Evaluation of Mold-Induced Adverse Health Effects

by Raymond Harbison, M.S., Ph.D.

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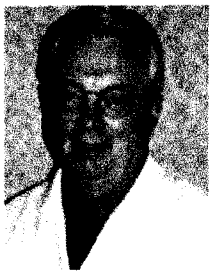

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The Supreme Court of the United States, in its 1993 decision in *Daubert v Merrill Dow Pharmaceuticals, Inc.* 509 US 579, ruled that the common law "general acceptance" test with reference to the admissibility of expert testimony in the Federal Courts of the United States was suspended by the test set out in the Federal Rules of Procedure. Therefore, a qualified expert may testify if:

1. the testimony is based upon sufficient facts or data,
2. the testimony is the product of reliable principles and methods, and
3. the witness has applied the principles and methods reliably to the facts of the case.

The Supreme Court prescribed the use of the scientific method for an expert witness to arrive at a cause and effect conclusion. There have been many publications describing the scientific method and its use in science and medicine (Yerushalmy and Palmer, 1959; Evans, 1976, U.S. Department of Health, Education, and Welfare, 1964, Hill, 1965, Hackney and Linn, 1979; Doll, 1984; Guidotti and Goldsmith, 1986; Susser, 1977, 1986 and 1991, Harbison, 1998).

This methodology is the same methodology a scientist would use to determine if a discovery in the laboratory or clinic is real and has not occurred by chance alone. If the scientific methodology is not followed, arbitrary and incorrect associations may be made because of individual bias, confounders and failure to use a precise and objective comparison.

The scientific method also is used to establish the practice of evidence-based medicine (Woolf, 2000).

Evaluation of the indoor environment has changed significantly over the past several decades. No longer are assessments of indoor environments confined to the air conditioner and heating contractor; but instead, now are evaluated by indoor air quality specialists, industrial hygienists, toxicologists, physicians, and others.

The widespread use of indoor air testing for mold and mold spores creates the opportunity for controversy and the inevitable complaints associated with the potential for exposure. Health complaints and conditions are alleged without apparent recognized diagnostic features, and controversy seems to exist when these allegations are subjected to an evaluation using evidence-based medicine and the scientific method. Thus determining the cause of an alleged mold-induced injury is contentious.

Indoor mold is generally a hygienic and aesthetic problem. Molds are ubiquitous in indoor and outdoor environments. There are significant seasonal and geographical variations in their growth and occurrence in air. For example, as many as 25,000 spores per cubic meter (spores/m^3) of air have been measured in outdoor air in Saint Louis in the spring and as many as 69,000 during the fall. Similarly, in California levels of 33,000 to half a million spores/m^3 of air can be measured in the spring and fall respectively. Levels in other areas of the west may be lower than 1,000 during these seasons and in the northeast levels of thousands to tens of thousands may be measured in the spring and fall.

Mold spore levels in cities around the United States are reported by the National Allergy Board (NAB) of the American Academy of Asthma, Allergy, and Immunology (AAAAI). These levels show remarkable geographic and seasonal variations that must be considered when making indoor and outdoor comparisons. For example, an allegation of indoor air contamination may be made because an indoor spore level may be twice that of an outdoor level in Austin, Texas. However, this level may be 10 times lower than an outdoor level in Corpus Christi.

Mold may result in some health complaints. Indoor air mold exposure may produce aller-

gic responses (sneezing, rhinitis, conjunctivitis), asthma-like conditions (wheezing, coughing, congestion), irritant effects (mucous membrane and eye irritation), and infections. Indoor air mold exposure does not cause brain damage, immunological disorders, fibromyalgia, attention deficit disorder, cancer, chronic fatigue syndrome, fungal syndrome, bioaerosol disease, and other similar claims.

Complaints of mold exposure are often influenced by subjective factors. Mental stress and perception bias are generally associated with a higher prevalence of symptoms and complaints among those experiencing alleged mold exposure.

A methodology often promoted for evaluating mold exposure is circular and without scientific merit (Figure 1). The reasoning used is that illness occurs because of mold exposure and because of illness mold exposure has occurred.

Indoor air mold concentrations are often compared to outdoor levels when residential testing is conducted. However, adverse health effects have not been shown to occur at any identified threshold level. Further, these measurements are often for only a few minutes and represent a mere snapshot that could be considerably different in an hour, day, or week depending on indoor and outdoor ventilation.

These measurements will also vary significantly depending on seasonal and geographic determinants (Shelton et al. 2002). Similarly, the mold genera are also likely to vary seasonally and geographically. Reporting genera only does not identify the many species that may exist (Table 1).

Indoor air mold levels are frequently lower than outdoor levels in residential, public, and commercial buildings. However, indoor air mold spore levels of greater than 1,000 spores/m^3 and 200 colony forming units per cubic meter (cfu/m^3) of air have not been determined to cause adverse health effects. A recent report of indoor (820 residences) and outdoor air levels of an average of 1,252 cfu/m^3 of air and 1,524 cfu/m^3 of air, respectively, were not associated with any health complaints (Gots et al. 2003). Similarly, no health complaints were associated with indoor spore levels (85 residences) of 68 to 2,307 spores/m^3 of air and a range of 400 to 80,000 spores/m^3 of air in outdoor air.

Further, occupational exposures to tens of thousands of mold spores/m^3 of air in saw mills, composting operations, honey and mushroom production, and farming have not been reported to produce, for example, brain damage, immunological disorders, fibromyalgia, attention deficit disorder, cancer, chronic fatigue syndrome, fungal syndrome, bioaerosol disease, and other similar claims (Duchaine et al. 2000 and Lacey and Crook 1988).

The genera of mold also varies seasonally and geographically. For example, *Stachybotrys* may be used by some practitioners as a sentinel of imminent public health risk. However, spores of this mold have been detected in indoor and outdoor air in areas in which occupants do not have any health complaints associated with the presence of mold (Baxter 1998, Harrison et al. 1992, Hawthorne et al. 1989, Shelton et al. 2002). Again, the mere presence of a mold does not result in adverse health effects, nor does it necessarily require extensive remediation. Mold is generally a hygiene or maintenance problem.

Evaluating allegations of mold-induced disease is complicated by many perception biases and misinterpretation of available information. Rather than relying on principles of evidence-based medicine, some practitioners ignore the scientific method. Some practitioners recommend residential, public, and commercial building remediation based upon arbitrary elevations of indoor air mold levels and minimal demonstrable mold presence. Further, they may proclaim that this indoor mold exposure is the cause of various conditions including brain damage, immunological disorders, fibromyalgia, attention deficit disorder, cancer, chronic fatigue syndrome, fungal syndrome, bioaerosol disease, and other similar claims.

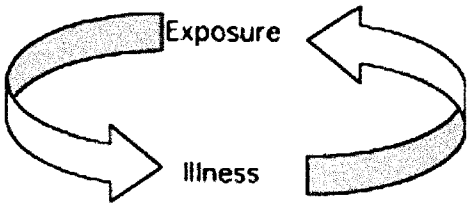

Figure 1. Circular reasoning.

Table 1: Mold Genera and Species

Genus of Mold	Number of Species
Aspergillus	Ca. 200
Alternaria	40-50
Aureobasidium	Ca. 15
Bipolaris	Ca. 45
Chaetomium	Ca. 80
Chrysosporium	Ca. 22
Cladosporidium	Ca. 40
Curvularia	Ca. 35
Epicoccum	2
Fusarium	50-70
Mucor	Ca. 50
Paecilomyces	9-30
Penicillium	Ca. 200
Stachybotrys	Ca. 15
Trichoderma	Ca. 20
Ulocladium	Ca. 9

Ca. = Approximately

These conclusions are not derived by using a scientific method but, instead, are derived by using circular reasoning.

Various individuals have attempted to devise a scientific methodology sufficient for linking a disease process in an individual with a specific exposure. There is general agreement

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that in the *absence* of certain information, no valid conclusion as to cause and effect can be drawn in a specific individual's case.

The scientific community generally requires the following minimal information before any reasonable medical or scientific probability can be expressed relating an exposure and an observed effect in a specific individual:

a. Exposure to a putative agent must be documented.
b. The exposure must occur in such a fashion that it is temporally eligible to be the cause of the observed effect.
c. The exposure level must be documented at a level capable of inducing a known toxic effect.
d. The observed toxic effect, whether acting directly on the target organ, or indirectly through alteration of body chemistry or function must be satisfactorily linked to the observed effect in the target organ. The observed effect must be biologically plausible and known to be caused by the agent.
e. A toxic effect suspected of being responsible, either directly or indirectly for injury to a specific organ must have been replicated in a general population upon identical exposure.
f. Confounding variables, such as drug and chemical-induced intrinsic factors or effects caused by infectious diseases, must be eliminated as potential causal or contributing factors.
g. If the latency period (the time between exposure and alleged effect) is extended, some plausible explanation for delay of onset of the disease process must be present, either through data from similarly exposed populations, or other sources.
h. The specific effect from the putative agent must be demonstrated as occurring in the specific individual involved. In cases where no effect can be demonstrated other than injury to a target organ, no conclusion can be drawn unless specific cytotoxicity affecting the target organ can be demonstrated.
i. A consistent pattern of identical effects under controlled circumstances must be demonstrated (literature precedence).
j. A consistent morphologic pattern under controlled circumstances (or a pathognomonic effect) must be demonstrated and existence of the specific morphologic pattern confirmed in the individual case under consideration.
k. Epidemiological and bioassay tests must be supportive.

There must be objective evidence that exposure to a putative agent from mold has occurred. Thousands of different compounds are produced by molds and exposure to these compounds indoors and outdoors occurs daily. Dozens of mycotoxins can be produced by a single mold. There are many other mold constituents. These are proteins and other biochemical products. These mold constituents have different physical and chemical properties. Therefore, the mere presence of visible mold does not prove exposure to any specific constituent.

Further, exposure is only the opportunity for contact. The dose of the mold constituent is the amount that enters the body. Exposure to mold may not necessarily result in a dose of mold constituent or putative agent. There must be a harmful level of mold constituent that enters the body before an adverse effect can be produced. Therefore, before a mold-induced causal relationship can be attributed in a specific individual, there must be evidence of exposure to a specific putative agent at a dose sufficient to cause an effect.

Moreover, the effect must be known to be caused by the putative mold constituent and the effect must be biologically plausible. There must also be an observed toxic effect capable of leading to the alleged injury or blood and tissue analyses that confirm an effect caused by the mold constituent. Specific putative agent-induced cytotoxicity may also be used to confirm the target organ injury.

Empirical data must be available to indicate that the mold exposure is capable of causing the observed or alleged injury. That is, the effect must be an effect known to be caused by this mold constituent or putative agent. If no direct or indirect data is available indicating that the mold constituent exposure is capable of causing the injury, then this would be the first time in the history of medicine anyone has claimed such a mold-induced injury. If this is the case, whoever is making such a claim has an obligation to describe the methodology they used to arrive at this conclusion.

Mold does not cause many different ailments. Mold may cause some specific allergic responses, minor irritant effects, and infections in some individuals with preexisting conditions and impaired immune responses. However, the risk of infection is low. Indoor mold exposure has not been shown to cause other ailments (Robbins et al. 2000, Fung, 2003). Conditions such as toxic fungal syndrome, toxic mold-induced encephalopathy, and mold-induced fibromyalgia are descriptions of alleged ailments that are not consistent with evidence-based medicine and are not generally accepted descriptions of human ailments.

There are no reliable epidemiological studies that demonstrate an association between mold exposure and, for example, brain damage (Fung et al. 1998, Page and Trout 2001, Robbins et al. 2000, Terr 2001, Fung and Hughson, 2003, Lees-Haley, 2003).

Similarly, there are no reliable epidemiological studies that demonstrate an association between mold exposure and immunological disorders, fibromyalgia, attention deficit disorder, cancer, chronic fatigue syndrome, fungal syndrome, bioaerosol disease, and other similar claims.

Most studies have no reported objective measurement of mold exposure that validates residential and occupant exposure air levels of mold. Rather, these studies use the circular reasoning methodology of relying on self-reported symptoms as a surrogate of mold exposure. Stakeholder self-reported symptoms are subjective, often biased, and nonspecific. They are inherently unreliable and cannot be used for determining cause and

effect relationships. Such self-reported symptoms cannot be extrapolated reliably to determine occupant exposure. Symptoms are subjective and often exaggerated as a result of perception bias because of perceived health hazards (Barsky, et al. 2001, Lees-Haley and Brown 1992, Kaye et al 1994, Lipscomb et al 1992, and Pennebaker 1983 and 1994).

The latency period between the mold exposure and the manifestation of the injury or effect must be plausible. There must be a reasonable explanation for a delay in onset or a continuation of the effect. There must be evidence in the literature of such a latency period having been established through epidemiological data.

A consistent pattern of similar effects under controlled circumstances must have been reported in the scientific literature. A consistent morphologic pattern (evidence of pathological changes in tissue) under controlled circumstances must have been reported in the scientific literature from similar mold constituent exposures. Specific physiological changes must be demonstrated and these physiological changes must be linked to the alleged injury.

There must be epidemiological data linking the mold exposure with a disease or injury, or a record of such data being linked to the alleged injury or disease. There must be bioassay tests, which indicate that the mold exposure is capable of causing the effect or contributing to physiological changes leading to the injury or disease.

The sole evidence of exposure cannot be anecdotal and based upon recall of an occupant of an office, home, or public building. No reasonable practitioner would conclude that sufficient evidence exists for linking an alleged indoor air mold exposure and an alleged injury using a historical scenario as reported by a stakeholder. Even under the most lax standards, the history is inadequate evidence to show that a purported indoor air mold exposure resulted in an injury. Again, there is no scientific or medical evidence that exposure to low concentrations of indoor air mold can cause brain damage, immunological disorders, fibromyalgia, attention deficit disorder, cancer, chronic fatigue syndrome, fungal syndrome, bioaerosol disease, and other similar claims.

Rigorous scientific methodology must be utilized to determine whether a disease has been caused by mold exposure or has occurred by chance as a result of the natural history of disease (background rate). If the scientific methodology is not followed then arbitrary, anecdotal, and incorrect associations may be made because of individual bias, confounders, and failure to use a precise and objective comparison. The scientific method is generally accepted as the minimum methodology for determining the cause of a human ailment or disease.

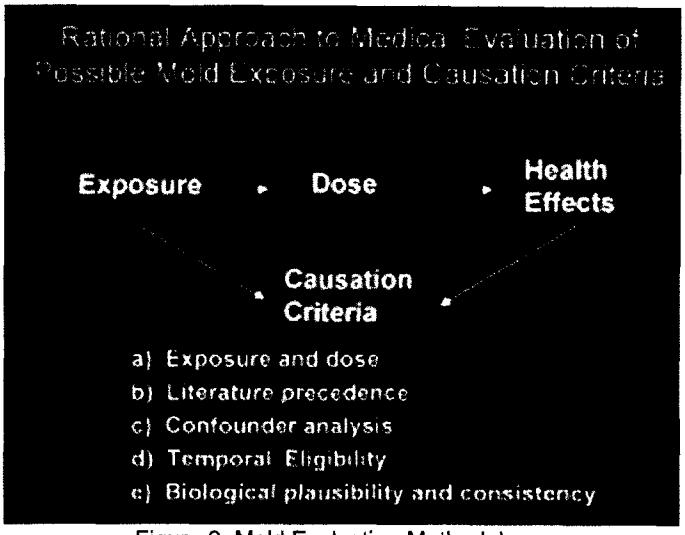

Figure 2. Mold Evaluation Methodology.

Finally, reliable testimony must be based upon sufficient facts or data, the testimony must be the product of reliable principles and methods, and the witness must apply the principles and methods reliably to the facts of the case (Figure 2).

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