Mold

Prevention Strategies and Possible Health Effects in the Aftermath of Hurricanes Katrina and Rita

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Executive Summary

The duration and extent of flooding and the number of structures flooded as a result of Hurricanes Katrina and Rita make the likelihood of massive mold contamination in buildings a certainty. Many structures remained flooded weeks after the hurricane and became saturated with water. Some early observers suggested that as many as 60% to 80% of residential structures in New Orleans sustained severe flood damage. Outside New Orleans, extensive hurricane damage without prolonged flooding occurred. This more typical pattern of destruction as a result of wind and rain will result in problems with mold, but will not be as extensive as in New Orleans.

This publication provides comprehensive information on how to limit exposure to mold and how to identify and prevent mold-related health effects. It will be especially useful to public health practitioners, health care providers, building managers, custodians, and others who are responsible for building maintenance. Contractors and other professionals (e.g. environmental consultants and other health or safety professionals) who respond to mold or moisture situations in buildings will also find the information of use, as might the public.

Mold growing on the ceiling and walls of a house after Hurricane Katrina

We reiterate established recommendations for control of mold exposure. Where uncertainties in our scientific knowledge exist, we focus on practical applications that are designed to be protective of people's health. Filling these uncertainties with new information through research to establish more effective guidelines and recommendations for the future is important, but such research is not discussed in this publication. Here, we include up-to-date information on assessing exposure (Chapter 2), cleanup and prevention (Chapter 3), personal protective equipment (Chapter 4), health effects (Chapter 5), and public health strategies and recommendations (Chapter 6).

Several factors are assumed:

- In the aftermath of Hurricanes Katrina and Rita, buildings or materials soaked for more than 48 hours contain potentially hazardous concentrations of mold unless proven otherwise or cleaned according to recommendations.
- The geographic area in which these conditions exist is extensive.
- Vast numbers of people (workers and residents) will be exposed to high levels of mold and other related contaminants associated with water-damaged buildings.
- Sufficient evidence exists of an association between several adverse health outcomes and exposure to damp indoor environments or to materials contaminated with fungal growth.
- There are no criteria for using either the concentration or type of mold in buildings to make informed decisions.

- Clear, concise, and practical recommendations and actions are necessary to limit exposure to mold and to prevent mold-related health outcomes where possible.

Public health recommendations related to exposure assessment:

- Assume that building interiors are significantly contaminated with mold in the following circumstances:
    - The building was saturated with water or was wet for more than 48 hours.
    - The visible mold growth is extensive and in excess of that present before Hurricanes Katrina and Rita.
    - Signs of water damage or mold are visible, or mold or mildew odors are strong.

- Assume that excessive exposure to materials and structures contaminated with mold can cause adverse health effects regardless of the type of mold.
- Risk of illness does not necessarily vary with the type of mold or the extent of contamination.

If left undisturbed, mold is generally not a significant health hazard for most people, and moderate exposure to mold will not adversely affect them. To prevent exposure that could result in adverse health effects from disturbed mold, it is good practice to implement environmental controls (e.g. isolating the contaminated area, ventilating the area, suppressing dust), use personal protective equipment, or both. How to protect individuals from exposure to mold depends on the extent of mold contamination in the building's fabric or materials, the duration and type of activity undertaken in the mold-contaminated area, and the susceptibility of the individual entering the area to the various health effects.

There are four methods for preventing exposure to mold:

- Stay away from indoor or outdoor areas where mold contamination is an obvious problem.
- Use environmental controls.
- Use personal protective equipment.
- Keep hands, skin, and clothing clean and free from mold-contaminated dust.

Health outcomes that might be related to fungal exposure are described in Chapter 5 and fall into several broad categories. Some potential health outcomes are rare, difficult to diagnose, and relatively specific for fungal exposure (e.g. blastomycosis). Other health outcomes are relatively easy to diagnose, but they have numerous etiologic factors and are difficult to attribute specifically to mold exposure (e.g., asthma exacerbations).

Health care providers should be watchful for unusual fungal-related diseases that may occur (e.g., hypersensitivity pneumonitis, organic dust toxic syndrome (ODTS), blastomycosis). Otherwise such diseases will not be recognized. If consulted by people who believe their illness is due to fungal exposure, health care providers should use the patient's clinical information (including history, a physical examination, and other laboratory data) to assess the case. Immunologic test results should be used cautiously and only in combination with other clinical information. There is insufficient scientific evidence to support the routine clinical use of immunodiagnostic tests as a primary means of assessing 1) environmental fungal exposure or 2) health effects related to fungal exposure. If appropriate allergy prick skin testing reagents or *in vitro* tests for serum specific IgE are available, they can be used to show specific IgE-sensitization to causative allergens. Unfortunately, skin testing reagents and blood tests

documenting IgE-sensitization to molds are, with few exceptions, poorly standardized and of unclear sensitivity and specificity. The conventional hierarchy of treatment for allergic diseases is avoidance of exposure to inciting agents; pharmacotherapy; and, as a last resort, allergen immunotherapy. Immunotherapy with fungal allergenic extracts is, with a few exceptions, of unknown efficacy.

It is important that clinicians report cases of mold-induced illness to local health authorities to assist in health surveillance efforts.

Because of the large number of flooded and mold-contaminated buildings in New Orleans and the repopulation of those once-flooded areas, a large number of people are likely to be exposed to mold and other microbial agents. Efforts to determine the health effects of these exposures and the effectiveness of recommendations to prevent health effects from mold exposure require a public health surveillance strategy. Developing such a strategy requires that federal and local health agencies work together to monitor trends in the incidence or prevalence of mold-related conditions throughout the recovery period. Tracking different health outcomes that may be caused by mold exposure requires different surveillance methods. In some cases, follow-up research will be needed to verify that surveillance findings and health outcomes are the result of mold exposure. For some conditions, difficulties in interpreting trends and in relating the outcome to mold exposure may suggest that surveillance is not an appropriate public health approach. Results of surveillance and follow-up activities will help CDC to refine the guidelines for exposure avoidance, personal protection, and cleanup. In addition, these activities should assist health departments to identify currently unrecognized hazards.

Chapter 1
Background

Mold: A Definition

Molds, mushrooms, mildews, and yeasts are all classified as fungi, a kingdom of organisms, distinct from plants and animals. Fungi differ from plants and animals in several respects: unlike animals, fungi have cell walls; however, unlike plants, which also have cell walls, fungal cell walls are made mostly of chitin and glucan. Fungi cannot produce their own nutrients, as plants do through photosynthesis. Fungi secrete enzymes that digest the material the fungi are imbedded in and absorb the released nutrients. Multicellular fungi do not differentiate into different organs or functional components the way plants and animals do.

It is estimated that there are between 50,000 and 250,000 species of fungi; however, many of these species have not been classified or named. Fewer than 200 fungal species have been described as human pathogens that can cause infections. Multicellular fungi consisting of branching filamentous structures are known popularly as molds, and we will use that terminology in this publication.

Molds are ubiquitous in nature and grow almost anywhere indoors or outdoors. More than 1,000 kinds of indoor molds have been found in U.S. homes. Molds spread and reproduce by making spores, which are small and lightweight, able to travel through air, capable of resisting dry, adverse environmental conditions, and hence capable of surviving a long time. The filamentous parts of mold (hyphae) form a network called mycelium which is seen when a mold is growing on a nutrient source. Although these mycelia are usually firmly attached to whatever the mold is growing on, they can break off and people may be exposed to fragments of them. Molds also produce characteristic volatile organic compounds (VOCs) or mycotic VOCs (mVOCs) and substances known beta glucans; mVOCs and beta glucans may be useful as markers of exposure to molds.

Some molds are capable of producing toxins (sometimes called mycotoxins) under specific environmental conditions, such as competition from other organisms or changes in the moisture or available nutrient supply. Molds capable of producing toxins are popularly known as toxigenic molds; however use of this term is discouraged because even molds known to produce toxins can grow without producing them, and many fungi are capable of toxin production.

Factors That Produce Mold Growth

Although molds can be found almost anywhere, they need moisture and nutrients to grow. The exact specifications for optimal mold growth vary by the species of mold. In general, however, mold grows best in damp, warm environments. The availability of nutrients in indoor environments rarely limits mold growth, since wood, wallboard, wallpaper, upholstery, and even dust can be nutrient sources. Similarly, the temperature of indoor environments, above freezing and below the temperature for denaturing proteins, can support mold growth, even if the actual temperature is not optimal.

The primary factor that limits the growth of mold indoors is lack of moisture. Substantial indoor mold growth is virtually synonymous with the presence of water inside the building envelope. This intrusion from the outdoors may be from rainwater leaking through faulty gutters or a roof

in disrepair, from a foundation leak, or from condensation at an interface, such as a window or a pipe, between a cold and a warm environment. Water can also come from leaks in the plumbing or sewage system inside the structure. Studies of mold growth on building materials, such as plywood, have found mold grows on materials that remain wet for 48 to 72 hours. Few materials can sustain mold growth on the basis of high relative humidity without being wet. Flooding, particularly when floodwaters remain for days or weeks, provides an almost optimal opportunity for mold growth.

Factors That Cause Disease From Mold

Mold exposure may produce disease in several ways. Although the health effects of mold exposure are addressed in more detail in Chapter 5, the following brief overview will acquaint readers with these effects.

Inhalation is usually presumed to be the most important mechanism of exposure to viable (live) or nonviable (dead) fungi, fungal fragments or components, and other dampness-related microbial agents in indoor environments. Most fungal spores have aerodynamic diameters of 2–10 micrometers (μm), which are the size ranges that allow particles to be deposited in the upper and lower respiratory tracts. Inhalation exposure to a fungal spore requires that the spore be initially aerosolized at the site of growth. Aerosolization can happen in many ways, ranging from disturbance of contaminated materials by human activity to dispersal of fungi from contaminated surfaces in heating, ventilating, and air-conditioning (HVAC) systems. Fungal spores can also be transported indoors from outdoors. Overall, the process of fungal-spore aerosolization and related issues (e.g., transport, deposition, resuspension, and tracking of fungi to other areas) are poorly understood.

The major noninfectious health effects of mold exposure have an immunologic (i.e., allergic) basis. Exposure to mold can sensitize individuals, who then may experience symptoms when re-exposed to the same mold species. For sensitized people, hay fever-like symptoms and asthma exacerbations are prominent manifestations of mold allergy. Although it is likely that different mold species have different propensities to cause allergy, current data do not permit a relative ranking of species by risk of creating or exacerbating allergy. In addition, exposure to beta glucans may have an inflammatory effect in the respiratory system.

Prolonged exposure to high levels of mold (and some bacterial species) can produce an immune-mediated disease known as hypersensitivity pneumonitis. Clinically, hypersensitivity pneumonitis is known by the variety of exposures that can cause this disorder (e.g., farmer's lung, woodworker's lung, malt worker's lung).

Ingesting toxins that molds produce can cause disease. Long-term ingestion of aflatoxins (produced by aspergillus species) has been associated with hepatocellular cancer. In addition, ingestion of high doses of aflatoxin in contaminated foods causes aflatoxicosis and can result in hepatic failure. Whether concentrations of airborne mold toxins are high enough to cause disease is unknown, and no health effects from airborne exposure to mold-related toxins are proven.

How People Are Exposed to Mold

People can be exposed to mold through skin contact, inhalation, or ingestion. Given the ubiquity of mold in the environment, some level of exposure is inevitable. People can become exposed to mold through contact with airborne spores or through contact with mycelial fragments. Exposure to high airborne concentrations of mold spores could occur when people come into contact with a large mass of mold, such as might occur in a building that has been flooded for a long time. Exposure to mycelia fragments could occur when a person encounters a nutrient source for mold that has become disrupted, such as would occur during removal of mold-contaminated building material. Skin contact or exposure by inhalation to either spores or mycelial fragments could also occur in a dusty environment, if the components of dust include these fungal elements.

Numerous species of mold cause infection through respiratory exposure. In general, people who are immunosuppressed are at increased risk for infection from mold. Immunosuppression can result from immunosuppressive medication, from medical conditions and diseases that cause immunosuppression, or from therapy for cancer that causes transient immunosuppression. Although many species of mold are documented to cause infection, there are many more mold species that do not cause infection. Infections from mold may be localized to a specific organ or disseminated throughout the body.

For most adverse health outcomes related to mold exposure, higher levels of exposure to live molds or higher concentrations of allergens on spores and mycelia are thought to result in a greater likelihood of illness. However, there is currently no standardized method to measure the magnitude of exposure to molds. For this reason, it is not possible to sample an environment, measure the mold level in that sample, and make a determination as to whether the level is low enough to be safe or high enough to be associated with adverse health effects. (See Chapter 5 for more information about potential health effects of fungal contamination.)

Issues Related to Hurricanes Katrina and Rita

The duration of flooding, the extent of flooding, and the number of structures flooded in New Orleans as a result of Hurricanes Katrina and Rita make the likelihood of massive mold contamination a certainty. Many structures remained flooded for weeks after the hurricanes and became saturated with water. Some early observers suggested that as many as 60% to 80% of residential structures in New Orleans sustained severe flood damage. In many cases, the damage was so severe that the structure will require demolition.

Outside New Orleans, extensive hurricane damage without prolonged flooding occurred. The more typical pattern of destruction as a result of wind and rain will result in problems with mold, but not as extensive as expected in New Orleans.

The only recent parallels to the kind of flooding seen in New Orleans as a result of Hurricanes Katrina and Rita occurred in 1997 in Grand Forks, North Dakota, and in 1999 in North Carolina after Hurricane Floyd. The number of structures affected was much smaller in North Dakota than in New Orleans, and the population affected in North Dakota was much more dispersed than the population affected in New Orleans.

Chapter 2

Assessing Exposure to Mold

Exposure Assessment: Flooded Buildings With Obvious Water or Mold Damage

Any structure that was flooded after Hurricanes Katrina and Rita is presumed to have materials contaminated with mold if the building's materials were not thoroughly dried within 48 hours. For most cases, the most appropriate immediate steps to reduce the risk of exposure to mold are described in Chapter 3, "Cleanup and Prevention."

Exposure Assessment: Flooded Buildings With Possible Mold Contamination

Assessing the level of people's exposure to mold in flooded buildings will be a central and ongoing activity in the recovery related to Hurricanes Katrina and Rita, since any structure not thoroughly dried within 48 hours will probably be contaminated by indoor mold. For safe, effective cleanup, it is important to understand the strengths and limitations of the approaches that are available to assess such exposures.

It is important to remember that buildings that were not flooded could also have mold. For example, leaking roofs or pipes allow water to penetrate building materials and cause mold to grow. In hot humid climates, such as the climate in New Orleans, buildings without air conditioning for a long time are susceptible to mold growth.

Visual Inspection

A visual inspection is the most important step in identifying a possible mold contamination problem. The extent of any water damage and mold growth should be visually assessed. This assessment is particularly important in determining remedial strategies and the need for personal protective equipment (PPE) for people in the contaminated area. Ceiling tiles, gypsum wallboard (sheetrock), cardboard, paper, and other cellulosic surfaces should be given careful attention during a visual inspection. It is also important to remember that not all mold contamination is visible: with a flood, it is common to have contamination in the interior wall cavities or ceiling. A common means of assessing the mold contamination of a building is to measure the total square feet of contaminated

Examples of mold (at right) found on the walls inside houses

building materials. However, professional judgment will necessarily play an important role in the visual inspection because less quantifiable factors (e.g., location of the mold, building use and function) and exposure pathways are also important in assessing potential exposure and health risks.

Ventilation systems should also be visually checked, particularly for damp filters, but also for damp conditions elsewhere in the system and overall cleanliness. HVAC systems known or suspected to be contaminated with mold should not be run to avoid spreading microorganisms throughout the building. The U.S. Environmental Protection Agency's guide *Should You Have the Air Ducts in Your Home Cleaned?* (available at http://www.epa.gov/iaq/pubs/airduct.html) and the CDC/National Institute for Occupational Safety and Health (NIOSH) publication *NIOSH Interim Recommendations for the Cleaning and Remediation of Flood-Contaminated HVAC Systems: A Guide for Building Owners and Managers* (available at http://www.cdc.gov/niosh/topics/flood/pdfs/Cleaning-Flood-HVAC.pdf) provide useful information concerning this topic. In addition, Chapter 3 of this publication provides some information concerning assessment and cleaning of heating, ventilation, and air conditioning (HVAC) systems.

Different algorithms for assessing and remediating mold-contaminated buildings are available and may be helpful. Examples of such algorithms are available from the U.S. Army (available at http://chppm-www.apgea.army.mil/mold/TG278.pdf) and from the New York City Department of Health (available at http://www.nyc.gov/html/doh/html/epi/moldrpt1.shtml#enviro.

Moisture meters provide qualitative moisture levels in building materials and may be helpful for measuring the moisture content in a variety of building materials following water damage. They also can be used to monitor the progress in drying wet materials. Damaged materials should be removed and discarded. Moisture meters can be used on materials such as carpet, wallboard, wood, brick, and concrete. Humidity meters can be used to monitor indoor humidity. Inexpensive (less than $50) models that monitor both temperature and humidity are available.

A *borescope* is a hand-held tool that allows users to see hidden mold problems inside walls, ceiling plenums, crawl spaces, and other tight areas. No major drilling or cutting of dry wall is required.

Sampling for Mold

Sampling for mold is not part of a routine building assessment. In most cases appropriate decisions concerning remediation and need for personal protection equipment (PPE) can be made solely on the basis of visual inspection. If visible mold is present, then it should be remediated regardless of 1) what types of microorganisms are present 2) what species of mold is present, and 3) whether samples are taken. Other than in a controlled, limited, research setting, sampling for biological agents in the environment cannot be meaningfully interpreted and would not significantly affect relevant decisions regarding remediation, reoccupancy, handling or disposal of waste and debris, worker protection or safety, or public health. If sampling is being considered, regardless of the purpose, there should be a clear question that the sample results will help to answer. The following are examples of instances when different types of sampling may be required:

- To help evaluate a source of mold contamination. For example, testing the types of mold and mold concentrations indoors versus outdoors can be used to identify an indoor source of mold contamination that may not be obvious on visual inspection.
- To help guide mold remediation. For example, if mold is being removed and there is a question about how far the colonization extends, then surface or bulk sampling in combination with moisture readings may be useful to answer this question.

Types of Samples: Types of samples used to assess the presence of mold and the potential for human exposure to mold in a water-damaged building include air samples, surface samples, bulk samples, and water samples from condensate drain pans or cooling towers. Detailed descriptions of sampling and analysis techniques are available in *Damp Indoor Spaces and Health* (a publication of the Institute of Medicine; see http://www.nap.edu/books/0309091934/html) and *Bioaerosols Assessment and Control* (published by the American Conference of Governmental Industrial Hygienists).

Airborne sampling may be a good indicator of exposure from a theoretical point of view, particularly for assessing acute short-term exposures. In practice, however, detection problems limit the use of these types of samples for most biological agents. If air sampling is conducted, personal measurements best represent the current exposure; therefore, personal sampling is generally preferred to area sampling. However, practical constraints may make personal sampling impossible. Area sampling is therefore the most commonly performed type of air sampling. The general problem with sampling may be the uncertainty about how accurately the measurements reflect actual personal exposure. Because few data are available on variation in exposure to biologic agents in the environment, it is not possible to recommend how many samples should be taken to produce an accurate exposure assessment. Airborne fungal concentrations are characterized by high variability over time and clinically significant variations in exposure may occur over short periods.

One type of surface sampling is the sampling of settled dust. A theoretical advantage of settled-dust sampling is the presumed correlation of concentrations of fungi in the settled dust with chronic exposure to those fungi. However, surface sampling is a crude measure and will yield a poor surrogate for airborne concentrations. Results of surface sampling as a measure of exposure should be interpreted with caution.

Bulk samples can provide information about possible sources of biologic agents in buildings as well as the general composition and relative concentrations of those biologic agents. Detailed information concerning bulk and other types of source sampling can be found in *Bioaerosols Assessment and Control*.

Assessment of Microorganisms: Two distinct approaches are used for evaluation of the presence of specific microbes: culture-based and nonculture-based. The strengths and limitations of the different approaches are discussed in *Damp Indoor Spaces and Health*.

Instead of measuring culturable or nonculturable fungi or fungal components, constituents or metabolites of microorganisms can be measured as a surrogate of microbial exposure. Examples of such techniques include polymerase chain reaction (PCR) technologies and immunoassays. Methods for measuring microbial constituents (with some exceptions) are in an experimental phase and have not yet been routinely applied in clinical assessments, risk assessments, or epidemiologic studies.

Evaluation Criteria: No health-based standards or recommended exposure limits (e.g. OSHA, EPA, NIOSH) for indoor biologic agents (airborne concentrations of mold or mold spores) exist. This makes the interpretation of sampling data difficult. Because of differences in season; climatic and meteorological conditions; type, construction, age, and use of the building and ventilation systems; and differences in measurement protocols used in various studies (e.g., viable versus nonviable microorganism sampling, sampler type, analysis), information from the medical literature can seldom be used. If sampling is performed, a strategy that can be used to evaluate exposure data (either quantitatively or qualitatively) is to compare 1) exposure data with background data 2) indoor environments with outdoor environments, or 3) problem areas with nonproblem areas. A quantitative evaluation involves comparing exposures, whereas a qualitative evaluation could involve comparing species or genera of microorganisms in different environments. Specifically, in buildings without mold problems, the qualitative diversity of airborne fungi indoors and outdoors should be similar. Conversely, the dominating presence of one or two kinds of fungi indoors and the absence of the same kind outdoors may indicate a moisture problem and degraded air quality. Also, the consistent presence of fungi such as *Stachybotrys chartarum*, *Aspergillus versicolor*, or various *Penicillium* species over and beyond background concentrations may indicate a moisture problem that should be addressed. Generally indoor and outdoor mold types should be similar, and indoor levels should be no greater than levels outdoors or in noncomplaint areas. Analytical results from bulk material or dust samples may also be compared with results of similar samples collected from reasonable comparison areas.

Other Issues

Biomarkers

For biologic agents, few biomarkers of exposure or dose have been identified, and their validity for exposure assessment in the indoor environment is often unknown. Testing to determine the presence of IgE to specific fungi may be a useful component of a complete clinical evaluation in the diagnosis of illnesses (e.g., rhinitis and asthma) that can be caused by immediate hypersensitivity. This is usually done by skin prick or puncture tests. Detection of IgG to specific fungi has been used as a marker of exposure to agents that may cause illnesses such as hypersensitivity pneumonitis. However, the ubiquitous nature of many fungi and the lack of specificity of fungal antigens limit the usefulness of these types of tests in evaluating possible building-related illness and fungal exposure. Specific serologic tests (such as tests for cryptococcal antigen, coccidioidal antibody, and *Histoplasma* antigen) are useful in the diagnosis of some fungal infections, but these are the exception, not the rule. There is currently not enough scientific evidence to support the routine clinical use of immunoassays as a primary means of assessing environmental fungal exposure or health effects related to fungal exposure. Health care providers whose patients express concern about the relationship between symptoms and possible exposure to fungi are advised to use immunoassay results with care and only in combination with other clinical information, including history, physical findings, and other laboratory results.

Mycotoxins

During the past few years, there has been increased concern related to exposure to specific molds that produce substances called mycotoxins. Health effects related to mycotoxins are generally related to ingestion of (eating) large quantities of fungal-contaminated material. There is currently no conclusive evidence of a link between indoor exposure to airborne mycotoxin and human illness. It is important to note that many molds can potentially produce toxins, given the right conditions. Some molds that produce mycotoxins are commonly found in moisture-damaged buildings; research related to the importance of these findings is ongoing. Although the potential for health problems is an important reason to prevent or minimize indoor mold growth and to remediate any indoor mold contamination, currently there is inadequate evidence to support recommendations for greater urgency of remediation in cases where mycotoxin-producing fungi have been isolated.

Resources

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US Army Center for Health Promotion and Preventive Medicine. Mold. Aberdeen Proving Ground, MD: US Army Center for Health Promotion and Preventive Medicine. Available at: http://chppm-www.apgea.army.mil/mold/.

Chapter 3

Cleanup and Prevention

> There are several sources of guidance on how to respond to mold. Determining when a remediation effort is warranted or when it is successful is subjective because there are no generally accepted health-based standards for acceptable concentrations of fungal spores, hyphae, or metabolites in the air or on surfaces. Very few studies have been conducted on the effectiveness of remediation actions in eliminating problematic mold contamination in the short and long term and on the effect of remediation actions on the health of building occupants.
>
> — *Institute of Medicine, 2004*

The best way to get rid of mold growth is to remove it from materials that can be effectively cleaned and to discard materials that cannot be cleaned or are physically damaged beyond use. Persons with respiratory conditions, allergies, asthma, or weakened immune systems should not attempt mold cleanup.

Cleanup

Removing mold problems requires a series of actions. The order of these actions is sometimes important. Typically, the following actions are taken almost regardless of whether a problem is small and simple or large and complex:

1. Take emergency action to stop water intrusion, if needed.
2. Determine the extent of water damage and mold contamination.
3. Plan and implement remediation activities.
    - If needed, establish containment and protection for workers and occupants.
    - Eliminate or limit water or moisture sources.
    - Dry any wet materials, if possible.
    - Decontaminate or remove damaged materials, as appropriate.
    - Evaluate whether space has been successfully remediated.
    - Reassemble the space to prevent or limit possibility of recurrence by controlling sources of moisture.

For small, simple problems, the entire list of tasks may be done by one person. Large, complex problems may require many people from different professions and trades. For circumstances that fall between those extremes, some combination of occupant action and professional intervention will be appropriate. In general, no single discipline brings together all the required knowledge for successful assessment and remediation.

Returning to Mold-Contaminated Homes or Buildings After a Flood

When people return to homes or buildings after a flood, they should take the following steps:

- Clean up and dry out the building quickly. Open doors and windows. Use fans or dehumidifiers to dry out the building.
- Remove all porous items that have been wet for more than 48 hours and that cannot be thoroughly cleaned and dried. These items can remain a source of mold growth and should be removed from the home or building. Porous, noncleanable items include carpeting and carpet padding, upholstery, wallpaper, drywall, ceiling tiles, insulation material, some clothing, leather, paper, wood, and food. Removal and cleaning are important because even dead mold may cause allergic reactions in some people.
- To *prevent* mold growth, clean wet items and surfaces with detergent and water.
- Returnees may want to temporarily store damaged or discarded items outside the home or building until insurance claims can be processed.

Removing and Cleaning Up Mold in a Building

Mold covering less than 10 square feet can be removed with a bleach solution of 1 cup chlorine bleach per 1 gallon of water. Remember: never to mix bleach or bleach-containing products with ammonia or ammonia-containing products. Wear a tight-fitting respirator, such as a NIOSH-approved N-95 respirator, which you can buy at home improvement stores. Wear gloves to limit contact of mold and cleaning solutions with skin. For detailed information about respirators and protective clothing, see Chapter 4.

If there has been a lot of water damage, or mold growth covers more than 10 square feet, consult the U.S. Environmental Protection Agency (EPA) guide, *Mold Remediation in Schools and Commercial Buildings.*

Some companies specialize in water damage restoration and can assess the issues involved in cleaning up homes after a flood. Two professional trade groups that may be able to help locate such an expert are the Association of Specialists in Cleaning and Restoration (http://www.ascr.org/) and the Institute of Inspection, Cleaning, and Restoration Certification (http://www.iicrc.org).

Make sure any contractor hired has experience in cleaning up mold. Check references and ask the contractor to follow the recommendations in the guidelines of the American Conference of Governmental Industrial Hygienists (ACGIH), or other guidelines from professional organizations or state agencies. Information about state licensing requirements for contractors is available at http://www.tdh.state.tx.us/beh/mold/ (Texas) and http://www.lslbc.louisiana.gov/ (Louisiana).

Cleaning Clothes, Textiles, or Stuffed Animals

Make sure that laundry is washed in safe water. Use only water that is properly disinfected or that the authorities have stated is safe.

Before washing clothes in a machine that was in a flooded house, run the machine through one full cycle. Be sure to use hot water and a disinfectant or sanitizer.

Take clothes and linens outdoors and shake off any dried mud or dirt before washing them. Hose off muddy items to remove all dirt before putting them in the washer.
If the items are only wet, they can be laundered normally. Make sure to dry them thoroughly. Check the labels on clothes and linens, and wash them in detergent and warm water if possible, or take them to a professional cleaner. Adding chlorine bleach to the wash cycle will remove most mildew and will sanitize the clothing. However, bleach may fade some fabrics and damage other fabrics. If the label says "dry clean only," shake out loose dirt and take the item to a professional cleaner.

Consult a remediation professional for advice on whether heavily mold-contaminated items made of leather, suede, or a similar material are salvageable or should be discarded.

Do not burn or bury textiles that cannot be cleaned. Put them into properly sealed plastic bags and dispose of them as you would normal household garbage in your area.

Salvaging Household Items

While assessing or remediating mold contamination to their houses, homeowners or clean-up personnel may decide to also repair or clean household items (e.g., or housewares, kitchen items) damaged or contaminated by flood waters. As with clothing and other textiles, make sure the water being used is safe. Use only water that is properly disinfected or that the authorities have stated is safe.

Nonporous items (such as dishes, pots, glass items, and hard plastic items) can be salvaged. However, because floodwaters are contaminated, nonporous items should be washed by hand in a disinfectant and then air-dried. Do not use a dish towel. Porous items such as cloth, wood, and soft plastic must be discarded because they probably absorbed whatever contaminants were in the floodwaters.

Before using the dishwasher, clean and disinfect it. Then use a hot setting to wash your pots, pans, dishes, and utensils. Do not use the energy-saving setting. Throw away canned foods that are bulging, opened, or damaged. Food containers with screw-caps, snap-lids, crimped caps (soda pop bottles), twist caps, flip tops, snap-open, and home-canned foods should be discarded if they have come into contact with floodwater because they cannot be disinfected. If cans have come in contact with floodwater or storm water, remove the labels, wash the cans, and dip them in a solution of 1 cup of bleach in 5 gallons of water. Re-label the cans with a marker.

Cleaning a Heating, Ventilating, and Air Conditioning (HVAC) System

All surfaces of an HVAC system and all its components that were submerged during a flood are potential reservoirs for dirt, debris, and microorganisms, including bacteria and mold. In addition, moisture can collect in areas of HVAC system components that were not submerged (e.g., air supply ducts above the water line), and this can also lead to the growth of microorganisms. Therefore, all flood water-contaminated and moisture-laden components of the HVAC system should to be thoroughly inspected, cleaned of dirt and debris, and disinfected by a qualified professional. CDC has prepared recommendations for professionals to help ensure that floodwater-contaminated HVAC system components are properly cleaned and remediated. The recommendations are available at http://www.cdc.gov/niosh/topics/flood/pdfs/Cleaning-FloodHVAC.pdf. If HVAC systems are not properly cleaned and disinfected to prevent the

dissemination of mold and other debris throughout a building, bio-aerosols of mold and other microorganisms can cause a variety adverse health effects to the building's occupants. Ensure that the HVAC system is shut down before any remedial activities.

Prevention

If property owners decide to make extensive repairs or completely rebuild after a flood, they may want to design and build in a way that will limit the potential for future mold growth. The key to prevention of mold is to limit water intrusion and nutrients that allow mold to grow. There are two basic methods:

- Keep moisture-sensitive materials dry.
- Use materials that offer a poor substrate for mold growth.

Little scientific information on the efficacy and impact of prevention strategies is available. Moreover, little of the practical knowledge acquired and applied by design, construction, and maintenance professionals has been subject to thorough validation.

Resources

Centers for Disease Control and Prevention. Clean up safely after a natural disaster. Available at: http://www.bt.cdc.gov/disasters/cleanup.asp

Centers for Disease Control and Prevention. Reentering your flooded home. Available at: http://www.bt.cdc.gov/disasters/mold/reenter.asp

Centers for Disease Control and Prevention. Prevention and remediation strategies for the control and removal of fungal growth. Available at: http://www.cdc.gov/mold/strats_fungal_growth.htm

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US Environmental Protection Agency. A brief guide to mold and moisture in your home. Available at: http://www.epa.gov/iaq/molds/moldguide.html.

US Environmental Protection Agency. Mold remediation in schools and commercial buildings. Available at: http://www.epa.gov/iaq/molds/mold_remediation.html

Chapter 4

Personal Protective Equipment

Minimizing exposure to mold involves using administrative and engineering controls. Administrative controls include identifying mold-contaminated areas promptly, restricting access to these areas, and minimizing aerosol generating activities (e.g., by suppressing dust). Engineering controls include ventilating mold-contaminated areas adequately and using heavy equipment with sealed positive pressure, air-conditioned cabs that contain filtered air recirculation units to protect the workers. To limit dust levels during debris removal, mist the contaminated materials with water.

This chapter provides public and worker guidance for people potentially exposed to mold. Workers and their employers may be required to wear or provide protection according to occupational regulatory standards. Workers and employers should refer to pertinent OSHA standards and NIOSH guidelines. Recommendations are also provided for the public.

In general, workers need to wear personal protective equipment (PPE) regardless of the engineering controls used, especially for skin and eye protection. A primary function of PPE in a mold-contaminated environment is to prevent the inhalation and ingestion of mold and mold spores and to avoid mold contact with the skin or eyes. The following sections discuss the various types of PPE that may be used during remediation activities. PPE requirements for workers are likely to differ from the PPE recommendations for homeowners or other building occupants who are less likely to disturb (and therefore aerosolize) contaminated materials. In addition, PPE recommendations for people with underlying illness or compromised immune systems will differ from PPE recommendations for healthy people.

Types of Personal Protective Equipment

Skin and Eye Protection

Gloves keep the hands clean and free from contact with mold. Gloves also protect hands from potentially irritating cleaning solutions. Long gloves that extend to the middle of the forearm are recommended. The glove material should be selected on the basis of the type of substance or chemical being handled. When using a biocide such as chlorine bleach, or a strong cleaning solution, select gloves made from natural rubber, neoprene, nitrile, polyurethane, or PVC. When using a mild detergent or plain water, ordinary household rubber gloves may be used. Use latex gloves if hands are likely to be in contact with infectious materials. Otherwise, nonlatex gloves provide adequate protection.

To protect eyes, use properly fitted goggles or a full face-piece respirator. Goggles must be designed to prevent the entry of dust and small particles. Safety glasses or goggles with open vent holes are not appropriate in mold remediation. The CDC/NIOSH publication *Eye Safety: Emergency Response and Disaster Recovery* provides further information on this topic and is available at http://www.cdc.gov/niosh/eyesafe.html

Protective Clothing

While conducting building inspections and remediation work, workers or homeowners may encounter hazardous biological agents as well as chemical and physical hazards. Consequently, appropriate personal protective clothing, either reusable or disposable, is recommended to minimize cross-contamination between work areas and clean areas, to prevent the transfer and spread of mold and other contaminants to street clothing, and to eliminate skin contact with mold or chemicals. In hot environments, take precautions to prevent dehydration and heat stress when wearing protective clothing (e.g., drink plenty of water).

Disposable PPE should be discarded after it is used. Such equipment should be placed into impermeable bags and, usually, can be discarded as ordinary construction waste. Select protective equipment for biocide applicators (e.g., goggles or face shield, aprons or other protective clothing, gloves, and respiratory protection) on the basis of the product manufacturer's warnings and recommendations. In addition, follow all the manufacturer's recommended precautions. Reusable protective clothing and equipment should be cleaned according to the manufacturers' recommendations for PPE exposed to mold and other potentially hazardous chemicals (e.g. bleach, biocides).

Respiratory Protection

Inhalation is the primary exposure route of concern related to mold for workers, homeowners, and building occupants. If administrative and engineering controls are not adequate to eliminate airborne exposure to mold (or dust containing mold), respirators provide additional protection from inhaling airborne mold, contaminated dust, and other particulates that are released during dust-generating processes (such as remediation processes or debris removal).

Respirator Selection

Respirators provide varying levels of protection. Selecting a respirator to minimize exposure to molds should be based on a qualitative assessment since quantitative data on mold-contaminated environments are not informative. All decisions concerning respirator selection should be made with knowledge of the relative protective capabilities as well as the advantages and disadvantages of different respirators. Further discussion of respirator selection is available in these CDC/NIOSH publications:

- *Histoplasmosis—Protecting Workers at Risk*. Available at: http://www.cdc.gov/niosh/docs/2005-109/.
- *What You Should Know in Deciding Whether to Buy Escape Hoods, Gas Masks, or Other Respirators for Preparedness at Home and Work.* Available at: http://www.cdc.gov/niosh/npptl/topics/respirators/factsheets/respfact.html.

Standard surgical or dust masks are intended for use only as barriers against large particles and do not provide protection against many airborne particles. Respirators used to protect people from airborne contaminants (including mold and mold spores) must be certified by CDC's National Institute for Occupational Safety and Health (NIOSH). In addition, as specified by the Occupational Safety and Health Agency's (OSHA's) respiratory protection standard (29 CFR 1910.134), workers whose employers require them to use respirators must be properly trained, have medical clearance, and be properly fit-tested before they use the respirator. Further, if a worker must use respirators, the worker's employer must develop and implement a written respiratory protection program, with worksite-specific procedures and elements. (More

information on respiratory protection is available from OSHA at: http://www.osha.gov/SLTC/respiratoryprotection/index.html.)

PPE Guidelines (in brief) for Workers in Mold-Contaminated Areas

Outdoors

Exposure to some level of airborne mold is inevitable because molds are found indoors and outdoors. However, demolishing or cleaning heavily mold-contaminated materials outdoors could lead to excessive exposure to mold. The level of exposure to mold outdoors is primarily based on the amount of mold-contaminated material, the amount of mold in the material, and type of work being performed. The need for PPE (including respiratory, skin, and eye protection) for outdoor workers requires ongoing professional judgment that takes into account the potential for exposure to mold as well as the potential for exposure to other hazardous substances that might be in the outdoor work area.

Indoors

Guidelines summarized below (under Category I Protection and Category II Protection) are based on guidelines from the Occupational Safety and Health Administration (OSHA), the U.S. Environmental Protection Agency (EPA), and the New York City Department of Health and Mental Hygiene. These guidelines recommend particular respirators on the basis of the size of the area of mold contamination. The size criteria, however, are based on general professional judgment and practicality because there are no adequate data that relate the extent of contamination to the frequency or severity of health effects.

When determining the potential for airborne exposure to mold, the size of the area is not the only criterion to be considered. The activities being performed in relation to the mold-contaminated materials are at least as important, if not more so. Therefore, ongoing professional judgment always must play a part in decisions concerning PPE. For example, any remediation or other work that disturbs mold and causes mold spores to become airborne increases the degree of respiratory exposure. Actions that tend to disperse mold include breaking apart moldy porous materials such as wallboard; destructive invasive procedures to examine or remediate mold growth in a wall cavity; removal of contaminated wallpaper by stripping or peeling; and using fans to dry items or ventilate areas.

Category I Protection

- Respiratory protection: (e.g., N-95 disposable respirator). Respirators must be used in accordance with the OSHA respiratory protection standard (29 CFR 1910.134).
- Gloves and eye protection.

To be used in the following areas:

- Small isolated areas (10 square feet or less) of heating, ventilation, and air-conditioning (HVAC) systems (includes pipes, ducts, and vents).
- Isolated areas (100 square feet or less) of building materials (e.g., ceiling tiles, small areas on walls, individual or multiple wallboard panels).

Category II Protection

- Respiratory protection with full face piece respirators, with N100, R100, P100 (or for powered air purifying respirators – HEPA) particulate filters. Respirators must be used in accordance with the OSHA respiratory protection standard (29 CFR 1910.134).
- Disposable protective clothing covering entire body including both head and shoes.
- Gloves.

For use while cleaning the following:

- Large contaminated areas (more than 10 square feet) of HVAC systems.
- Extensively contaminated (more than 100 contiguous square feet) of building materials/
- Any size area where a lot of dust is generated during cleaning or debris removal (e.g., when abrasives must be used to clean contaminated surfaces or plaster walls are being demolished).
- Areas where the visible concentration of mold is heavy (blanket coverage rather than patchy).

These guidelines should be followed according to professional judgment. For example, more protective respirators may be required if toxic contaminants such as asbestos or lead are encountered during cleanup. All workers dealing with large areas of contamination should be properly trained to handle hazardous materials.

PPE Guidelines for the Public (Non-Workers) in Residences and Non-Occupational Settings

For the Public Involved in Cleanup, Debris Removal, or Similar Activities

The activities (and possible exposure to mold) of people re-entering their homes or working outside may be similar to those of workers. Preventing the creation of dust and limiting exposure to dust are always the best ways to minimize exposure to mold. For example, using wet mops or vacuums with HEPA filters instead of dry sweeping dust and debris will decrease the amount of dust in the air.

If building occupants, residents, or anyone must be around mold-contaminated dust, respirators will offer some protection. Particulate respirators (such as NIOSH-certified N-95 respirators) can be purchased in safety supply stores and in most home improvement stores. Several factors are required in order for respirators to provide protection from inhalation hazards:

- The respirator must fit well and be worn correctly. The manufacturer's instructions on the package should be followed. Beards will prevent the respirator from fitting correctly. Because respirators are meant to be used by healthy workers who have had training, medical evaluations, and a proper fitting, the amount of protection provided by a respirator to the general public may be much less.

- No U.S. agency tests and certifies respirators for public use. However, CDC/NIOSH tests and certifies respirators for use by workers to protect against workplace hazards. Respirators certified by CDC/NIOSH will say "NIOSH Approved" and will have an approval label that identifies the hazard it will protect against. The N-95 respirator is approved only for particulates including dust in the air from sweeping, sawing, mold removal, and other activities that cause dust. The N-95 respirator is not designed to

protect against exposure to vapors or gases, such as carbon monoxide, and will **not** provide protection from them.

The pictures below show a properly worn disposable respirator:

- Metal nose piece, if present, is on the top to adjust the fit to the wearer's nose.
- NIOSH label is on the bottom outside of the respirator
- Both respirator retaining straps are in place, and they are securing the respirator to the face. A few respirators have only one strap.

Proper way to wear an N-95 respirator

For the Public *Not* Involved in Cleanup, Debris Removal, or Similar Activities

People not involved in activities that disturb mold-contaminated materials have a lower risk of inhalation exposure relative to people performing those types of activities. People collecting belongings, visually inspecting homes or buildings, or doing basic clean up for short periods in a previously flooded home or building will not usually need to use a respirator.

For the Public Unable to Use PPE or at High Health Risk from Exposure to Mold

The effect of exposure to mold varies widely. The following is a list of people who may be affected to a greater extent than most healthy adults:

- Infants and children
- Elderly people
- Pregnant women
- People with respiratory conditions (such as asthma) or allergies.
- People with weakened immune systems (e.g., chemotherapy patients, organ or bone marrow transplant recipients, people with HIV infections or autoimmune diseases)

People with special health concerns should consult their health care provider if they are concerned about mold exposure. Symptoms that may seem related to mold exposure may be due to other causes, such as bacterial or viral infections or other allergies. In addition, it is possible that using respirators or other PPE may increase health risks for people with underlying health conditions. People who have trouble breathing while using a respirator should stop working and contact a doctor or other medical provider.

The level of risk associated with exposure activities and the potential benefit of recommended PPE are unknown for pregnant women, person older than 65 years, and children younger than 12 years. Due caution is recommended.

Exposure-reducing behavior and respiratory protection are problems for children younger than 12 years.

Resources

Centers for Disease Control and Prevention. Public Health Consequences Assessment Team Report. Response to Hurricane Floyd. Atlanta: US Department of Health and Human Services; 1999.

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Chapter 5

Potential Effects of Fungal Contamination on Health

In recent years, the health effects of exposure to mold in built environments have been a subject of intense public concern. These concerns and how they are approached will have important implications for the reconstruction and rehabilitation of New Orleans and surrounding areas.

Many clinical conditions could be caused by the fungal contamination due to flooding after Hurricanes Katrina and Rita. Predicting what might occur is speculative. However, many of these conditions are uncommon and will be recognized only if there is a high clinical index of suspicion. It is therefore worthwhile to attempt to anticipate them (Table 1). By anticipating what medical problems could be associated with post-flood fungal contamination, it may also be possible to prevent them by identifying susceptible populations and making recommendations for reducing potentially harmful exposures (see Public Health Strategies and Recommendations in Chapter 6).

Although we focus here on potential health effects of fungal contamination, we also recognize that there are many other exposures of concern. For example, dampness favors proliferation of dust mites and microorganisms such as bacteria and nontuberculous mycobacteria. Microbial growth derived from the walls of Gram-negative bacteria has strong inflammatory properties. Wetness can also release chemical constituents from building materials. Standing water supports rodent and cockroach infestations and proliferation of mosquitoes. Fecal contamination of the environment raises concerns for protozoal and helminthic parasites. Thus, fungi are not the sole potential cause of many conditions discussed in this chapter; and these conditions are only a subset of the conditions of concern to clinicians and public health professionals dealing with the aftermath of Hurricanes Katrina and Rita. For more information, see *Medical Care of Ill Hurricane Evacuees: Additional Diagnoses to Consider* at: http://www.bt.cdc.gov/disasters/hurricanes/katrina/medcare.asp.

Overview of Fungal-Induced Diseases

Fungi can cause a number of infectious and noninfectious conditions. Several basic mechanisms can underlie these conditions, including 1) immunologic (such as IgE-mediated allergic), 2) infectious, and 3) toxic. It is common for several of these mechanisms to contribute to pathogenesis of a fungal-induced disease. The types and severity of symptoms and diseases related to mold exposure depend in part on the extent of the mold present, the extent of the individual's exposure, and the susceptibility of the individual (e.g., people who have allergic conditions or who are immunosuppressed are more susceptible than those without such conditions). Molds produce a variety of volatile organic compounds (the most common being ethanol), which are responsible for the musty odors associated with fungal growth. Exposure to moldy indoor environments is also associated with a variety of upper and lower respiratory tract symptoms.

Institute of Medicine (IOM) Report on Damp Indoor Spaces and Health

In recent years, the issue of how damp indoor spaces and mold contamination affect human health has been highly controversial. In response, CDC commissioned the IOM to perform a comprehensive review of the scientific literature in this area. The resulting report, *Damp Indoor Spaces and Health*, was published in 2004 and remains the most current and authoritative source of information on this subject. The IOM categorized its findings into four categories:

- Sufficient evidence of a causal relationship.
- Sufficient evidence of an association.
- Limited or suggestive evidence of an association.
- Inadequate or insufficient evidence to determine whether an association exists.

It should be noted that "inadequate or insufficient evidence to determine whether an association exists" does not rule out the possibility of an association. Rather, it means that no studies examined the relationship or that published study results were of insufficient quality, consistency, or statistical power to permit a conclusion about an association.

Table 2 summarizes the findings of the IOM. Several of the conditions noted in the table are of particular interest to those engaged in the response to Hurricanes Katrina and Rita. There is sufficient evidence linking upper respiratory tract symptoms (such as nasal congestion, sneezing, runny or itchy nose, and throat irritation) to damp indoor environments and mold (with exposure to mold often determined by self-report). Similarly, there is sufficient evidence for a link with the lower respiratory tract symptoms of cough and wheeze. Sufficient evidence was also found for a link between damp indoor environments, mold, and asthma symptoms in sensitized people with asthma. There is also sufficient evidence for an association between mold exposure and hypersensitivity pneumonitis in a small proportion of susceptible people, invasive respiratory and other fungal infections in severely immunocompromised people, and fungal colonization of the respiratory tract or infection in individuals with chronic pulmonary disorders.

IgE-Mediated Diseases Caused by Fungi

IgE-mediated, or allergic, responses underlie the most common types of diseases associated with exposure to fungi. Atopy, or the genetic predisposition to form IgE responses to aeroallergens, is an important risk factor. Clinical conditions associated with allergy include allergic rhinitis and asthma. Allergic rhinitis is often associated with allergic conjunctivitis and sinusitis.

Symptoms of allergic rhinitis include sneezing; itching of the nose, eyes, mouth, or throat; nasal stuffiness; clear rhinorrhea; and, if associated with allergic conjunctivitis, red, itchy eyes. If associated with sinusitis, individuals may also complain of sinus fullness or post-nasal drip, often purulent. Signs on physical examination include pale, boggy nasal mucosa; nasal obstruction; and conjunctival redness. Examination of nasal scrapings or secretions shows eosinophilic inflammation. If appropriate allergy prick skin testing reagents or in vitro tests for serum specific IgE are done, they demonstrate specific IgE-sensitization to causative allergens. Unfortunately, skin testing reagents and blood tests documenting IgE-sensitization to molds are, with few exceptions, poorly standardized and of unclear sensitivity and specificity. The conventional hierarchy of treatment is avoidance of exposure to inciting agents; pharmacotherapy with antihistamines, decongestants, or anti-inflammatory agents such as nasal steroid sprays; or, as a last resort, allergen immunotherapy. Immunotherapy with fungal allergenic extracts is, with a few exceptions, of unknown efficacy.

Asthma is a disease characterized by episodic, reversible airways obstruction and eosinophilic airways inflammation. Over time, chronic asthma can lead to airways remodeling and irreversible airways obstruction. People with asthma often have symptoms such as chest tightness, wheezing, dyspnea, or cough. Physical examination during active asthma may show wheezing, but results of examinations between attacks are most often normal. If performed during active asthma, spirometry most often shows obstruction that reverses with inhalation of a bronchodilator. People with asthma generally exhibit bronchial hyperreactivity to methacholine challenge. However, a substantial proportion of people without asthma may also exhibit hyperreactivity to inhaled methacholine, so test results must be considered together with other clinical information. Approaches to demonstrating specific IgE sensitization to molds and limitations of available methods are as described for allergic rhinitis. Asthma is associated with airways inflammation that can be demonstrated by examining induced sputum for eosinophils or measuring exhaled nitric oxide, but these tests are often not performed in clinical settings.

Comprehensive guidelines for the staging and treatment of asthma are provided by the National Institutes of Health. Identifying and avoiding triggers, including occupational triggers, is a critical element of treatment. It is important to identify those with asthma triggered by materials in flood-damaged areas so avoidance measures can be taken. Drug treatment of asthma is with symptom controllers such as bronchodilators and anti-inflammatory agents such as corticosteroids or leukotriene antagonists. The role of allergen immunotherapy with most fungal agents in treatment of asthma is unclear. Therapy with monoclonal anti-IgE is a recently developed treatment option that can be tried when other, less expensive, modalities fail to reduce dependence on systemic corticosteroids

Allergic Diseases Associated With Airways Colonization

Allergic bronchopulmonary aspergillosis (ABPA) is a disease that occurs when the airways of individuals with obstructive pulmonary diseases such as asthma, cystic fibrosis, or chronic obstructive pulmonary disease (COPD) become colonized with *Aspergillus fumigatus* or other *Aspergillus* species. Inflammatory responses lead to additional airways damage. Marked worsening of existing asthma is a typical presentation of ABPA. The range of symptoms include recurrent episodes of bronchial obstruction, fever, malaise, expectoration of brownish plugs, peripheral blood eosinophilia, hemoptysis, and sometimes asymptomatic pulmonary consolidation. Other features include immediate skin test reactivity to *Aspergillus* antigens, precipitating serum antibodies to *A. fumigatus*, markedly elevated serum total IgE, fleeting lung infiltrates, and central bronchiectasis. Various authors have published criteria for diagnosis (see Adkinson et al. 2003). Airways colonization with other fungal species can result in a similar clinical picture. Although there is no known relationship between levels of exposure to *Aspergillus* and development of ABPA, clinicians should suspect and evaluate for the condition when appropriate.

Allergic fungal sinusitis (AFS) is noninvasive and typically occurs in allergic, immunocompetent patients: most have asthma, and 85% have nasal polyps. Fungal colonization is associated with a characteristic allergic mucin containing high levels of eosinophils. The mere presence of fungi in the nasal passages is not indicative of an active infection.

Hypersensitivity Pneumonitis

Hypersensitivity pneumonitis (HP), also known as extrinsic allergic alveolitis, is a granulomatous interstitial lung disease. A wide range of materials, including fungi, can be inhaled and thus sensitize susceptible people by inducing both antibody and cell-mediated immune responses. Re-exposure of sensitized individuals leads to lung inflammation and disease. Building-related HP caused by fungi and bacteria has been well demonstrated. Usually, only a small fraction of those with a given exposure develop HP, so poorly understood host factors play an important role in disease pathogenesis.

The presentation of HP is complex and can be either acute or chronic. The acute form is often associated with heavy exposures and characterized by chills, fever, malaise, cough, and dyspnea appearing 4 to 8 hours after exposure. It is often confused with pneumonia. The chronic form is thought to be induced by continuous low-level exposure. Onset generally occurs without chills, fever, or malaise and is characterized by progressive shortness of breath with weight loss. Chronic HP can be confused with idiopathic pulmonary fibrosis or other forms of interstitial lung disease.

The diagnosis of HP, especially the chronic form and the mild form, is often missed early in the course of the disease. If it does occur in the aftermath of Hurricanes Katrina and Rita, it will take a high degree of clinical suspicion to detect it. In general, when HP is suspected, a careful clinical and exposure history should be performed. Patients should be asked about their possible exposure to damp and water-damaged areas, farms, birds, hot tubs, and other environments that might cause HP. Environmental sampling for the presence of microorganisms known to cause HP and serologic testing for circulating precipitins can help to establish causative exposures. Chest imaging using chest x-rays or high-resolution computed tomography scanning of the thorax, lung-function tests, broncholaveolar lavage, and lung biopsy all have roles in diagnosis. A recent, large multicenter study found that under conditions of low or high prevalence, six predictors could be used in combination for noninvasive diagnosis of HP:

1) exposure to a known offending antigen,
2) positive precipitating antibodies to the offending antigen,
3) recurrent episodes of symptoms,
4) inspiratory crackles on physical examination,
5) symptoms occurring 4 to 8 hours after exposure, and
6) and weight loss.

Optimal treatment is elimination of causative exposures. The IOM report provides information about management of building-related HP that will be relevant to reoccupation of structures contaminated by fungi after Hurricanes Katrina and Rita. Such management includes giving standard medical therapy, such as systemic corticosteroids and removing sources of fungal contamination from the environment. The report notes that, in some cases, if efforts to remove mold from a building are unsuccessful in relieving symptoms, then the patient may need to move to another home or office.

Inhalation Fevers

Inhalation fever is a general name given to a variety of flu-like, self-limited syndromes that may be caused by a variety of stimuli. Two types of inhalation fevers are of particular concern in the wake of Hurricanes Katrina and Rita:

Humidifier fever is characterized by fever, respiratory symptoms, and fatigue with onset within hours after exposure to contaminated humidification systems. Obtaining a supportive history is critical to diagnosis. Thermophilic actinomycetes; other bacteria, including species of *Legionella* and *Pseudomonas*; and protozoa have been associated with humidifier fever. Aerosolized endotoxin derived from Gram-negative bacteria has an important role in this condition. Although humidifier fever can be confused with acute HP, it is a short-term ailment and removal from exposure is effective treatment. Humidifier fever is thought to represent a nonspecific inflammatory response to exposure.

Organic dust toxic syndrome (ODTS) has been reported among workers in a variety of agricultural and industrial settings and is thought to involve inhalation exposure to materials with heavy microbial contamination. Etiologic exposures that cause ODTS are often to a poorly defined mixture of substances, including fungi, bacteria, and microbial constituents such as endotoxin. ODTS is characterized by fever and flu-like symptoms, including general weakness, headache, chills, body aches, and cough occurring 4 to 12 hours after heavy exposure to organic dust. Dyspnea is also sometimes present. Results of chest auscultation and chest radiographs are usually normal. The peripheral white blood count is often elevated during attacks. Accurate patient history is critical to making a correct diagnosis. Although the symptoms resemble those of acute HP, they are not immune mediated. ODTS poses a risk for workers performing renovation work on building materials and is a realistic concern for workers handling heavily contaminated materials in the aftermath of Hurricanes Katrina and Rita. ODTS is best prevented by minimizing exposure through engineering controls, administrative controls, and respirators. For agricultural workers handling organic dusts, CDC recommends using the most practical respirator with the highest assigned protection factor. Chapter 4, "Personal Protective Equipment," and "Public Health Strategies and Recommendations" in Chapter 6 describe prevention recommendations for dusty and mold-disturbing activities such as remediation work.

Toxic Effects of Fungi

Many common molds can produce metabolites with a wide range of toxic activities such as antibiotic (e.g., penicillium), immune-suppressive (e.g., cyclosporine), carcinogenic (e.g., aflatoxins), emetic, and hallucinogenic (e.g., ergot alkaloids). Mycotoxins are fungal metabolites that poison humans and animals. Although ingestion is the most common route of exposure, inhalation and dermal contact can also cause adverse health effects. Mycotoxin production is dependent not only on species and strain of mold, but also on environmental conditions (e.g., temperature, water activity, light) and growth substrate. Thus, the presence of toxin-producing mold species does not necessarily indicate whether mycotoxins are present.

Mycotoxins were prematurely proposed as the cause of a disease outbreak of eight cases of acute pulmonary hemorrhage/hemosiderosis in infants in Cleveland, Ohio, in 1993 and 1994. The cluster was attributed to exposure to mycotoxins produced by *Stachybotrys chartarum*. Subsequent reviews of the evidence concluded that insufficient information existed and no such association was proven.

Almost all of the known effects of mycotoxin exposures are attributable to ingestion of contaminated food. Health effects from inhalational exposures to toxins are not well documented. The IOM found inadequate or insufficient evidence for a link between exposure to damp indoor environments and molds with a variety of conditions that have been attributed to toxicity (Table 2). A few case studies of agricultural and remediation workers have described

adverse health effects such as skin irritation, skin necrosis, cough, rhinitis, and bloody nasal exudate after inhaling or touching materials with heavy fungal contamination. We do not know if these effects were a result of exposure to mycotoxins or a general overload of organic material (see earlier discussion on ODTS). Currently no commercial clinical diagnostic tools are available to determine whether an individual's health effect is related to exposure to mycotoxins. Given the lack of information regarding noningestion mycotoxin exposure and adverse health effects in humans, it would be prudent to take precautions when handling heavily contaminated building materials.

Fungal Infections

Infection with fungal species that contaminated buildings, building constituents, and the environment after Hurricanes Katrina and Rita is an important concern. In general, individuals with impaired host defenses (especially if impaired because of cell-mediated immunity or neutropenia) suffer the most severe types of fungal infections (Table 3). However, invasive fungal infections can also occur in individuals with normal host defenses and, in certain situations, can even be life threatening (Table 4).

Individuals at greatest risk for developing invasive fungal infection from heavy fungal contamination after Hurricanes Katrina and Rita are those with impaired host defenses (Table 3). Any impairment in cell-mediated immunity or neutropenia (e.g., human immunodeficiency virus [HIV] infection, leukemia, lymphoma, diabetes mellitus) increases risk for many types of invasive fungal infections. Severely immunosuppressed individuals, such as solid-organ or stem-cell transplant recipients, or those receiving cancer chemotherapy agents, corticosteroids, or other agents inhibiting immune function are at much higher risk for these infections: locally invasive infections of the lungs, sinuses, or skin; and systemic infections. *Aspergillus* species, zygomycetes, and *Fusarium* species are particularly important problems. These serious infections are often fatal, even with aggressive antifungal therapy.

Protective measures, such as HEPA filtration, implemented during periods of extreme susceptibility to invasive fungal infections are well established and effective in hospitals. For more information, see the CDC *Guidelines for Environmental Infection Control in Health-Care Facilities* at: http://www.cdc.gov/mmwr/PDF/rr/rr5210.pdf. However, preventive measures outside the hospital are less well established. Current guidelines emphasize the importance of avoiding areas of high dust (e.g., excavation sites, building construction or renovation sites, chicken coops, caves) and factors associated with fungal infections (e.g., foods that increase a person's risk for fungal exposure).

As noted earlier, obstructive pulmonary diseases such as asthma, cystic fibrosis, and COPD may predispose people to airway colonization with *Aspergillus*. Inflammatory host responses to colonization can lead to ABPA. *Aspergillus* can also cause invasive or semi-invasive infection in people with COPD, especially in those being treated with corticosteroids. Chronic necrotizing pulmonary aspergillosis is an indolent condition seen in individuals with underlying lung disease.

Colonization of lung cavities (such as tuberculosis cavities or emphysematous blebs) by *Aspergillus* can cause pulmonary aspergillomas (fungus balls), which are conglomerations of *Aspergillus* hyphae matted together with fibrin, mucus, and cellular debris. These often do not cause symptoms, but they can be associated with hemoptysis. An exposure-response relationship

has never been established linking levels of exposure to *Aspergillus* with development of any of these conditions. It is therefore unclear to what degree exposure to fungal contamination after Hurricanes Katrina and Rita would increase any risk. However, despite unknown benefit, it seems prudent for individuals with clinically significant obstructive pulmonary diseases (such as asthma, cystic fibrosis, COPD), and individuals with cavitary lung disease from conditions such as tuberculosis to avoid airborne exposure to materials that have become heavily contaminated with fungal growth in the wake of Hurricanes Katrina and Rita.

Individuals with normal host defenses are also subject to fungal infections (Table 4), and people with impaired host defenses can acquire any of these, often with greater severity. Ocular, skin, and superficial infections occur in those with normal host defenses and run from the relatively common (e.g., ringworm, athlete's foot) to the relatively rare (e.g., sporotrichosis). Of particular relevance to post-Hurricanes Katrina and Rita areas of fungal contamination are organisms that cause localized skin and superficial infections following traumatic inoculation with soil and plant saprophytes, which are found in air, soil, and plant materials. For example, S*cedosporium apiospermum* (*Pseudallescheria boydii*) can be recovered from polluted water, sewage, swamps, and poultry or cattle manure. This organism can cause a soft tissue infection called Madura foot, a mycetoma in which the draining sinuses show white grains containing fungal elements. This organism can also produce septic arthritis or osteomyelitis after penetrating trauma. *Sporothrix schenckii* is a dimorphic fungus that produces soft tissue infections after traumatic inoculation from a contaminated environmental source, such as sphagnum moss, roses, plant seedlings, and other vegetation. Lymphocutaneous lesions are the hallmark of sporotrichosis, as the organisms spread through the local lymphatics after primary inoculation. A high degree of clinical suspicion is needed to diagnose the less common, locally invasive fungal infections. Diagnosis is made by histopathology and culture after biopsy of the affected lesion. Histopathology must be performed to verify that a recovered isolate is, in fact, the cause of disease and not an environmental contaminant. Culture must be performed to identify the agent correctly. Fungal isolates are identified in a clinical mycology laboratory.

Invasive pulmonary mycoses in individuals with normal host defenses are generally thought to occur outdoors where there has been active disturbance of a reservoir. The mode of transmission is inhalation of fungal spores. Person-to-person transmission of pulmonary mycoses does not occur. Diseases relevant to Louisiana include histoplasmosis and blastomycosis. Histoplasmosis is unlikely to be increased as a result of fungal contamination after Hurricanes Katrina and Rita. It is caused by *Histoplasma capsulatum*, a dimorphic fungus found in soil enriched with the droppings of birds and bats. Endemic areas in the United States are around the Mississippi and Ohio River valleys. Many individuals develop no symptoms when exposed to *H. capsulatum* in an endemic setting.

Blastomycosis deserves special attention post-Hurricanes Katrina and Rita because 1) it can cause serious disease even in those with normal host defenses and 2) an endemic area is in Louisiana about 70 miles from New Orleans. Blastomycosis is caused by the dimorphic fungus *Blastomyces dermatitidis.* The organism is found in moist soil, frequently along streams or rivers enriched with decaying vegetation. In the United States, the organism is most commonly found in states surrounding the Mississippi and Ohio rivers. Cases in Louisiana occur at an incidence of about 1 to 10 per year, mostly in the endemic area of Washington Parish, Louisiana. Outbreaks have been associated with manipulation of decaying vegetation or recreational activity near lakes or rivers. The incubation period is not certain but, on the basis of data from outbreaks, appears to be about 45 days (ranging from weeks to months).

The clinical spectrum of blastomycosis includes asymptomatic infection, acute or chronic pneumonia, and disseminated disease. Pulmonary infection can mimic acute bacterial pneumonia or tuberculosis with progression to acute respiratory distress syndrome. Alveolar infiltrates, mass lesions that mimic bronchogenic carcinoma, and fibronodular interstitial infiltrates are the most common radiographic findings. Disseminated blastomycosis often appears as ulcerative skin lesions with multiple necrotic bone lesions in the vertebrae, skull, or long bones.

Culture of lesions or histopathologic evidence from infected tissue is required for diagnosis of blastomycosis. Direct microscopy of pus, scrapings from skin lesions, or sputum showing thick-walled broad-based budding yeast cells 5–15 μm in diameter supports a presumptive diagnosis of blastomycosis and may, in the appropriate clinical setting, prompt the initiation of antifungal therapy. Serologic tests can be performed on serum from patients showing signs of suspected pulmonary blastomycosis or with suggestive skin lesions. A positive immunodiffusion (ID) test, showing a precipitin band with the *Blastomyces* A antigen, is highly specific for the disease, and does not require paired serum samples. However, the sensitivity is poor (33%–88%), so a negative ID test does not rule out the disease. For cases with negative results, the test should be repeated in 3 to 4 weeks after the initial sampling. The complement fixation (CF) test for blastomycosis has poor sensitivity and specificity.

Fungal brain abscesses are uncommon in healthy individuals, but they can occur. The primary infection results from inhalation of infectious conidia from the environment; the route of infection appears to be hematogenous dissemination from the lungs. Of particular interest post-Hurricanes Katrina and Rita is *Scedosporium apiospermum* (*Pseudallescheria boydii*). Many case reports in the medical literature document patients with focal neurologic defects caused by multiple brain abscesses weeks or months after nearly drowning. The organism apparently spreads hematogenously after initial aspiration of sewage-laden water (from floods, lagoons, or bayous) into the lungs. It is presumed that the near drowning results in a massive inoculation of mold into the lungs.

Preventing Adverse Health Effects From Environmental Fungal Contamination After Hurricanes Katrina and Rita

People should strive to reduce their exposure to molds as much as possible, especially people with underlying or induced immunosuppressed conditions or diseases caused by immune sensitization to fungal constituents present in mold growth. If exposure to heavily mold-contaminated materials is unavoidable, refer to Chapter 4, “Personal Protective Equipment” and Chapter 6, “Public Health Strategies and Recommendations” regarding proper selection of administrative, engineering, and personal protection controls. Because an individual’s likelihood of developing adverse health effects from mold exposure depends on the type of exposure and on individual susceptibility, precautionary measures need to be customized. On the basis of experience and published study results, a reasonable approach to preventing these conditions is proposed in Chapter 6. In large part, these recommendations are based on professional judgment rather than on scientific evidence. For example, no research studies have evaluated the effectiveness of personal protective equipment in preventing illness from mold exposure. Total avoidance is suggested for individuals with specific underlying conditions such as profound immunosuppression. Respiratory protection, dermal protection, and occlusive eye protection recommendations are customized to various populations and exposure-associated activities. It is reasonable to assume that repeated or prolonged exposure poses a greater health risk than do

exposures of a similar intensity, but short duration. Preventive precautions are therefore especially important for people who expect to be highly exposed for a long time.

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Table 1. Health Effects of Fungal Contamination After Hurricanes Katrina and Rita: Conditions of Special Concern

	Presentation	Specific Condition	Risk Factors and Mechanisms	Clinical and Diagnostic Considerations
Non-Infectious Syndrome				
Upper Respiratory	Nasal congestion, sneezing, runny or itchy nose, sore throat	Irritation	Not immunologic	Self –limited
		Allergic rhinitis, conjunctivitis, sinusitis	IgE-mediated, atopy a risk factor	Positive skin or blood tests for IgE sensitization; eosinophilic nasal inflammation; colonization is not diagnostic; effective treatment available.
Lower Respiratory	Cough, wheeze	Irritation	Not immunologic	Self-limited
		Asthma	Often IgE-mediated; small exposures can cause symptoms in sensitized individuals; ability of exposures to cause asthma is unclear	Skin or blood tests for IgE sensitization are often positive; airways instability documented as spirometric obstruction reversible with bronchodilators or by methacholine challenge; well-established treatment guidelines.
	Pneumonia-like presentation with cough, dyspnea, fever, chills (acute form); dyspnea, weight loss (chronic form)	Hypersensitivity Pneumonitis	Granulomatous interstitial lung disease; even low levels of airborne exposure can trigger symptoms if susceptible (unknown host factors contribute to susceptibility)	Symptom onset in acute form within hours of exposure; chronic form requires ongoing exposures and often lacks acute symptoms; diagnosis by criteria including history, physical, chest imaging, serum precipitins, etc.
	Worsening of existing asthma; pneumonia-like episodes; coughing up brown plugs	Allergic bronchopulmonary aspergillosis (ABPA)	Airways colonization with *Aspergillus* in the setting of obstructive lung diseases (asthma, cystic fibrosis, or COPD); risk from increased *Aspergillus* exposure is unclear	Diagnosis is based on multiple criteria, including fleeting infiltrates, central bronchiectasis, positive sputum culture for *Aspergillus,* positive Aspergillus skin test, positive serum precipitins, and increased serum IgE
Inhalational Fevers	Fever, flu-like symptoms within hours of exposure	Humidifier fever	Inflammatory response to bioaerosols from contaminated humidification systems	Self-limited if remove exposure
	Fever, flu-like symptoms within hours of exposure	Organic dust toxic syndrome (ODTS)	Inflammatory response to heavy dose of bioaerosols generated from contaminated materials	Prevention during renovation tasks is critical

Infectious Syndrome				
Upper Respiratory	Inflammation of mucosa with ischemia and necrosis	Acute invasive fungal sinusitis	Poorly controlled diabetes, ketoacidosis (especially zygomycosis), immunosuppressed persons.	Histopathology is critical
Pneumonia	Fever, malaise, fatigue, cough, dyspnea, often presents with mild symptoms.	Aspergillosis, Fusariosis, *Scedosporium* infection	Immunosuppressed persons, e.g., impaired host defense from, leukemia, lymphoma, organ transplant, or treatment with corticosteroids, cancer chemotherapy, immunosuppressive medications.	Histopathology is critical; skin lesions common and blood culture often positive in fusariosis.
	Fever, malaise, fatigue, cough, dyspnea	Blastomycosis	Normal hosts are susceptible; endemic to Washington Parish, LA; exposure to dirt excavation, decaying vegetation, or river water should be suspect	Often extrapulmonary (e.g., skin, skeletal) lesions; consider histopathology and culture of any respiratory and skin illness
Skin	Post-traumatic infection	*Scedoporium apiospermum*	Inoculation of mold while exposed to polluted water, usually feet or legs	Madura foot, a mycetoma with draining sinuses demonstrate white grains of fungal elements
		Sporothrix schenckii	Inoculation from vegetation (e.g., bushes)	Spread through local lymphatics
Endophthalmitis, keratitis	Ocular pain, redness, photophobia	Various	Minor trauma to eye with inoculation of soil or plant saprophytes	Full ophthalmologic exam, corneal scraping, vitreous tap for culture
Central Nervous System	Brain abscess	*Scedosporium apiospermum* (classically)	Transient pulmonary infection with hematogenous spread after massive aspiration of polluted water (near drowning)	Can present up to 3 months after near drowning

Table 2. Summary of Institute of Medicine's *Damp Indoor Spaces and Health* (2004)

Evidence of an association between damp indoor environments and mold health outcomes		
Health outcome or symptom	**Exposure to damp indoor environments**	**Presence of mold or other agents in damp indoor environments**
Upper respiratory tract symptoms[1]	Sufficient evidence of an association[7]	
Cough[2]	Sufficient evidence of an association	
Mucous membrane irritation syndrome	Inadequate or insufficient evidence	
Wheeze[2]	Sufficient evidence of an association	
Asthma symptoms in sensitized persons with asthma	Sufficient evidence of an association	
Asthma development	Limited or suggestive evidence	Inadequate or insufficient evidence
Airflow obstruction in otherwise healthy persons	Inadequate or insufficient evidence	
Chronic obstructive pulmonary disease	Inadequate or insufficient evidence	
Hypersensitivity pneumonitis[3] in susceptible persons	Studied in relation to specific agents	Sufficient evidence of an association
Shortness of breath (dyspnea)[2]	Limited or suggestive evidence[8]	Inadequate or insufficient evidence[9]
Respiratory illness in otherwise healthy children	Limited or suggestive evidence	
Respiratory illness in otherwise healthy adults	Inadequate or insufficient evidence	
Acute idiopathic pulmonary hemorrhage in infants	Inadequate or insufficient evidence	
Fungal sinusitis[4]	No specific studies associated the condition with damp or moldy indoor spaces	
Severe respiratory infections in people whose immune system is severely immunocompromised[5]	Not applicable[10]	Sufficient evidence of an association
Fungus-related illnesses in people whose immune system is severely immunocompromised[5] and who have chronic obstructive pulmonary disease (COPD)	Not applicable[10]	Sufficient evidence of an association

Colonization and potential lung infection in people with some chronic pulmonary disorders[6]	Not applicable[10]	Sufficient evidence of an association
Skin symptoms, gastrointestinal problems, fatigue, neuropsychiatric symptoms, cancer, reproductive effects, and rheumatologic and other immune conditions	Inadequate or insufficient evidence	

Footnotes:

1. Upper respiratory tract symptoms include nasal congestion, rhinitis, allergic rhinitis (“hay fever"), sneezing, runny or itchy nose, sinusitis, and sore throat.
2. Lower respiratory tract symptoms include cough, with or without production of phlegm; wheeze; chest tightness; and shortness of breath.
3. Hypersensitivity pneumonitis is a lung disease that results from exposure and sensitization to antigens inhaled with a variety of organic dusts. Symptoms include dry cough, dyspnea, fever, and sometimes acute bronchospasm.
4. Fungal sinusitis is associated with molds, but molds may come from the indoor or the outdoor environment.
5. Immunocompromised people are at increased risk for fungal colonization or opportunistic infections.
    - It is well established that fungal exposure causes opportunistic cutaneous and subcutaneous fungal infections of the skin of severely immunocompromised persons.
    - Respiratory infections can result from exposure to fungi, including *Aspergillus* spp. and *Fusarium* spp.
    - Severely immunocompromised persons include persons who undergo high-dose cancer chemotherapy, are recent recipients of a solid-organ transplant, or are otherwise immunocompromised.
6. Chronic pulmonary disorders include cystic fibrosis, asthma, and COPD. Colonization and infections result from exposure to fungi such as *Aspergillus*.
7. "Sufficient evidence of an association" means that studies show an association between the agent and disease and that chance, bias, and confounding factors were ruled out with reasonable confidence.
8. "Limited or suggestive evidence of an association" means that evidence is suggestive of an association between the agent and the disease but is limited because chance, bias, and confounding factors cannot be ruled out with confidence.
9. "Inadequate or insufficient evidence to determine whether an association exists" means that the available studies are of insufficient quality, consistency, or statistical power to permit a conclusion regarding the presence of an association. It could also mean that no studies have examined the relationship.
10. Respiratory infections, fungus-related illnesses, and colonization with lung infection relating to specific organisms.

Source:

Institute of Medicine. Damp indoor spaces and health. Washington, DC: National Academies Press; 2004. Available at: http://www.nap.edu/books/0309091934/html/.

Table 3. Fungal Infections in Immunosuppressed Hosts (Most Common Agents)

Route	**Syndrome**	**Organism**
Inhalation	acute sinusitis	zygomycetes (*Rhizopus, Rhizomucor, Absidia*); *Aspergillus* species
Inhalation	rhinocerebral mucormycosis brain abscess	zygomycetes (*Rhizopus, Rhizomucor, Absidia*); *Aspergillus* species
Dissemination from primary focus in lungs	skin lesions bone lesions other body sites	*Blastomyces dermatitidis; Histoplasma capsulatum*
Dissemination from primary focus in lungs	skin lesions meningitis fungemia	*Cryptococcus neoformans*
Inhalation	invasive pulmonary aspergillosis	*Aspergillus* species (*A. fumigatus* and *A. flavus* most common)
Inhalation	invasive systemic infections	*Fusarium* species
Inhalation	Pneumonia	*Scedosporium* species
Inoculation	skin/soft tissue	*Fusarium* species

Note: Immunosupressed hosts may also acquire any of the agents/syndromes shown in Table 4.

Table 4. Fungal Infections in Normal and Compromised Hosts (Most Common Agents)

Route	Syndrome	Organism
Traumatic implantation	Chronic sinusitis	*Alternaria*, *Bipolaris*, *Curvularia*, *Exserohilum* species; *Aspergillus* species
Inhalation/implantation	Brain abscess	*Scedosporium apiospermum*; *Cladophialophora bantiana; Ochroconis (Dactylaria) gallopava; Exophiala (Wangiella) dermatitidis; Curvularia*, *Bipolaris, Exserohilum* species
Inhalation	Aspergilloma (fungus ball) chronic necrotizing pulmonary aspergillosis	*Aspergillus* species (*A. fumigatus* and *A. flavus* most common)
Inhalation	Pulmonary	*Blastomyces dermatitidis; Histoplasma capsulatum* Note: The Gulf Coast is not in the endemic area but is adjacent to an endemic area
Trauma to eye	Keratitis/other Ocular infections	*Fusarium*, *Aspergillus, Scedosporium*, *Paecilomyces, Acremonium* species; *Curvularia, Exserohilum, Bipolaris* species; Zygomycetes (*Rhizopus* and others);
Person to person Fomite to person or Animal to person Note: clusters and outbreaks possible	Skin/hair/nails	Dermatophytes (*Microsporum*, *Trichophyton Epidermophyton* species)
Inoculation Note: not contagious	Skin/nails	*Scytalidium*, *Candida*, *Scopulariopsis* species
Inoculation	Skin/deep tissue	*Aspergillus, Fusarium Scedosporium, Acremonium* species (hyalohyphomycosis); *Alternaria, Exophiala jeanselmei, Exophiala (Wangiella) dermatitidis, Phialophora, Curvularia, Bipolaris* species (phaeohyphomycosis); *Fonsecaea pedrosoi, Cladophialophora carrionii, Phialophora verrucosa* (chromoblastomycosis); *Sporothrix schenckii (sporotrichosis)*

Chapter 6

Public Health Strategies and Recommendations for State and Local Officials

This chapter contains CDC's recommendations for protecting and monitoring the health and safety of workers and residents who enter, repair, or destroy buildings that were flooded as a result of Hurricanes Katrina and Rita. The recommendations are focused on limiting 1) human exposure to mold and other microbial agents and 2) preventing any adverse health effects related to such exposure. Wherever possible these recommendations are based on existing recommendations or guidelines. When adequate guidelines do not exist, the authors reached consensus on a recommendation based on their experience and expertise. Several factors are assumed:

- In the aftermath of Hurricanes Katrina and Rita, buildings or materials soaked for more than 48 hours are contaminated with mold unless proven otherwise by adequate environmental sampling or cleaned according to the Environmental Protection Agency's recommendations. See *Mold Remediation in Schools and Commercial Buildings.* Available from: http://www.epa.gov/iaq/molds/mold_remediation.html.
- The geographic area in which these conditions exist is extensive.
- Vast numbers of people (workers and residents) will be exposed to high levels of mold-related contaminants.
- Sufficient evidence exists of an association between adverse health outcomes and exposure to damp indoor environments or materials contaminated with fungal growth.
- Insufficient evidence exists for establishing health-related guidelines on the basis of concentrations of mold (quantitative measure) or species of mold (qualitative measure) in either indoor or outdoor environments.
- Clear, concise, and practical recommendations and actions are necessary to limit exposure to mold and to prevent mold-related health outcomes where possible.

Assessing Exposure to Mold

Exposure assessment is usually a critical step in determining whether people are exposed to a hazard at a level that could have an adverse health effect. The mere presence of a chemical or biological hazard in the environment is insufficient to create a public health hazard. The contaminant must be present in an environmental medium (e.g. air, water, food, dust) that allows it to come in contact with people and move along a biologic pathway (e.g., inhalation, ingestion, absorption). In addition, the concentration of the contaminant must be sufficient to create a biologic response that leads to an adverse health outcome. Mold and its spores exist in damp materials. Disturbing mold releases potentially hazardous particulates into the air, which can then be drawn into the sinuses and lungs. Although molds may also directly attack the skin or openings in the skin, the most common route of exposure is through the air and into the body by inhalation.

Environmental sampling for molds has limited value and, in most instances, is not needed after Hurricanes Katrina and Rita.

Public Health Recommendations Related to Exposure Assessment

- Assume that building interiors are significantly contaminated with mold in the following circumstances:
    - The building was saturated with water for more than 48 hours.
    - Visible mold growth is extensive and in excess of that present before Hurricanes Katrina and Rita.
    - Signs of water damage are visible, or mildew odors are strong.

- Assume that exposure to materials and structures contaminated with mold may present a health risk regardless of the type of mold. Risk of illness does not necessarily vary with the type of mold or the extent of contamination.

Preventing Excessive Exposure to Mold

Preventing excessive exposure to mold is the best way to avoid harmful health consequences. The preferred approach to preventing mold exposure is to prevent water from infiltrating a building or damaging household goods and structures. Unfortunately, post Hurricanes Katrina and Rita, substantial water damage and mold growth has already occurred in most buildings.

If left undisturbed, mold is generally not a hazard, and most people will not be adversely affected by moderate exposure to mold. To prevent excessive exposure to mold in contaminated areas that are disturbed, people who enter those areas should implement environmental controls (e.g., suppress dust, isolate the contaminated area), use personal protective equipment, or both.

How to protect people from exposure to mold depends on three factors:

1) The likely concentration of mold in the building fabric or materials.
2) The duration and type of activity undertaken in the mold-contaminated area.
3) The susceptibility of the individual entering the area to the various health effects.

There are four methods for preventing exposure to mold:

1) Avoid exposure.
2) Use environmental controls.
3) Use personal protective equipment (PPE).
4) Be strict about personal hygiene.

Next, each method is discussed in detail.

Avoiding Exposure

People

The following people should *avoid* mold-contaminated environments entirely:

- Transplant recipients, including those who received organ or hematopoietic stem cell transplants within the last 6 months or who are undergoing periods of substantial immunosuppression
- People with neutropenia (neutrophil count < 500/μL) due to any cause, including neoplasm, cancer chemotherapy or other immunosuppressive therapy
- People with CD4+ lymphocyte counts < 200/μL due to any cause, including HIV infection

- Other individuals considered by their physicians to have profoundly impaired antifungal host defenses due to congenital or acquired immunodeficiency
- Infants and children

The following people may be able to tolerate limited exposure, but they should consult with their physicians and should consider avoiding areas where moldy materials are disturbed:

- People receiving chemotherapy for cancer, corticosteroid therapy, or other immunosuppressive drug therapy, as long as neutropenia or CD4+ lymphopenia are not present
- People with immunosuppressive diseases such as leukemia or lymphoma, as long as there is not marked impairment in immune function
- Pregnant women

Places

- All buildings with extensive mold contamination require remediation before rehabitation. Remediation includes structural repairs to prevent additional water intrusion; removal of mold-contaminated materials that cannot be adequately cleaned and decontaminated; and cleaning and decontamination of mold-contaminated materials that can withstand such treatment. Health care facilities and other locations that house highly susceptible people require special attention. These facilities must be adequately remediated before being occupied by highly susceptible people. Guidelines for remediating such facilities are published in these documents:
    - Remediation and Infection Control Considerations for Reopening Healthcare Facilities Closed due to Extensive Water and Wind Damage, available at http://www.bt.cdc.gov/disasters/hurricanes/katrina/reopen_healthfacilities.asp and
    - Check List for Infection Control Concerns when Reopening Healthcare Facilities Closed due to Extensive Water and Wind Damage, available at http://www.bt.cdc.gov/disasters/hurricanes/katrina/reopen_healthfacilities_checklist.asp

Using Environmental Controls

Examples of environmental controls include isolating or containing the contaminated area, ventilating the area, and suppressing the dust in the area (e.g., by wet-mopping the mold-contaminated surfaces to reduce airborne mold concentrations).

Many methods of isolation can be used to minimize mold exposure. For example, workers operating heavy equipment during the demolition and removal of mold-contaminated materials can be isolated in sealed, positive-pressure, air-conditioned cabs that contain filtered air recirculation units. Another method of isolation involves sealing off the mold-remediation areas in occupied, mold-contaminated buildings. However, isolated areas must also be adequately ventilated.

Preventing the creation of dust and limiting exposure to dust are essential to minimizing exposure to mold. For example, when cleaning up dust, workers should use wet mops or vacuums with HEPA filters instead of dry sweeping.

Using Personal Protective Equipment

Respirators

Inhalation is the primary exposure route of concern related to mold for workers, homeowners, and building occupants. Environmental controls are sometimes inadequate to control airborne exposure to mold or dust containing mold. In such cases, respirators protect people from inhaling the airborne contaminated dust and other particulates released during dust-generating processes (such as cleanup or debris removal). Recommendations on when to wear a respirator depend on the severity of the mold contamination, whether the person's activity is such that mold or endotoxin particles are likely to be released into the air, and the person's health status (Table 5).

The following recommendations are made with the assumption that heavy mold contamination is present.

Respiratory Protection

Use of respirators is discussed in detail in Chapter 3 and Table 5 in this chapter. Here are the recommendations in brief:

- Healthy people who are in a building for a short time or who are in a place where activity minimally disturbs contaminated material (such as retrieving personal possessions) may not need a respirator.
- People engaged in activities that moderately disturb contaminated material (such as light cleaning by removing mold from surfaces with a wet mop or cloth) and people with health conditions that place them at risk for mold-related health problems should use at least a N-95 respirator that is certified by CDC's National Institute of Occupational Safety and Health (NIOSH).
- People doing remediation work that involves extensive exposure to mold should have respiratory protection greater than that provided by a NIOSH-certified N-95 respirator. We recommend protection with full face-piece respirators that have NIOSH-certified N100, R100, P100 particulate filters. For powered air-purifying respirators, use a HEPA filter.
    - Respirator selection is made after considering the characteristics of the work activities; the specific exposures of concern; and the protection factors, advantages, and disadvantages of various respirators.
    - The determination of whether a person will have extensive exposure to mold should be based on several factors including the size of the mold-contaminated area, the type of mold-contaminated material, and the activities being performed. Guidelines based solely on area of contamination define extensive contamination as being more than 100 square feet.
    - Formal fit testing is recommended for anyone engaging in remediation work causing extensive exposure to mold.

The following is important information for everyone who uses respiratory protection:

- Respirators must fit well and be worn correctly.
- NIOSH tests and certifies respirators for use by workers to protect against workplace hazards. Respirators certified by NIOSH have "NIOSH Approved" written on them and have a label that identifies the hazard the respirators protect against.
- The N-95 respirator is approved only as protection against particulates (including dust) and will not protect people from vapors or gases such as carbon monoxide.

Eye Protection and Protective Clothing

Eye protection is warranted for workers cleaning up mold-contaminated areas and for people with health conditions that place them at high health risk **(**Table 5). To protect eyes, use properly fitted goggles or a full face-piece respirator. Goggles must be designed to prevent the entry of dust and small particles. Safety glasses or goggles with open vent holes are not appropriate during mold remediation. The CDC/NIOSH publication *Eye Safety: Emergency Response and Disaster Recovery* provides further information on this topic and is available at http://www.cdc.gov/niosh/eyesafe.html. While conducting building inspections and remediation work, people may encounter hazardous biological agents as well as chemical and physical hazards. Consequently, appropriate personal protective clothing, either reusable or disposable, is recommended to minimize cross-contamination between work areas and clean areas, to prevent the transfer and spread of mold and other contaminants to street clothing, and to eliminate skin contact with mold and chemicals. In hot climates, wearing protective clothing may increase risk for dehydration or heat stress. Take special precautions to avoid these conditions (e.g., drink plenty of water).

Hygiene

Disposable PPE should be discarded after it is used. Such equipment should be placed into impermeable bags and usually can be discarded as ordinary construction waste. Appropriate precautions and protective equipment for biocide applicators should be selected on the basis of the product manufacturer's warnings and recommendations (e.g., goggles or face shield, aprons or other protective clothing, gloves, and respiratory protection). Reusable protective clothing should be cleaned according to the manufacturers' recommendations for cleaning after the product has been exposed to mold. Hands should be washed with clean potable water and soap after gloves are removed.

See also protection recommendations in Table 5.

General Distribution of PPE

Health officials should consider whether their agencies should supply PPE to residents who may not otherwise be able to acquire the necessary equipment. Providing PPE to the local population would require significant resources and a mechanism for distributing them.

Cleanup

To clean mold-contaminated areas

- Take out and discard items that have soaked up water and that cannot be cleaned and dried.
- Use fans and dehumidifiers to remove moisture, and open doors and windows.

To remove mold

- Mix 1 cup of bleach in 1 gallon of water.
- Wash the item with the bleach mixture.
- Scrub rough surfaces with a stiff brush.
- Rinse the item with clean water.
- Dry the item, or leave it to dry.

To clean hard surfaces that do not soak up water

- Wash the surfaces with soap and clean water.
- Disinfect them with a mixture of 1 cup of bleach in 5 gallons of water.
- Allow to air dry.

Important

- Wear rubber boots, rubber gloves, and goggles when cleaning with bleach.
- Open windows and doors to get fresh air.
- Never mix bleach and ammonia: the fumes from the mixture can kill.

Health-Outcome Surveillance and Follow Up

State and local public health agencies do not generally collect information on the conditions related to mold exposure. Because of the large number of flooded and mold-contaminated buildings in New Orleans and the repopulation of those once-flooded areas, a large number of people are likely to be exposed to potentially hazardous levels of mold and other microbial agents.

Efforts to determine the health effects of these exposures and the effectiveness of recommendations to prevent these adverse health effects require a surveillance strategy. Developing such a strategy requires that federal and local health agencies work together to monitor trends in the incidence or prevalence of mold-related conditions throughout the recovery period.

Health outcomes that might be related to mold exposure include those listed in Chapter 5. Monitoring trends in these conditions will require substantial human and financial resources and will face several challenges. Health outcomes that may be attributed to mold exposure fall into several broad categories. Some potential health outcomes are rare, difficult to diagnose, and relatively specific for fungal exposure (e.g., blastomycosis). Other health outcomes are relatively easy to diagnose, but they have numerous etiologic factors and are difficult to attribute specifically to mold exposure (e.g., asthma exacerbations). Tracking different health outcomes that may be caused by mold exposure requires different surveillance methods. In some cases, follow-up research will be needed to verify that surveillance findings and health outcomes are the result of mold exposure. For some conditions, difficulties in interpreting trends and in relating the outcome to mold exposure may suggest that surveillance is not an appropriate public health approach.

Results of surveillance and follow-up activities will help CDC to refine the guidelines for exposure avoidance, personal protection, and cleanup. In addition, these activities should assist health departments to identify currently unrecognized hazards.

Surveillance

Public health agencies should consider collecting health outcome information from health care facilities to monitor the incidence or prevalence of selected conditions. State or local agencies should determine the feasibility of this approach and consider the required resources available or attainable to accomplish this goal. Institutions from which data could be collected include hospitals, emergency departments, clinics, and (for some outcomes) specific subspecialty providers. Surveillance will require the establishment of case definitions and reporting sources;

development of reporting mechanisms; training of data providers; and the collection, analysis, and reporting of data. The surveillance data should be used to identify increases in disease that are significant enough to trigger public health interventions or follow-up investigations to learn the reason for the increase and establish targeted prevention strategies.

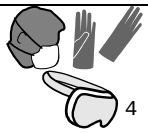
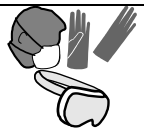
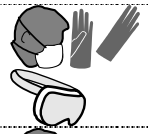
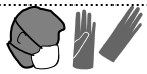
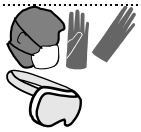
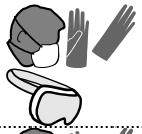
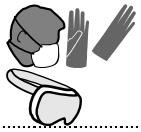
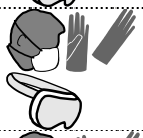
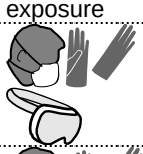
Public health agencies should consider the need for clinicians to report cases of known or suspected mold-associated illnesses (e.g., invasive fungal disease, blastomycosis, hypersensitivity pneumonitis attributed to mold contamination, ODTS attributed to contaminated dust exposure, alveolar hemorrhage in infants) to public health authorities for tracking and follow-up investigations. Providers caring for patients at high risk for poor health outcomes related to mold exposure could be targeted. For example, hematologists, rheumatologists, and pulmonologists may care for many patients at risk for invasive mold infections because of underlying malignancies and immunosuppression. Enhancing provider-based surveillance requires targeting and educating providers; developing reporting mechanisms; and the collecting, analyzing, and reporting data.

Public health agencies should consider the need for establishing laboratory-based surveillance as an efficient method for monitoring mold-related illnesses that involve laboratory analyses (e.g., invasive fungal disease, blastomycosis, invasive aspergillosis, histoplasmosis, *Aspergillus* preceptins, zygomycosis, fusariosis).

Clinical Care

Health care providers should be watchful for unusual mold-related diseases that may occur (e.g., hypersensitivity pneumonitis, organic dust toxic syndrome (ODTS), blastomycosis). Otherwise, such diseases will not be recognized. There is insufficient scientific evidence to support the routine clinical use of immunodiagnostic tests as a primary means of assessing environmental fungal exposure or health effects related to fungal exposure. Health care providers who care for people who are concerned about the relationship between their symptoms and exposure to fungi are advised to use immunodiagnostic test results with care and only in combination with other clinical information, including history, physical examination, and other laboratory data. If appropriate allergy prick skin testing reagents or in vitro tests for serum specific IgE are available, they can be used to show specific IgE-sensitization to causative allergens. Unfortunately, skin testing reagents and blood tests documenting IgE-sensitization to molds are, with few exceptions, poorly standardized and of unclear sensitivity and specificity. The conventional hierarchy of treatment for allergic diseases includes avoidance of exposure to inciting agents; pharmacotherapy; and as a last resort, allergen immunotherapy. Immunotherapy with fungal allergenic extracts is, with a few exceptions, of unknown efficacy. It is important that clinicians report cases of mold-induced illness to local health authorities to assist in surveillance efforts.

Table 5. Population-Specific Recommendations for Protection From Exposure to Mold in Buildings Flooded After Hurricanes Katrina and Rita,[1] by Specific Activity[2] and Risk Factor

Exposure Activity					
Risk Factor	**Observing from outside the demolition area (disturbs no dust)**	**Inspecting or Assessing Damage (disturbs little dust or mold)**	**Recovering moldy personal belongings (Disturbs some dust or mold)**	**Sweeping, light cleaning, removing mold (disturbs much dust or mold)**	**Using power tools, cleaning, demolishing (disturbs all dust and mold)**
None	No special precautions Needed	No special precautions needed	 3	 4	
People at High Risk for Infection or Colonization					
Profound immuno-suppresssion[5]	Avoid exposure	Avoid exposure	Avoid exposure	Avoid exposure	Avoid exposure
Immunosuppression[6]			Avoid exposure	Avoid exposure	Avoid exposure
Obstructive or cavitary lung disease[7]					Avoid exposure
People Who Have Diseases With Immune Sensitization[8]					
Allergic rhinoconjunctivitis (exacerbated by moldy materials)					Avoid exposure
Asthma (exacerbated by moldy materials)				Avoid exposure	Avoid exposure
Hypersensitivity pneumonitis caused by moldy materials				Avoid exposure	Avoid exposure
People With Unknown Risk[9]					
Younger than 12 years[10]	Avoid exposure	Avoid exposure	Avoid exposure	Avoid exposure	Avoid exposure
Pregnant				Avoid exposure	Avoid exposure
Older than 65 years				Avoid exposure	Avoid exposure

Note: Everyone should avoid unnecessary exposure to mold, especially anyone at high risk for infection and anyone with a disease caused by immune sensitization to mold and mold constituents

Important: See footnotes on next page.

Footnotes to Table 5

1. Significant mold contamination is assumed if the building's interior was saturated with water for more than 48 hours, extensive water damage is present, extensive mold growth is visible, or "mildew" odors are clearly stronger than before Hurricanes Katrina and Rita.

2. A visible dust cloud suggests high potential for exposure. However, activities can be associated with high fungal exposure even without visible dust. Consider more protective interventions for activities of longer duration or greater frequency.

3.  Recommended respiratory protection for residents is a respirator at least as protective as an N-95 filtering face piece. Respirator protection for workers in isolated areas of mold contamination (100 square feet or less) or small isolated areas of heating, ventilation, and air conditioning (HVAC) systems (10 square feet or less) where mold is disturbed is a respirator at least as protective as an N-95 filtering face piece. For working in areas of extensive contamination (greater than 100 contiguous square feet) or HVAC systems with large areas of contamination (greater than 10 square feet) and significant mold-containing dust, full face-piece respirators with N100, R100, P100 particulate filters (or for powered air-purifying respirators – HEPA filters) are recommended.

 Gloves and dermal protection.

4.  Occlusive eye protection (safety goggles, not regular eyeglasses); see discussion of personal protective equipment in Chapter 4.

5. Transplant recipients, including organ or hematopoietic stem cell recipients within 6 months of transplant or during periods of substantial immunosuppression; neutropenia (neutrophil count < 500/μL) due to any cause (including neoplasm, cancer chemotherapy); CD4+ lymphopenia (lymphocyte count < 200/μL) due to any cause, including HIV infection. Affected individuals should consult with their physicians before entering the affected area.

6. Includes immunosuppressant drug therapy, such as cancer chemotherapy, corticosteroid, or other immunosuppressive drug therapy; and diseases impairing host defense such as leukemia or lymphoma. Affected individuals should consult with their physicians before entering the affected area. Duration and frequency of exposures should be minimal.

7. Such diseases include COPD, asthma not exacerbated by mold, cystic fibrosis, and cavitary tuberculosis. Risk of airway colonization and subsequent diseases following mold exposure is unknown. Recommendations are based on best professional judgment.

8. The optimal treatment for allergic rhinitis, allergic asthma, or hypersensitivity pneumonitis is avoidance of the sensitizing agent. If symptoms occur despite the recommended preventive measures, avoidance of exposure is indicated. In many cases, allergic etiology of rhinitis or asthma needs to be inferred from clinical information, since the available diagnostic reagents for documenting IgE-sensitization to fungi are mostly unstandardized. Similarly, the precise antigenic agent causing hypersensitivity pneumonitis is often unclear.

9. The level of risk associated with exposure activities and the potential benefit of recommended PPE are unknown for these vulnerable populations. Due caution is recommended.

10. Exposure-reducing behavior and respiratory protection are problems for this group.

Appendix A

Publications on Exposure to Mold and Related Health Effects

Audience	Title and Online Location
Workers whose occupation exposes them to mold	A Brief Guide to Mold in the Workplace http://www.osha.gov/dts/shib/shib101003.html Interim Recommendation for the Cleaning and Remediation of Flood-Contaminated HVAC Systems: A Guide for Building Owners and Managers http://www.cdc.gov/niosh/topics/flood/pdfs/Cleaning-Flood-HVAC.pdf OSHA Safety and Health Topics Web page: Personal Protective Equipment http://www.osha.gov/SLTC/personalprotectiveequipment/index.html OSHA Safety and Health Topics Web page: Respiratory Protection http://www.osha.gov/SLTC/respiratoryprotection/index.html NIOSH Hazard-Based Interim Guidelines: Protective Equipment for Workers in Hurricane Flood Response http://www.cdc.gov/niosh/topics/flood/pe-workers.html NIOSH Safety and Health Topic: Respirators http://www.cdc.gov/niosh/npptl/topics/respirators/ Protect Yourself from Mold http://www.bt.cdc.gov/disasters/mold/protect.asp Respiratory Protection for Residents Reentering Previously Flooded Areas and Homes http://www.bt.cdc.gov/disasters/hurricanes/katrina/respiratorypub.asp
People whose health conditions make them particularly vulnerable to mold	Basic Facts About Asthma http://www.cdc.gov/asthma/faqs.htm Facts About Mold and Dampness http://www.cdc.gov/mold/dampness_facts.htm Living With HIV/AIDS http://www.cdc.gov/hiv/pubs/brochure/livingwithhiv.htm Molds in the Environment http://www.cdc.gov/mold/faqs.htm Protect Yourself From Mold http://www.bt.cdc.gov/disasters/mold/protect.asp Questions and Answers on *Stachybotrys chartarum* and other molds http://www.cdc.gov/mold/stachy.htm

Health care providers	Institute of Medicine's *Damp Indoor Spaces and Health* http://www.nap.edu/books/0309091934/html/ (Summary table: http://www.cdc.gov/mold/iom_sum.htm) State of the Science on Molds and Human health http://www.cdc.gov/mold/pdfs/moldsci.pdf
General public and news media	Facts About Mold and Dampness http://www.cdc.gov/mold/dampness_facts.htm Get Rid of Mold; simplified flyer http://www.bt.cdc.gov/disasters/pdf/flyer-get-rid-of-mold.pdf Institute of Medicine's *Damp Indoor Spaces and Health* http://www.nap.edu/books/0309091934/html/ (Summary table: http://www.cdc.gov/mold/iom_sum.htm) Mold remediation advice from the U.S. Environmental Protection Agency; includes home and school cleanup information http://www.epa.gov/mold/ Molds in the Environment http://www.cdc.gov/mold/faqs.htm Prevention and Remediation Strategies for the Control and Removal of Fungal Growth http://www.cdc.gov/mold/strats_fungal_growth.htm Protect Yourself From Mold http://www.bt.cdc.gov/disasters/mold/protect.asp Questions and Answers on *Stachybotrys chartarum* and Other Molds http://www.cdc.gov/mold/stachy.htm Respiratory Protection for Residents Reentering Previously Flooded Areas and Homes http://www.bt.cdc.gov/disasters/hurricanes/katrina/respiratorypub.asp