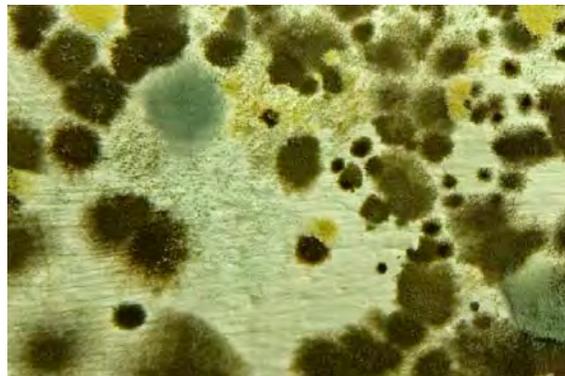




Health Effects from Mould Exposure in Indoor Environments

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Summary

- Moulds are naturally occurring and widespread in the environment; therefore, it is not possible to eliminate exposure.
- Sufficient evidence exists to conclude that exposure to mould in indoor environments is associated with asthma and asthma-like symptoms (in asthmatic people), upper respiratory tract symptoms, cough and wheeze, and hypersensitivity pneumonitis in susceptible people.
- There is insufficient evidence to conclude that a causal relationship exists between mould exposure in indoor environments and human health effects (although associational relationships exist for some health effects as indicated above).
- It is not possible to set guidelines based on levels of exposure at which effects will or will not occur, as a reliable quantitative relationship between mould exposure and health has not been established.

Introduction

This document provides public health inspectors and environmental health officers with a summary of the current knowledge about mould and human health effects. It summarizes the conclusions of the benchmark review of dampness/mould and health effects called “Damp Indoor Spaces and Health” by the Institute of Medicine (IOM), and provides an update from subsequent reviews.

The information in this document is based on a report of a more comprehensive review commissioned by the National Collaborating Centre for Environmental Health (NCCEH) (available upon request). Strategies for mould assessment and remediation are important to public and environmental health professionals and will be covered in separate documents by the NCCEH, to be released shortly.

What is mould?

Mould is the common term for the microscopic multi-cellular spore-bearing organisms that grow as a mat of intertwined filaments or hyphae.¹ Moulds are eukaryotic (with a nucleus) and exist in a separate phylogenetic kingdom from plants and animals.

evidence
review

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Mould is naturally occurring and ubiquitous, located both indoors and out, so exposure to it is unavoidable; humans are routinely exposed to 200 types of moulds.² Some moulds produce mycotoxins (e.g., *Stachybotrys chartarum*, *Aspergillus* species, *Fusarium* species, etc.). However, all moulds can potentially affect health. For healthy individuals, most case reports of adverse health reactions from mould (e.g., mucus membrane irritation syndrome, organic dust toxic syndrome, interstitial lung disease, and inhalation fevers) have been associated with mould exposures in agricultural or industrial environments but not in residential environments.^{2,3}

Indoor environments contain the components necessary for mould growth, including: oxygen, carbon-based nutrient sources, and an acceptable temperature range. The only additional requirement for mould growth is moisture, which usually makes the difference between the growth of mould on surfaces, and the absence of growth. Indoor dampness is the presence of excess moisture or even liquid water, and can result from various sources including: normal human activity (such as exhalation and then condensation), improper or inadequate ventilation, flooding, slow plumbing leaks, high humidity due to having excessive numbers of indoor plants or through illegal indoor agriculture (like marijuana grow ops), pet urine, and structural damage and leaks to roofs, walls or windows.⁴ Any dampness, including condensation, can result in mould growth.

There is a correlation between the length of time dampness exists in an indoor environment and increased damage and deterioration of building components and an increased opportunity for mould growth.^{2,5}

Damp environments encourage the presence or growth of other agents influencing indoor air quality and health including: bacteria, cockroaches, dust mites, combustion gases (NO₂, CO, associated with poor ventilation and other indoor air pollutants that may accumulate when ventilation is restricted or low.^{2,6,7} Other agents such as organic and inorganic dusts, pet allergens, environmental tobacco smoke, household chemicals, and pesticides, can also influence indoor air quality. There is evidence that many of the agents present in damp indoor

environments may contribute to human illness, and many of the health effects attributed to the presence of mould have also been attributed to agents other than mould.

Health effects ascribed to indoor mould exposure

The most significant mechanism of exposure to indoor mould is inhalation, but mould exposure can also occur through ingestion and by skin coming into contact with mouldy surfaces.⁸

It is difficult to determine conclusively the exact mechanism by which mould in the indoor environment causes health effects, and it is likely that some health effects result from one or more of the following mechanisms:²

- **Systemic infections** (e.g., certain lung infections) are usually only significant in people with severely compromised immune systems;
- **Allergic or hypersensitivity reactions** result when people develop allergic sensitivity to mould;
- **Irritant/toxic reactions** can contribute to respiratory, immune, and neurologic effects.

Also influencing a person's response to mould is personal susceptibility: age, health status, immune status, concurrent exposures, previous sensitizations, socioeconomic status, and even genetic factors.^{4,10,11,12}

Mould components (i.e., spores, beta-1,3)-glucans) and metabolic by-products (i.e., mycotoxins, volatile organic compounds) can influence human health. While a broad range of allergic and non-allergic health effects have been attributed to exposure to these mould components, evidence does not always support the associations.

Since IOM's publication on health effects and mould and damp agents in indoor spaces, additional reviews have, for the most part, confirmed the conclusions of the IOM. There are more recent reviews that have cited limited evidence for an association between mould and asthma development. The following list is

based on the IOM and subsequent evidence for associations between mould exposure in indoor environments and health (Table 1):

- **Causal relationship**
 - None
- **Sufficient evidence for association**
 - Asthma symptoms (in asthmatic people)
 - Upper respiratory tract symptoms (i.e., sore throat, conjunctivitis, allergic rhinitis, and nasal symptoms (nasal congestion or runny nose)^{2,8})
 - Cough, wheeze
 - Hypersensitivity pneumonitis in susceptible people
- **Limited or suggestive evidence for association**
 - Lower respiratory tract symptoms in otherwise healthy children
- **Inadequate or insufficient evidence for association**
 - Asthma development, although more evidence is accumulating^{2,11}
 - Dyspnea (shortness of breath)
 - Skin symptoms
 - Airflow obstruction (in otherwise healthy persons)
 - Mucous membrane irritation syndrome
 - Gastrointestinal tract problems
 - Chronic obstructive pulmonary disease
 - Fatigue
 - Inhalation fevers (non-occupational exposures)
 - Neuropsychiatric symptoms
 - Lower respiratory illness in otherwise healthy adults
 - Cancer
 - Rheumatologic and other immune diseases
 - Reproductive effects

- Acute idiopathic pulmonary haemorrhage in infants.

Limitations

- Although there is clear evidence that dampness contributes to illness, the exact agent has not been determined. For example, as previously explained, mould has been associated with asthma symptoms, but there is insufficient evidence that indicates mould exposure triggers the occurrence of asthma sensitivity.
- There are no quantitative exposure relationships between mould and health effects.
- Despite decades of study and an enormous amount of research, there are many significant gaps in the evidence and numerous important limits regarding information in this field, such as, limitations in defining what constitutes a “dampness” problem;^{2,14} limitations in exposure assessment methods; lack of knowledge about types of mould possibly associated with health outcomes; contribution of other factors in damp indoor environments; and limitations regarding the nature of human exposure. As well, the fact that the reporting of health effects is not standardized is problematic.

Most publications emphasize a need for continued research in the area of mould and human health effects to obtain more comprehensive information/evidence.



Table 1. Conclusions from consensus and systematic review documents about health effects from mould exposure in indoor environments adapted from the IOM ratings for categories of evidence (2)

Study	Methodology	Agent of Interest	Conclusion					
			Asthma symptoms	Asthma development	Allergy/hypersensitivity	Upper respiratory symptoms	Lower respiratory symptoms	General/toxic health effects
IOM ² (2004)	Scientific review of literature through late 2003	Indoor mould	+	0		+	(-)	0
Storey et al., ³ (2004)	Guidance for physicians	Indoor mould						0
Curtis ¹³ (2004)	Qualitative systematic literature review for health professionals	Indoor mould and mycotoxins						*
Douwes ¹⁹ (2005)	Literature review of observational and experimental studies	Beta 1-3 glucan, mould structural components			0	0		0
Richardson et al. ^{18*} (2005)	Literature review to examine all factors in the indoor environment and asthma	Dust mite allergen	+					
		Other agents including mould	0					
AAAAI, Bush et al. ¹⁷ (2006)	Position statement based on a review of scientific evidence	Indoor mould	0	0	+	0		0
Committee on Environmental Health ^{14*} (2006)	Position paper reviewed literature for pediatricians and government. Supported by accompanying report ⁹	Indoor mould	+		+			+
Mazur et al. ⁸ (2006)	Literature review focusing on children's health	Indoor dampness and mould	+		+			+
Fisk et al. ^{16*} (2007)	Meta-analysis of 33 papers included in the IOM review	Indoor dampness and mould	+	(-)		+		
Mudarri and Fisk ²⁰ (2007)	Literature review – public health risk and economic impact	Indoor dampness and mould	+	(-)		+		
Health Canada ²¹ (2007)	Guideline founded on earlier Health Canada reviews (1995, 2004 ⁵), updated	Indoor mould	+					
Seltzer and Fedoruk ^{15*} (2007)	Literature review of over 150 papers focusing on children's health and mould	Indoor mould	+	0	0	+	(-)	0
Hope and Simon ²² (2007)	Literature review of epidemiological and biological studies	Indoor dampness and mould				+		
Dales et al. ²³ (2008)	Qualitative literature review of 71 studies – includes other factors such as tobacco smoke and radon	Indoor air (many factors examined)				+		

Table 1 (cont'd)

Study	Methodology	Agent of Interest	Conclusion					
			Asthma symptoms	Asthma development	Allergy/hypersensitivity	Upper respiratory symptoms	Lower respiratory symptoms	General/toxic health effects
Sahakian et al. ^{11*} (2008)	Literature review examined epidemiologic evidence	Indoor dampness and mould	+	+		+	+	
NYC ¹⁰ (2008)	Guideline for inspection and remediation, with literature review about health effects	Indoor damp environments	+		+	+		0
Portnoy et al. ⁹ (2008)	Literature review	Indoor mould	+	0	+			
Pestka et al. ²⁴ (2008)	Literature review	<i>Stachybotrys chartarum</i>	0	0				
Bush ¹² (2008)	Qualitative literature review	Indoor allergens including mould	+		0			

*Asterisked references regarded the Institute of Medicine³ reference as a benchmark.

Legend

++	Sufficient Evidence of a Causal Relationship Evidence is sufficient to conclude that a causal relationship exists between the agent and the outcome. The evidence fulfills the criteria for “sufficient evidence of an association” and also satisfies the following criteria: strength of association, biologic gradient, consistency of association, biologic plausibility and coherence, and temporally correct association.
+	Sufficient Evidence of an Association An association between the agent and the outcome has been observed in studies in which chance, bias, and confounding can be ruled out with reasonable confidence.
(-)	Limited or Suggestive Evidence of an Association Evidence is suggestive of an association between the agent and the outcome but is limited because chance, bias, and confounding cannot be ruled out with confidence.
(0)	Inadequate or Insufficient Evidence to Determine Whether an Association Exists The available studies are of insufficient quality, consistency, or statistical power to permit a conclusion regarding the presence of an association. Alternatively, no studies exist that examine the relationship.
	Association not examined in this publication (blank)

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