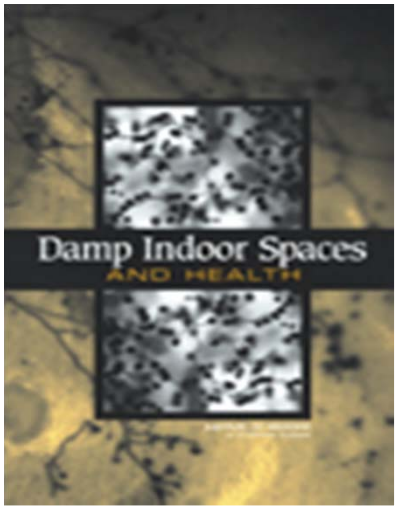
Infectious Disease Epidemiology Section
Office of Public Health
Louisiana Dept. of Health & Hospitals
800-256-2748 (24 hr. number)
www.infectiousdisease.dhh.louisiana.gov
...Your Taxes at Work...

Mold

Reference:
2004 Institute of Medicine
Damp Indoor Spaces & Health
Committee on Damp Indoor Spaces and Health
370 pages



Spores & Fragments of Fungi

- Fungal spores: 2 – 10 μ
  - Penicillium & Aspergillus produce lots of spores, disseminate easily
  - Stachybotrys &Chaeromium produce fewer spores, usually wet and disseminate much less
  - 10μ spore falls in 5mn, 5μ spore falls in 20mn
  - Resuspension by walking, cleaning ↑ conc by 1.5 to 10
- Mycelium fragments < 1 μ
  - Role unknown in causing health effects
  - Penetrate up to alveoli
- In comparison bacterial spores are ~1 μ

Species

- >100,000 known species
- >1,000 species common in USA
- ~ 20 species common in homes

Acremonium	Alternaria	Aspergillus	Botritys	Chaetomium	Cladospori
Doratomyces	Eurotium	Fusarium	Geomyces	Gliocladium	Humicola
Mucor	Oidiodendron	Paecilomyces	Penicillium	Phialophora	Rhizopus
Rhodotorula	Scopulariopsis	Stachybotrys	Torula	Trichoderma	Tritirachium
Ulocladium	Verticillium	Wallemia			

Diagnosing Environmental Mold

Look and sniff

If it didn't get wet, doesn't look moldy, doesn't smell moldy,
then it is unlikely to be meaningfully contaminated.

Exposure pathway

Inhalation primary exposure pathway

Spores, hyphae, conidia or byproducts

Mold or byproducts must be airborne and respirable

Microbial VOCs are volatile

Other mold constituents/byproducts

Factors affecting respirability

Particles larger than 5 microns not respirable

5 microns to 0.005 micron respirable

Mold Allergens, Irritants, Toxins & More: Health Effects

Fungal armory

Allergens
Irritants
Mycotoxins

Allergens

Interaction of IgE antibodies with specific antigens (pollens, dusts, molds)
Followed by histamine release and inflammation
Major Allergens:

Aspergillus fumigatus	Asp f1, Asp f2
Malassezia furfur	Mal f1
Trichophyton tonsurans	Tri t1
Penicilium chrysogenum	
Penicillium citrinum	

Irritants

Microbial volatile organic compounds (mVOCs)
- lightweight, typically with noxious odors
- Odorons: smell of mold (alcohols, aldehydes, ketones, lactones, hydrocarbons, terpenes, sulfur, nitrogen
- inked to irritation, headaches, fatigue, nausea

Fungal cell walls fragments: acetyl-glucosamine polymer
- fibrils $\beta 1 \rightarrow 3$ glycans, pieces of cell walls
- Gram-negative-endotoxin-like effects,
- organic toxic dust syndrome

Mycotoxins

Mycotoxins often shown to occur
- In spores or hyphal fragments
- On mold-infected materials
- On house dust from damp, moldy buildings
- Seldom directly in the air

Few are volatile, most semi-volatile, Only partially water soluble
Species specific dissemination:
- Asp. & Pen: 1-2μ, easily dispersed
- Stachybotrys: 5-7 μ, wet and slimy during sporulation

Large dose: horse eating from hay full of mold and mycotoxin
???: Inhalation from indoor air

Immuno-Active Mycotoxins

Aflatoxin	Aspergillus fiavus, parasiticus
Ochratoxin	Asp. ochraceus, Pen verricosum,
Sterigmatoxin	Asp. versicolor, nidulans
Gliotoxin	Asp. fumigatus
Cyclopiazoic acid	Asp. spp, Pen. spp
Citrinin	Pen. spp
Patulin	Asp. spp, Pen. spp
Trichotecenes	Stachybotrys chartarum
	Trichoderma viride
Cyclosporin A	Stachybotrys chartarum
	Streptomyces sutubaensis
Zearalenone	Fusarium spp
Rapamycin	Streptomyces hygroscopicus

Nephrotoxicity

Dermal toxicity

Trichothecenes
Skin reddening, edematous damage to skin
One example of worker exposed to Stachy trichothecene: painful skin lesions

Neurotoxic Mycotoxins

Penitrem A	Pen cyclopium, verruculosum
Penitrem E	Pen. crustosum,
Aflatrem	Asp. flavus
Roquefortine	Asp. commune, palitans, crustosum
Verrucologen	Pen. verrucolosum
Verrucosidin	Pen. verrucolosum
Patulin	Asp. spp, Pen. spp
Fumitrem B	Asp. fumigatus
Cyclopiazonic acid	Pen. cyclopium, Asp. flavus
Territrem	Asp. terreus
Citreoviridin	Pen. citroviride Asp. terreus
Ochratoxin A	Asp. ochraceous, Pen. verrucosum
Gliotoxin	Asp. fumigatus
Trichothecenes	Stachybotrys chartarum

NeuroToxicity

Neurotoxic effects:
Fatigue
Headache
Memory loss
Depression
Mood swings
Sensory irritation: Irritative stimulus to nerve ending
VOC from fungus or building materials
(new bldg = 25 mg/m^3)
Categories:
A-Tremor generating
B-Paralyzing
C-Neuro transmitter interference
Animal consumption: Rye grass staggers

Carcinogenicity

Aflatoxin	Asp.flavus, parasiticus, Pen.puberulum	Liver, lung
Sterigmatocystin	Asp. versicolor, flavus, Pen. luteum,	Liver rats/mice
Ochratoxin	Asp. ochraceus, alutaceus, Pen. Verrucosum, viridicatum, cyclopium,	Kidney, bladder
Zearalenone	Fusarium graminearum	
Penicillin Acid	Asp. Ochraceus	Liver
Luteoskyrin	Pen. Islandicum	Liver

Health Effects Associated with Molds

Primary complaints are respiratory
Immunocompromised: Infection
Allergic individuals: Hay-fever-like symptoms: runny nose and eyes
Asthma: Exacerbation of symptoms in people with asthma
Others: Respiratory tract irritation

Sensitive groups
People with allergies
People with chronic respiratory illness
Immune compromised individuals
Hospital settings: 10% of nosocomial infections

Infections

Immuno-compromised: High dose chemotherapy, transplant patients; Aspergillus, Fusarium
Source: Indoor fungi, not specially those which flourish in damp environments
Cystic fibrosis, asthma, COPD: Colonization then infection; Aspergillus
Normal children: Several studies showed association between bronchitis, LRTI and moldy indoor environment
Brunekreef, 1989; Six US cities; OR 1.17<1.48<1.87
Dales & Miller, 1999; Ontario; OR 7.76<1.51<3.02

Allergies

General allergy symptoms, signs: puffy eyes, runny nose, hives, eczema; elevated total serum IgE
Assessment of specific sensitivities: scratch tests (archaic?); elevated serum IgE for particular allergens

Asthma

Reversible airway obstruction determined by:
symptoms of cough, wheezing & chest tightness
reduction in peak expiratory flow
response to inhaled bronchodilators
bronchoconstriction following methacholine challenge
Allergic asthma IgE mediated
Intrinsic non-allergic variant: No detectable sensitization, Low IgE concentration,Irritant response
Asthma exacerbation
Self report of physician diagnosed asthma and self report of asthma when exposed to damp /moldy indoors
21 studies: OR 0.8 to 5, Most OR 1 to 3, 7 Sig
Examples: asthma exacerbation and mold indoor
Zock, 2002: 19,000 subjects; OR 0.94<1.13<1.35, Kilpeläinen, 2001: 10,667 subjects; OR 1.48< 2.21< 3.28
Asthma development: Difficulty in ascertainment of new onset asthma, Difficulty in children <3yrs because of bronchial reactivity
8 studies: OR 0.4 to 4, Most 1.5 to 3, Sig 7
Association with indoor damp environment and development of asthma. Not clear which of exposure to fungi, bacteria, constituents or emissions, dust mites, roaches is responsible
Not sufficient evidence to establish association between asthma development and indoor fungus

Hypersensitivity Pneumonitis :Asthma-like immune-mediated lung disease

Characterized by cough, chest tightness & wheezing; Fever, myalgias & fatigue
Restrictive pattern on pulmonary function tests
Inflammation in the alveoli, not the airways: Lymphocytic infiltrate on bronchoalveolar lavage
Immune-mediated in sensitized individuals
Interstitial fibrosis on lung biopsy
Related to cold-contaminated humidifiers and ventilation systems
Relation to mycotoxin raised by Trout (2001) but
Minute fraction of exposed develop disease
No dose relationship

Irritation

Upper Respiratory Tract

Nasal congestion, Sneezing, runny, itchy nose, common cold
Allergic rhinitis (Hay fever)
Hoarseness, sore throat
Eye irritation
14 studies; 31,000 participants; OR from 0.94 to 4.6; Most OR 1.1 to 1.9; 10 Sig

Mucous Membrane Irritation Combination of URT and LRT irritation

Rhinorrhea, nasal congestion, sore throat AND cough, lower respiratory tract symptoms
Commonly seen in agricultural exposure to organic dusts
Mucosal hyper-reactivity with release of pro-inflammatory cytokines (TNFα, IL-1, IL-6, NO)
Mold spores stimulates pro-inflammatory cytokine release from macrophagess
One experimental study with high level exposure to fungal spores NOT associated with high NO or pro-inflammatory cytokines
Insufficient information to draw conclusions

Lower Respiratory Tract

Cough

22 studies; OR 0.7 to 5.0; Most OR 1 to 2; 14 Sig
Consistent statistical association between cough and damp indoors / moldy environment

Wheeze

Labored breathing, chest tightening; Inflammatory process in non-asthmatics; Asthmatics
20 studies; OR 0.8 to 6;Most OR 1.2 to 2; 17 Sig
Consistent statistical association between cough and damp indoors / moldy environment

Dyspnea, shortness of breath

Lung or heart disease
4 studies; 2 Sig; OR 2 to 3
Associated with damp environment but small # of studies; Association with mold inadequately proven

Asthma and COPD

Measured with Forced Expiratory Volume (FEV)
Bronchial hyper-responsiveness or bronchial hyper-reactivity = ↓ of ≥20% in FEV after metacholine or histamine challenge
Hyper-reactivity → cough & wheezing
Seen in normal individuals, asthmatics, chronic airway disease, organic dust exposure
No sufficient evidence: not all studies consistent

Sinusitis: Inflammation of paranasal sinus

Usually microorganisms; Edema prevents draining of increased mucus production; Microbial super-infection

Fungi commonly isolated from nasal secretions of healthy and chronic rhino-sinusitis

Braun 2003. The Laryngoscope 113 (2): 264-269

- 91% healthy volunteers w positive fungal culture
- 91% chronic sinusitis w positive fungal culture
- 33 genera isolated, mean 3.2 species /person

No definitely proven association

COPD

Disease characterized by progrssive airflow limitation

Associated with abnormal inflammatory lung response to noxious particles or gases

Smoking primary cause

Other causes: ETS, air pollutants, organic and inorganic dust

Not fully reversible

Immuno-compromised + COPD at higher risk

Cause of COPD: insufficient evidence

Pulmonary Hemorrhage in Children or Hemosiderosis

Abnormal accumulation of hemosiderin in lung tissue

Diffuse bleeding and hemorrhage in alveoli

Reported with

- Heiner syndrome (hypersensitivity to caw's milk)
- Auto-immune diseases: Goodpasture Syndrome, Wegner's granulomatosis, celiac disease, high dose chemotherapy
- Particularly infants and prematures
- Recurrent episodes of fever, tachypnea and pm bleeding

Horse

Cluster of 8 cases in Cleveland 1993/4

Farmer's Lung

Growth of fungi found in hay, straw or grain dust within lungs

Inhalation Fevers

Organic Dust Toxic Syndrome (ODTS)

Self limiting non-infectious febrile illness

After organic dust inhalation exposure

Malaise, myalgia, dry cough, fever, nausea, headache

Similar to acute hypersensitivity pneumonitis but no prior sensitization

No infiltrates, no restriction

Not associated with fungus indoor, only in occupation setting

Humidifier Fever

Febrile reaction with resp tract symptoms, Chest Xray OK

No association with fungus exposure

Serologic Diagnosis Not effective
People are all constantly exposed to fungi
Most people may have antibody response to those fung
Lack of specificity of antifungal antibodies: many cross-reactive
Antibody tests are of very limited utility in making a diagnosis.

Mold Concentrations: Studies comparing residences and offices

Klánová, 2000	68 Rooms	Concentration cfu/m^3
1-No complaints, no molds	20	0-230
2-Complaints, no molds	20	0-140
3-No complaints, visible mold	10	60-3,190
4-Complaints, visible mold	18	120-17,930

Note the inconsistencies:
(3) has 3,190 and no complaints; (4) has 120 with complaints

No Mold Standards
No federal or state standards for indoor airborne concentrations of mold
No threshold limit values (TLVs) for human exposure
Why? Individual sensitivities vary greatly
No correlations established between health effects and measurements

Toxic Mold: Phantom Risk vs Science. Chapman JA, Terr AI, Jacobs RL, Charlesworth EN, Bardana EJ Ann Allergy Asthma Immunol. 2003 Sep;91(3):222-32

OBJECTIVE: To review the available literature on the subject of fungi (molds) and their potential impact on health and to segregate information that has scientific validity from information that is yet unproved and controversial. DATA SOURCES: This review represents a synthesis of the available literature in this area with the authors' collective experience with many patients presenting with complaints of mold-related illness. STUDY SELECTION: Pertinent scientific investigation on toxic mold issues and previously published reviews on this and related subjects that met the educational objectives were critically reviewed. RESULTS: Indoor mold growth is variable, and its discovery in a building does not necessarily mean occupants have been exposed. Human response to fungal antigens may induce IgE or IgG antibodies that connote prior exposure but not necessarily a symptomatic state. Mold-related disease has been discussed in the framework of noncontroversial and controversial disorders. CONCLUSIONS: When mold-related symptoms occur, they are likely the result of transient irritation, allergy, or infection. Building-related illness due to mycotoxicosis has never been proved in the medical literature. Prompt remediation of water-damaged material and infrastructure repair should be the primary response to fungal contamination in buildings.

Mycotoxins are ell studied when toxins are ingested in food; Almost all real episodes human illness due to fungal toxins have followed ingestion of the toxin. Very little information on inhalational route particularly in humans with indoor contamination

The role of toxigenic fungal exposure has yet to be determined - IOM,2004 Damp indoor spaces and health

Anecdotal reports of health problems attributed to mold often dominate mass-media attention, but they are not a source of reliable information"

Despite this list of impressive effects in some settings, the vast majority of the time it has been difficult to link a particular fungal toxin to a particular effect or complaint. The toxins are generally present in low quantities and only occasionally will enough toxin be present acutely to cause a dramatic and clearly linked syndrome. Mycotoxins are relatively large and non-volatile molecules (that is, they do not readily release into the air). Thus, very direct contact with the mycotoxin is required.

Although evidence was found of a relationship between high levels of inhalation exposure or direct contact to mycotoxin-containing molds or mycotoxins, and demonstrable effects in animals and health effects in humans, the current literature does not provide compelling evidence that exposure at levels expected in most mold-contaminated indoor environments is likely to result in measurable health effects. Even though there is general agreement that active mold growth in indoor environments is unsanitary and must be corrected, the point at which mold contamination becomes a threat to health is unknown. Research and systematic field investigation are needed to provide an understanding of the health implications of mycotoxin exposures in indoor environments. Robbins, CA 2000. Health effects of mycotoxins in indoor air: A critical review. Appl. Occup. Environ. Hyg. 15 (10): 773-784

Guidelines

1980 USDA Bulletin…control dampness, use bleach

1984, 1996: International Society of Inddor Air Quality and Climate (ISIAQ) Control of Moisture Problems Affecting Biological Indoor Air Quality (Flannigan & Morey)…moisture control, ventilation from outside, respirators

1989, 1999: Bioaerosols Committee, American Conference of Government Industrial Hygienists (ACGIH)…vacuuming, HEPA filtration, caution with biocides

1992: Repairing your Flooded Home, American Red Cross (ARC) & Federal Emergency Management Agency (FEMA)

1992: American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE)…remediation with containment, air leak barrier

1993: New York City Dept of Health Guidelines for Remediation of Stachybotrys

1995: Health Canada, Fungal Contamination in Buildings, Guide for Recognition & Management

2000: New York City Dept of Health Guidelines for Remediation of Fungi in Indoor Environments

2001: Environmental Protection Agency (EPA) Mold Remediation in Schools and Commercial Buildings

2001: American Industrial Hygiene Association (AIHA) Report of the Microbial Growth Task Force

Preventing Indoor Mold

Respond quickly to moisture problems

Dry wet materials within 48 hours

Replace water-damaged materials

Regularly inspect for leaks, mold growth, and musty odors

Preventing Indoor Mold

Maintain indoor relative humidity below 60%

- Ideal 30% - 50%
- Air conditioners and/or de-humidifiers
- Exhaust fans or open windows in bathrooms, kitchens
- Vent clothes dryers to outside
- Reduce condensation

Mold Remediation Principles

Identify and control moisture sources before remedial actions

Inspect for visible mold and damage to determine scope of remedial activities and necessary control measures

Small area cleanups may be performed by residents or building custodial staffs

Remove heavily contaminated porous materials

- Biocides, antimicrobial agents, ozone not adequate substitutes

Remediation of heavily contaminated areas may require complex contaminant controls and careful work practices

Industrial hygienists and/or environmental consultants often required to oversee or perform prudent cleanup processes

Preventing Indoor Mold

Mold Clean-Up 101

Do-It-Yourself (<10 ft^2)

Hard, non-porous surfaces: Damp wipe

Hard, semi-porous: Scrub surface

Porous materials: Discard and replace

Bag and seal moldy materials; Disposal same as construction debris

Personal Protection: Use common sense

- Wear goggles that do not have ventilation holes or use a full-face respirator
- Wear water-resistant boots and gloves and disposable protective clothing (such as a Tyvek™ suit)
- Use duct tape to seal the gaps around the ankles and wrists. Wear a water-resistant disposable protective suit for wet work. Discard your protective suit at the end of your workshift.
- Use a NIOSH-approved respirator
  - To get a good fit: fit-testing and medical clearance at occupational medicine clinic.
  - For small jobs a NIOSH-approved N-95 respirator may be used. NIOSH-certified N-95 respirators will have "N95" and "NIOSH" printed on the facemask. These respirators will remove particles (such as mold spores) from the air.
  - For large or dusty jobs, a full face piece air-purifying respirator with a particulate filter, or a higher level protection (such as a powered air purifying respirator with a particulate filter) is needed.

Air Ducts

- This area is a source of great confusion; Exceptions exist;
- Short answer: NO, ducts do not need to be cleaned
- Cleaning can shake things loose and make situation worse

See EPA Website: EPA document entitled Should You Have the Air Ducts in Your Home Cleaned? EPA 402-K-97-002.

Professional Remediation

When: Large area of contamination, Health conditions not permitting

Who: Environmental consultants/engineers

Industrial hygienists

Flood restoration specialists

Asbestos remediators

How to locate: Yellow pages; Professional associations

Considerations: Industry not [yet] regulated; Check with Better Business Bureau; Referrals / reputation

Experience, training, professional affiliations, certifications, degrees

NIOSH / US EPA

Building Air Quality: A Guide for Building Owners and Facility Managers

http://www.cdc.gov/niosh/pdfs/sec_8.pdf

US EPA

Indoor Air Quality Tools for Schools: IAQ Coordinator's Guide

http://www.epa.gov/iaq/schools/tfs/guidea.html

AIHA brochure

Guidelines for Selecting An Indoor Air Quality Consultant

http://www.aiha.org/ConsultantsConsumers/html/OOiaq.htm

Successful Remediation

A determination must be made that remediation has been completed and that the space is suitable for re-occupation. Such determinations are necessarily subjective because there are no generally accepted health-based standards for acceptable concentraions of fungal spores, hyphae or metabolites in the air (ACGIH 1999, AIHA 2001)

Bottom Line

Moisture control is key

Respond quickly

If moisture problem is not fixed, mold will return

All indoor mold should be treated the same, with regards to:

Cleaning / removal

Personal precautions

Prevention