1. **Immediate hypersensitivity:** The most common form of hypersensitivity to molds is immediate type hypersensitivity or IgE-mediated "allergy" to fungal proteins. This reactivity can lead to allergic asthma or allergic rhinitis that is triggered by breathing in mold spores or hyphal fragments. Residential or office fungal exposures may be a substantial factor in an individual's allergic airway disease depending on the subject's profile of allergic sensitivity and the levels of indoor exposures. Individuals with this type of mold allergy are "atopic" individuals, ie, have allergic asthma, allergic rhinitis, or atopic dermatitis and manifest allergic (IgE) antibodies to a wide range of environmental proteins among which molds are only one participant. These individuals generally will have allergic reactivity against other important indoor and outdoor allergens such as animal dander, dust mites, and weed, tree, and grass pollens. Among the fungi, the most important indoor allergenic molds are *Penicillium* and *Aspergillus* species.<sup>1</sup> Outdoor molds, eg, *Cladosporium* and *Alternaria*, as well as pollens, can often be found at high levels indoors if there is access for outdoor air (eg, open windows). About 40% of the population are atopic and express high levels of allergic antibodies to inhalant allergens. Of these, 25%, or 10% of the population, have allergic antibodies to common inhalant molds.<sup>2</sup> Since about half of persons with allergic antibodies will

establish exposure to *S. chartarum* in home, school, or office environments as a cause of adverse human health effects. Levels of exposure in the indoor environment, dose-response data in animals, and dose-rate considerations suggest that delivery by the inhalation route of a toxic dose of mycotoxins in the indoor environment is highly unlikely at best, even for the hypothetically most vulnerable subpopulations.

Mold spores are present in all indoor environments and cannot be eliminated from them. Normal building materials and furnishings provide ample nutrition for many species of molds, but they can grow and amplify indoors only when there is an adequate supply of moisture. Where mold grows indoors there is an inappropriate source of water that must be corrected before remediation of the mold colonization can succeed. Mold growth in the home, school, or office environment should not be tolerated because mold physically destroys the building materials on which it grows, mold growth is unsightly and may produce offensive odors, and mold is likely to sensitize and produce allergic responses in allergic individuals. Except for persons with severely impaired immune systems, indoor mold is not a source of fungal infections. Current scientific evidence does not support the proposition that human health has been adversely affected by inhaled mycotoxins in home, school, or office environments.

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† 5th percentile body weight for 1-month-old male infants, 3.16 kg; respiratory rate for infants under 1 year of age, 4.5 m<sup>3</sup>/day<sup>78</sup>

† †50th percentile body weight for 6-year-old boys, 22 kg; respiratory rate for children age 6-9, 10.0 m<sup>3</sup>/day<sup>78</sup>

† † 50th percentile body weight for men aged 25-34 years, 77.5 kg; respiratory rate for men age 19-65, 15.2 m<sup>3</sup>/day<sup>78</sup>

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indoors; air samples may also assist in evaluating the extent of potential indoor exposure. Bulk, wipe, and wall cavity samples may indicate the presence of mold, but do not contribute to characterization of exposures for building occupants.

- When patients associate health complaints with mold exposure, treating physicians should evaluate all possible diagnoses, including those unrelated to mold exposure, i.e., consider a complete appropriate differential diagnosis for the patient's complaints. To the extent that signs and symptoms are consistent with immune-mediated disease, immune mechanisms should be investigated.
- If a diagnosis of mycotoxicosis is entertained, specific signs and symptoms ascribed to mycotoxins should be consistent with the potential mycotoxins present and their known biological effects at the potential exposure levels involved.

### Summary

Molds are common and important allergens. About 5% of individuals are predicted to have some allergic airway symptoms from molds over their lifetime. However, it should be remembered that molds are not dominant allergens and that the outdoor molds, rather than indoor ones, are the most important. For almost all allergic individuals, the reactions will be limited to rhinitis or asthma; sinusitis may occur secondarily due to obstruction. Rarely do sensitized individuals develop uncommon conditions such as ABPA or AFS. To reduce the risk of developing or exacerbating allergies, mold should not be allowed to grow unchecked indoors.

Fungi are rarely significant pathogens for humans. Superficial fungal infections of the skin and nails are relatively common in normal individuals, but those infections are readily treated and generally resolve without complication. Fungal infections of deeper tissues are rare and in general are limited to persons with severely impaired immune systems. The leading pathogenic fungi for persons with non-impaired immune function, *Blastomyces*, *Coccidioides*, *Cryptococcus*, and *Histoplasma*, may find their way indoors with outdoor air, but normally do not grow or propagate indoors. Due to the ubiquity of fungi in the environment, it is not possible to prevent immune-compromised individuals from being exposed to molds and fungi outside the confines of hospital isolation units.

Some molds that propagate indoors may, under certain conditions, produce mycotoxins that can adversely affect living cells and organisms by a variety of mechanisms, for example, the ingestion of contaminated foods. Occupational diseases are also recognized in association with inhalation exposure to fungi, bacteria, and other organic matter, usually in industrial or agricultural settings. One mold, *Stachybotrys chartarum*, is known to be able to produce mycotoxins under appropriate growth conditions. However, years of intensive study have failed to establish exposure to *S. chartarum* in home, school, or office environments as a cause of adverse human health effects. Levels of exposure in the indoor environment, dose-response data in animals, and dose-rate considerations suggest that delivery by the inhalation route of a toxic dose of mycotoxins in the indoor environment is highly unlikely, even for the most vulnerable subpopulations.

Mold spores are present in all indoor environments and cannot be eliminated from them. Normal building materials and furnishings provide ample nutrition for many species of molds, but they can grow and amplify indoors only when there is an adequate supply of moisture. Where mold grows indoors there is an inappropriate source of water that must be corrected before remediation of the mold colonization can succeed. Mold growth in the home, school, or office environment should not be tolerated because mold physically destroys the building materials on which it grows, mold growth is unsightly and may produce offensive odors, and mold is likely to sensitize and produce allergic responses in allergic individuals. Except for persons with severely impaired immune systems, indoor mold is not a source of fungal infections. Current scientific evidence does not support the existence of a causal relationship between inhaled mycotoxins in home, school, or office environments and adverse human health effects.

### Acknowledgments

This revised ACOEM position statement was prepared under the auspices of the Council of Scientific Advisors and approved by the ACOEM Board of Directors on February 14, 2011. This revised statement updates the previous (2002) position statement which was prepared by Bryan D. Hardin, PhD; Bruce J. Kelman, PhD, DABT; and Andrew Saxon, MD; under the auspices of the ACOEM Council on Scientific Affairs.

<sup>a</sup> 5th percentile body weight for 1-month-old male infants, 3.16 kg; respiratory rate for infants under 1 year of age, 4.5 m<sup>3</sup>/day.<sup>73</sup>

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