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Mold Exposure and Mold-Associated Diseases- Does the Public Healthcare System Protect Us? A Comment

René Gordon Holzheimer[1*], & Nadey Hakim[2]

[1]*Professor, Department of Surgery – Sports Medicine, Ludwig Maximilians University Munich, Grünwalderstr. 55, D-82064 Straßlach-Dingharting, Germany.*

[2]*Professor, Imperial College London, United Kingdom.*

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***Corresponding Author:** René Gordon Holzheimer, Professor, Department of Surgery – Sports Medicine, Ludwig Maximilians University Munich, Grünwalderstr. 55, D-82064 Straßlach-Dingharting, Germany.

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Abstract

Moisture-induced mold is a significant threat to the public health and economic challenge in Europe and the USA. The widespread mold problems caused by moisture emphasize the need for effective moisture control and building maintenance to reduce the mold-associated health risk. A leading cause is moisture intrusion. Identifying visible and hidden indoor mold is crucial for assessing health risks and planning effective remediation. Methods for indoor mold detection are inspection, air sampling, surface and bulk sampling, measuring volatile organic compounds, airborne enzyme activity, molecular techniques. Each method has its strengths and limitations. Combining different approaches is necessary. Indoor dampness and mold pose significant health risks – respiratory issues, asthma and allergic symptoms, and adverse mental health. Epidemiological studies have established a strong association between indoor mold exposure and respiratory infections, allergic rhinitis and conjunctivitis, asthma exacerbation, hypersensitivity pneumonitis, and aspergillosis. Laboratory tests for diagnosing indoor mold-associated disease should be interpreted cautiously alongside clinical symptoms, environmental exposure history and other diagnostic findings. There are reports on the significance of mycotoxins produced by indoor molds and possible health effects. Identifying the specific types of indoor mold may be essential for assessing potential health risks, implementing effective remediation and preventing future mold growth. Various health authorities implemented preventive measures and legal frameworks to mitigate associated diseases. However, inconsistent enforcement of guidelines, missing standards and federal regulations, insufficient public awareness and variability in medical education are challenges for public health authorities. Local state health authorities are tasked to conduct thorough investigations whenever there is a suspicion of mold contamination in medical facilities and may enforce remediation. Mold prevention failures stem from the disregard of standards, regulations, and guidelines by healthcare professionals in state healthcare institutions and industries, as well as real estate shortcomings in the construction and maintenance of buildings. Legal action may arise when indoor mold results in health problems and property damage, and court experts get involved. Healthcare and construction professionals and court experts may face challenges in the case of a lack of impartiality, insufficient expertise, biased opinion, misinterpretation of evidence, and flawed assessment. A conflict of interest may exist when court experts have financial, professional, or personal ties to the parties. Identifying and resolving these conflicts is vital to maintaining fairness in legal proceedings. Nondisclosure of conflict of interest upholds the justice system's integrity. In summary, protection against indoor moisture and mold is limited. Despite numerous expert reports on moisture and mold caused by construction and maintenance defects, the protective measures stipulated in the guidelines and standards may not be observed without the necessary sanctions.

Keywords: Indoor Mold, Dampness Induced Mold, Mold Associated Disorders, Mold Detection Methods, Indoor Mold Health Risks, Medical Diagnosis of Mold Associated Disorders, Indoor Mold-Related Mycotoxins, Protection Against Indoor Mold by Health Authorities, Indoor Mold and Industry/Real Estate Failures, Indoor Mold in Legal Proceeding

Introduction

Dampness-induced mold came into the focus of internationally recognized media. Health symptoms caused by mold exposure may be disregarded as a cold or feeling tired. If left untreated, mold can become life-threatening [1]. Moisture-induced mold is a significant issue in Europe and the USA, affecting many residential and non-residential buildings. A study estimated that between 10% and 15% of European homes experience mold growth due to excessive humidity. Another analysis reported prevalence estimates of 12.1% for dampness, 10.3% for mold, and 10.0% for water damage in European housing. In educational settings, a study conducted in the Netherlands, Spain, and Finland found that 20% to 41% of school buildings had moisture-related issues, which could negatively impact students' health and their learning environment [2-4]. In the USA, approximately 21.8 million people have asthma. Around 4.6 million (range 2.7 to 6.3 million) of these cases are estimated to be due to exposure to dampness and mold in homes. The annual cost associated with asthma cases due to damp and moldy conditions in residences is estimated to be $3.5 billion (range $2.1 to $4.8 billion): exposure to dampness and mold in buildings presents significant public health and economic challenges in the USA [5].

Based on the "Dampness and mould in homes" study (2000/2001) involving 12,000 individuals in 5,530 randomly selected homes, people in Germany spend an average of 15.7 hours per day indoors. Similar results are found in US (15.6 h/day) and Canadian (15.8 h/day) surveys from the 1990s [6]. Babies and toddlers growing up in mold-infested homes suffered from intellectual impairments, i.e., losses in IQ scores [7], reduced cognitive abilities, reduced memory functions and executive function [8]. To fully appreciate the significance of such neuropsychiatric measurements, one should be aware that 26% of households with children in Germany report active mold growth indoors, with inhabitants unaware of the massive health threats [9]. Bennett emphasized at the German Federal Environment Agency (UBA) indoor air conference in May 2024 that up to 3 million German families and around 1 million German toddlers (5 years and younger) are exposed to Volatile organic compounds (VOCs) from indoor mold daily for many hours [10]. The widespread mold problems in the US and Europe caused by moisture emphasize the need for effective moisture control and building maintenance strategies to reduce associated health risks. One frequently asked question remains if federal and local health authorities could and will give protection in case of indoor mold-induced dampness.

Causes of Indoor Mold

Indoor mold growth primarily results from moisture and specific environmental conditions. The leading causes are moisture intrusion (leaks in roofs or walls), high indoor humidity, condensation, poor ventilation, and structural deficiencies (poor construction and maintenance). Structural defects are the leading cause of mold in buildings [11-13]. It is of utmost importance that inspectors of local healthcare institutions and court experts recognize and analyze structural deficits in buildings associated with mould-related adverse health effects. Unfortunately, there are examples where healthcare inspectors and court experts disregard this [14]. The composition of building materials determines the nutrient availability on its surface, which is a key driver for the material's susceptibility to fungal growth and abundance. Building materials have distinct compositions and contain different organic compounds, which can be a good nutrient source for most fungi or specific species that can utilize them. High humidity or water ingress is always the reason for fungal growth, even though the water source is not apparent or the building has dried out. An inspection aims to ascertain the existence of fungal growth, locate the source of humidity/water and design a remediation plan. To assess the building-related fungal contamination risk and confirm any moisture problems, it is necessary to quantify the fungal load, identify the microbial diversity and determine the contamination source. The assessment procedure is performed in four phases: (1) physical inspection of the building, (2) sample collection, (3) fungal detection and identification and (4) evaluation report [15]. It is hard to understand when an inspector restricts the inspection to phase one in case of severe wall defects and discolouration of the wall [14].

Methods for Indoor Mold Detection

Identifying indoor mold is crucial for assessing health risks and planning effective remediation. This initial assessment involves checking for visible mold and musty odors. It is effective for obvious mold issues but may miss hidden mold or airborne spores [3].

Air sampling captures airborne mold spores, comparing indoor samples with outdoor controls to evaluate respiratory exposure. This method aids in identifying hidden mold sources and assessing remediation success [16]. Studies performed up to date consistently identified *Alternaria, Cladosporium, Penicillium, Aspergillus, and Fusarium* as the predominant fungal genera in various indoor environments. Among bacteria, *Bacillus, Streptococcus, Micrococcus, Enterococcus, and Pseudomonas* emerged as the dominant genera in air samples collected from numerous environments. Public awareness and further research are vital in safeguarding human health in the face of risks posed by airborne microbial contaminants [17]. Air sampling provides a short-term exposure assessment through the active or passive collection of airborne fungal biomass [15]. Surface sampling collects samples from indoor surfaces using swabs or tapes to identify mold species. It helps determine the source and extent of contamination but may not fully represent airborne mold levels or detect hidden mold [18]. Bulk sampling involves collecting materials like drywall or carpet suspected of mold contamination for analysis, while dust sampling uses specialized vacuums or wipes to gather settled dust. Both methods help identify mold species and assess exposure risks but may not accurately reflect airborne mold levels and require lab analysis [19]. Molds emit specific volatile organic compounds (VOCs) as byproducts, which can indicate their presence in indoor air even before visible growth appears. This method aids in early mold detection, though it requires careful interpretation since VOCs can come from various sources [20, 21]. Airborne enzyme activity measurements identify enzymes from molds. Elevated levels in indoor air suggest mold contamination, and this method is sensitive and specific for detecting mold issues, although it may not specify mold species. Measurement is under dispute [22]. Molecular techniques like Polymerase Chain Reaction (PCR) and Quantitative PCR (qPCR) detect and quantify mold DNA in high-sensitivity air, surface, or dust samples, identifying specific mold species. However, they require specialized equipment and expertise [23]. Each method has its strengths and limitations. Combining different approaches may yield the most thorough assessment of indoor mold conditions. It is advisable to consult with professionals experienced in environmental assessments to identify the most suitable methods for specific situations [16, 24-28]. Detection and identification methods concern the laboratory analyses of the collected samples to confirm the presence of fungal contaminants, estimate the fungal load and/or perform species identification. The analysis can be quantitative, assessing the amount of fungal biomass, or qualitative, listing the identity of the different fungal species: direct microscopy, culture-based analysis, molecular analysis and enzymatic/chemical analysis [15].

Surface Indoor Mold Sampling Techniques

Surface indoor mold sampling techniques, such as swabbing and bulk sampling, are commonly used to identify and quantify mold species in indoor environments. One primary concern is that while these methods can detect the presence of mold, they may not accurately reflect actual exposure levels, as they do not account for airborne spores that individuals might inhale. Additionally, surface samples may not fully capture the mold species' diversity in the air. The United States Environmental Protection Agency (EPA) states that sampling is unnecessary if visible mold growth is present, as a visual inspection often provides sufficient information. Sampling should be conducted by trained professionals using standardized methods, and results must be interpreted cautiously, considering each sampling technique's limitations [29]. The RODAC plate method is a standardized technique for assessing surface contamination by microorganisms, including molds, in indoor environments. It involves pressing a RODAC plate filled with growth medium against a surface to collect samples for culturing. A study titled "Microbiological contamination with molds in the work environment in libraries and archive storage facilities" used this method to evaluate mold contamination on artefacts. Researchers cultured samples from RODAC plates to identify mold species like *Cladosporium* and *Penicillium*, highlighting health risks from mold exposure. While effective for detecting surface contamination, the RODAC method may not fully capture airborne mold spores, so combining it with air sampling provides a more thorough assessment of mold presence and health risks [30].

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Health Risks of Indoor Dampness and Mold

Mold growth in damp homes poses significant health risks to inhabitants, affecting both physical and mental well-being. Extensive studies have shown that exposure to indoor mold can harm health. Physical health effects consist of respiratory issues (asthma, wheezing, coughing, and respiratory infections), children's respiratory symptoms (higher rates of wheezing and persistent coughs in infants, particularly among high-risk groups), occupational asthma (mold exposure in workplaces is connected to the incidence and worsening of occupational asthma), allergic reactions (allergic responses such as nasal congestion, sneezing, and skin rashes), allergic rhinitis (strongest associations found with mold odors, indicating microbial involvement), allergic sensitization (children exposed to high levels of specific mold spores, such as *Cladosporium* and *Aspergillus*, are more likely to develop allergic sensitization, which can lead to symptoms like rhinoconjunctivitis). Certain molds can produce mycotoxins, harmful compounds that may adversely affect human health through various mechanisms, including respiratory and neurological effects [31-35].

Research has shown that exposure to residential dampness and mold is linked to adverse mental health outcomes. Adults may experience higher levels of depression, stress, and anxiety, while children can also exhibit emotional symptoms. Residing in homes affected by dampness and mold can significantly impact psychological well-being, indicating a connection between poor housing conditions and mental health issues [32, 33, 36-40].

Addressing indoor mold is crucial for protecting both physical and mental health. This involves controlling indoor moisture levels, ensuring adequate ventilation, and promptly repairing water leaks. If there is significant mold growth, professional remediation may be necessary. In cases where a real estate company has refused control of moisture, repair of water intrusion, and professional remediation, this may be followed by severe adverse health events [14].

Causal Relationships Between Indoor Mold and Health Issues

Epidemiological studies have established a strong association between indoor mold exposure and health outcomes. Mold spores can sensitize individuals, leading to allergic reactions and the development of asthma. Children living in mold-affected homes have a higher incidence of asthma and allergic rhinitis. Living in damp or moldy environments is linked to increased respiratory symptoms, such as coughing and wheezing. For immunocompromised individuals, inhaling airborne mold spores can lead to invasive fungal infections, such as aspergillosis. Certain molds produce mycotoxins that can cause adverse health effects, including respiratory and neurological symptoms [35, 41-44].

Medical clinical diagnosis of mold-associated disease

Exposure to indoor mold has been linked to various health conditions, particularly those affecting the respiratory system. A growing body of evidence supports clinical diagnoses of mold-related diseases. Allergic reactions to mold spores can result in nasal congestion, runny nose (rhinorrhea), sneezing, and itchy, watery eyes [35]. Indoor mold exposure triggers asthma attacks, leading to wheezing, shortness of breath, and chest tightness [35]. Also known as extrinsic allergic alveolitis, this condition presents with cough, dyspnea, and fever due to immune-mediated inflammation of the lung parenchyma following inhalation of organic antigens, including mold spores [45]. Prolonged exposure to indoor mold can predispose individuals to respiratory infections, including bronchitis and sinusitis [46]. Aspergillus species can cause infections ranging from allergic bronchopulmonary aspergillosis to invasive aspergillosis, particularly in immunocompromised individuals [47]. Infections are caused by dematiaceous (pigmented) fungi, which present with subcutaneous nodules or, in severe cases, neurological symptoms [48]. Fungal pathogens like *Cryptococcus neoformans* can invade the central nervous system, leading to meningitis and other neurological manifestations [49]. The occurrence of mycobacteria increased with increasing concentrations of fungi. Mycobacteria may contribute to indoor exposure and associated adverse health effects [50]. Mycobacteria, both potentially pathogenic and saprophytic species, may be released into the indoor air during the remediation of buildings [51].

Diagnosing Indoor Mold-Associated Diseases

Diagnosing mold-induced diseases requires clinical evaluation, environmental assessment, and laboratory tests. Specific blood tests may help identify exposure to mold and measure the body's immunological response under strict provisions. Basic analysis includes electrolytes, blood sugar, liver and kidney status. Further analysis may be performed in specific cases: Antibodies to molds and mycotoxins in the serum, test for mycotoxins, visual contrast sensitivity test, immune tests for autoantibodies, complement, gamma globulins, lymphocyte panel, heart rate variation and pupillometry for evaluation of the autonomic nervous system, standard neuropsychological test, EEG and brain imaging, SPECT and MRI, pulmonary function test. Failure to perform objective evaluations to assess system or organ dysfunction accounts for the position that airborne mold exposure has no significant adverse effects [33, 52] Measuring specific IgE and IgG antibodies against mold antigens can indicate sensitization and exposure [53]. Elevated levels of these antibodies suggest an allergic response or chronic mold exposure. A test detects galactomannan, a component of the *Aspergillus* cell wall, in blood samples. It is beneficial for diagnosing invasive *aspergillosis*, especially in immunocompromised patients [54]. The results of these tests should be interpreted with caution alongside clinical symptoms, environmental exposure history, and other diagnostic findings. Awareness of the potential for false positives and negatives is essential. Certain antibiotics or blood products may cause false-positive results in galactomannan tests. Healthcare providers should apply their clinical judgment to determine the necessity and relevance of these tests based on each patient's circumstances. It is recommended to consult with a healthcare professional experienced in diagnosing and managing mold-related health issues for comprehensive and personalized advice [53]. The detection of specific IgE or a positive reaction in the skin test may indicate that a specific sensitization to corresponding allergens is present. A clinically relevant allergy can be diagnosed in connection with typical allergic symptoms. A negative result of a skin test or a specific IgE test for molds does not reliably exclude sensitization to molds due to the varying composition and quality of test extracts or the absence of relevant allergens. Microbiological, immunological, molecular biological and radiological methods are core elements of mold infection diagnostics and shall be used depending on the indication [55].

Significance of Mycotoxins Regarding Health Effects

Prolonged and continuous exposure to indoor dampness microbiota (DM) is considered a serious health hazard. DM consists of molds, yeasts, and gram-positive and gram-negative bacteria. Mycotoxins are regarded as biological weapons. Mycotoxins become better soluble in fat, penetrate the skin, and store in adipose tissue and the brain. "Dampness and mold hypersensitivity syndrome is a biotoxicosis that should be diagnosed promptly" [56]. The sampling technique generally in use may underestimate concentrations measured from dust. Sampling should be done to detect toxins by wiping with a cloth dampened with alcohol or with a cup of sticks directly from the interior surface instead of vacuuming or sweeping dust. The so-called "health-based accepted cut-off levels" for myo-/biotoxins should be abandoned. In environmental toxicology, there are no "acceptable levels". Different toxins work synergistically. Small amounts of myco-/biotoxin may have detrimental health effects, especially in a vulnerable person, or when exposed simultaneously to heavy metal, e.g. amalgam [56]. Molds such as *Stachybotrys chartarum*, *Aspergillus*, and *Penicillium* can produce mycotoxins indoors. *Stachybotrys chartarum*, in particular, has been associated with various health concerns. High levels of exposure to mycotoxins

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can lead to neurological problems and, in severe cases, death. However, typical indoor concentrations are usually too low to trigger such effects. Prolonged exposure may contribute to respiratory issues and allergic reactions. The Centers for Disease Control and Prevention (CDC) has previously investigated associations between mycotoxins and health issues, such as infant pulmonary hemorrhage [57, 58].

Gareis reported 2024 that *Aspergillus, Penicillium*, and *Strachybotrys* produce specific mycotoxins in indoor dampness. Mycotoxins may be detected indoors even when no positive mould test exists. The specific detection of mycotoxins in plasterboard, textiles, wood and wood wool, cellulose, dust, and wall and floor material provides unambiguous evidence of which fungus was the producer, even if the fungus itself can no longer be detected. According to Gareis, mycotoxins can be measured by LC-MS/MS multimycotoxin liquid chromatography and tandem mass spectrometry. As mycotoxins have a toxicity spectrum dangerous for human health (carcinogenic, mutagenic, genotoxic, embryotoxic, immunotoxic, haemorrhagic, nephrotoxic, hepatotoxic, cytotoxic, neurotoxic, dermatotoxic) protection measures should be immediately installed in indoor dampness and suspected mold [59, 60]. There is mounting evidence that many mycotoxins cause both neurotoxicity and immune suppression. These mycotoxins may be able to explain the full spectrum of pathology in Amyotrophic Lateral Sclerosis without a secondary event [61]. Mycotoxins produced by indoor molds can potentially cause serious health issues. Individuals with sensitivities or compromised health should be cautious. Ongoing research is essential for fully understanding the implications of indoor mycotoxin exposure [24, 62-74]. A previously fit and healthy man developed acute respiratory failure due to environmental mould exposure from living in damp rental accommodation [75]. In addition to mycotoxins secreted by mold, there may be endotoxin production by gram-negative bacteria in indoor dampness, which is relevant. Endotoxin measurement may be possible when bacteria cannot be detected [76].

Specific Types of Indoor Mold for Health Risk Assessment

Identifying the specific types of indoor mold present in a building is essential for assessing potential health risks, implementing effective remediation strategies, and preventing future mold growth. Different mold species can have varying effects on human health and damage to building materials. Identifying mold species is crucial for evaluating health risks, as some molds are more likely to cause adverse reactions. For example, *Penicillium* species have been linked to respiratory issues in infants. Research has shown that infants exposed to *Penicillium* molds in their homes have a higher risk of developing asthma and allergic rhinitis. Knowing the specific types of mold present allows for tailored remediation approaches. Some molds produce mycotoxins, which can pose significant health risks. For instance, *Stachybotrys atra* has been associated with severe respiratory problems in infants. Addressing the specific mold species involved enables more effective and focused remediation efforts. Understanding the mold species present can inform preventive strategies. Some molds thrive in specific conditions; *Aspergillus* species are commonly found in damp environments. Implementing measures to control moisture levels can help prevent the growth of these molds. Certain molds, such as *Trichoderma*, can damage building materials. Identifying these molds allows for preventive actions to be taken to protect structural elements and maintain the integrity of the building. In some regions, regulations require identifying and managing specific mold species in indoor environments. Adhering to these regulations ensures a safe living or working space and helps avoid legal issues [77, 83]. For comprehensive guidelines on indoor mold assessment and management, the World Health Organization [85] and other health organizations provide detailed information on health effects and recommendations [84].

Indoor Mold and Health Authorities

Indoor mold exposure poses significant health risks, leading various health authorities to implement preventive measures and legal frameworks to mitigate associated diseases. The Centers for Disease Control and Prevention (CDC) advises controlling indoor moisture by promptly repairing leaks, maintaining low indoor humidity, and ensuring proper ventilation [85]. The World Health Organization (WHO) emphasizes the importance of moisture control in buildings [86]. The Environmental Protection Agency (EPA) recommends identifying and eliminating sources of moisture, cleaning and drying affected areas within 24-48 hours, and removing or replacing materials that cannot be adequately cleaned. "The key to mold control is moisture control ". They also advise using appropriate personal protective equipment during mold remediation [87].

Legal Instruments and Enforcement Mechanisms

Many jurisdictions have established building codes that mandate moisture-resistant construction materials and designs to prevent mold growth. These codes are enforced through building inspections and permit requirements. In Germany, the generic requirements for structural works and the use of construction products are laid down in the Building Codes of the federal states. Where necessary, these generic requirements can be specified by Technical Building Rules [88]. Deficiencies and violations of building codes/regulations could lead to many shortcomings, particularly regarding the minimum requirements for public health, safety, general welfare, building quality and environmental protection [89]. Public housing authorities often implement standards requiring landlords to keep properties free from health hazards, including mold. Non-compliance can lead to penalties or loss of housing subsidies [90]. Occupational Safety and Health Administration (OSHA) sets standards for workplace safety, including regulations to control exposure to airborne mold in occupational settings. Employers who fail to comply may face citations and fines [91]. Health departments can issue orders to remediate mold in residential and commercial properties that pose health risks. Failure to comply can result in legal actions, including fines or mandatory closure of affected facilities [92, 93]. However, failures to comply with building codes and regulations and non-compliance with standards to keep properties free from health hazards will not be punished [14].

Indoor Mold and German Healthcare Authorities

In Germany, several key healthcare institutions and authorities are responsible for addressing indoor mold and preventing associated health issues. The Umweltbundesamt (Federal Environment Agency) provides comprehensive guidelines for preventing, detecting, and remediating indoor mold. Their guidelines emphasize the importance of eliminating sources of indoor mold to protect health and offer evaluation schemes to detect and assess mold infestations [94]. In collaboration with other medical societies, the Gesellschaft für Hygiene, Umweltmedizin und Präventivmedizin (GHUP), has developed guidelines for diagnosing indoor mold exposure. These guidelines outline diagnostic procedures, including medical history assessments, physical examinations, and allergy diagnostics, to address health complaints arising from mold exposure [95]. The Robert Koch Institute (RKI) is Germany's national public health institute. Although it does not provide specific guidelines on indoor mold, the RKI contributes to research and recommendations concerning environmental health hazards, including indoor air quality [96]. The Federal Ministry of Health (Bundesministerium für Gesundheit) oversees public health policies and may issue regulations and recommendations to protect public health regarding indoor environmental factors, including mold [97]. These institutions collaborate to provide guidelines, conduct research, and implement policies to prevent health issues related to indoor mold exposure in Germany [98]. According to these guidelines, health should be protected. Unfortunately, this may be neglected [14].

The Challenge of Enforcement and Coverage by the Health Authority

Indoor mold poses significant health risks. While health organizations have established guidelines to address this issue, challenges in enforcement and comprehensive coverage persist [99]. Inconsistent enforcement of guidelines, missing standards and federal regulations, insufficient public awareness and variability in healthcare provider training are challenges for public health authorities [100]. Information about the effectiveness of legislation as prevention is lacking [101]. Risks for indoor mold in both older and newer housing raise concerns about the extent of the indoor mold problem in Australia. Understanding the national prevalence of housing risks and the "root cause" associated with indoor mold is inconclusive from the limited existing evidence. Synthesis of this evidence reveals a lack of coverage on national and geographical representation, climatical coverage, housing typologies, housing defects, maintenance, impact from urbanization, and occupant's behaviour [102]. Addressing these challenges requires a coordinated effort among government agencies, healthcare providers, and the public to mitigate the health risks associated with indoor mold effectively [103, 104]. Healthcare professionals, building managers, homeowners and the general public need to be much more aware of the potential adverse health effects of high indoor fungal exposure and the need for proper building construction, maintenance, and remediation of dampness to prevent dangerous adverse events. Prompt removal from exposure to fungal contamination remains the treatment of choice.

Managing Indoor Mold Issues in Medical Facilities by Local German State Health Authorities

In Germany, local state health authorities play a crucial role in addressing indoor mold issues within medical facilities to ensure the health and safety of patients and staff. State health authorities are tasked with conducting thorough investigations whenever there is a suspicion of mold contamination. This involves inspecting medical facilities to identify the presence of mold, assessing the extent of the contamination, and evaluating the potential health risks associated with exposure. The German Environment Agency (Umweltbundesamt) provides guidelines for detecting, assessing, and remedying indoor mold, highlighting the importance of these evaluations [105]. These authorities ensure that medical facilities comply with established health and safety standards regarding indoor air quality and mold prevention. They may enforce regulations that limit indoor air contaminants, including mold spores, to safeguard the health of occupants [106, 107]. Local health authorities have specific legal powers to control and regulate moisture-induced mold growth in medical facilities, working to protect the health of patients and staff. If mold is suspected, the health authority can mandate actions ranging from examining affected areas to enforcing remediation work. However, according to a local Bavaria health authority, the focus is on public state buildings (personal communication) [108]. Indoor mold in medical facilities is a significant concern in Europe, Germany, the United States, and Australia, impacting patient health and building integrity. Using an indoor environmental professional to generate evaluation reports and remediation activities can contribute to an overall allergen avoidance strategy [109]. Specific data on the incidence of indoor mold in medical facilities is limited; however, mold growth is typically associated with moisture issues such as leaks, inadequate ventilation, and high indoor humidity. In Germany, guidelines have been established to diagnose indoor mold exposure in medical settings, indicating a growing awareness of the issue [110]. Mold infestations in US healthcare settings are primarily caused by water intrusion due to leaks, floods, or condensation. The Occupational Safety and Health Administration (OSHA) provides guidelines on managing mold in the workplace, emphasizing the importance of moisture control to prevent growth [111]. The WHO emphasizes preventing and remediating mold-related problems to protect public health. Addressing indoor mold in medical facilities is essential for safeguarding patient health and maintaining the integrity of healthcare environments [102, 112].

Indoor Mold and Industry/Real-Estate Company Failures

Indoor mold poses significant health risks, and preventing it is a shared responsibility among various stakeholders, including industry players, health organizations, and building owners. While health organizations provide guidelines and recommendations, mold prevention failures often stem from industry and real-estate company shortcomings [113]. Although health hazards of indoor air mycotoxins and biotoxins are documented, there is still a gap between scientific knowledge and clinical reality. "Resistance from the construction industry, environmental control authorities and mainly from insurance companies restricts the adoption of adequate sampling techniques and legal consequences because that means responsibility and monetary compensation" [56]. Key industry failures contributing to indoor mold issues include inadequate building design and construction practices, moisture control failures, vapor barrier misplacement, substandard building materials, use of moisture-susceptible materials, insufficient maintenance and moisture management, neglecting moisture sources, lack of regular inspections, inadequate ventilation systems, poor airflow design. The primary cause of neglect in preventing indoor mold and associated health issues is a combination of factors, including poor enforcement of existing regulations, a lack of public awareness, and substandard construction practices. These issues often lead to health risks such as respiratory problems, allergies, and worsened asthma symptoms [33, 114-116]. The following statement highlights the disobedience of important health protection regulations. "The photos do not show that the occupational and environmental protection measures specified by the employers' liability insurance association, described in DGUV Information 201-028, were applied. From this, I conclude that a specialist company was commissioned that lacks the necessary expertise or does not take the requirements seriously. Inadequate environmental protection endangers the room occupants and can lead to unacceptable contamination of the rooms. Furthermore, there is a concern that the microbially contaminated material was not identified and removed, as required by the relevant guidelines." (Personal communication Dr W. L., expert in indoor damage and mold 2024) "Moisture damage was verified and documented by several specialists/experts. Sections of the exterior walls and parts of the floor were or are affected. The court-appointed expert prepared a report based on moisture measurements using an unsuitable method and did not inspect the facade thoroughly. The expert overlooked clear signs of moisture damage (water stains on the window sills). The moisture damage was not present for a short time. It must have occurred repeatedly in the facade area. Technical measures did not remove the moisture in the floor. With repeated and prolonged moisture occurrences, mold and/or bacteria colonisation is inevitable. Without an individual assessment of the symptoms, however, I can determine that they are typical of chronic exposure to microbial substances from "mold damage." A connection is plausible and likely." (Personal communication Dr. W.L. expert in indoor damage and mold 2024)

Indoor Mold and Legal Proceedings

Indoor mold in homes and medical facilities can lead to significant health problems. Legal action may arise when these mold problems result in health concerns or property damage, often involving court experts who assess the situation [117]. In mold-related cases, court experts are hired to provide specialized knowledge regarding the health impacts of mold exposure, the extent of contamination, and effective remediation measures. Their assessments help the court understand the case's complex scientific and medical aspects. Toxic mold lawsuits, in particular, are usually complicated and require specific medical and scientific expertise [118, 119]. Court experts may fail in mold cases if they lack impartiality, possess insufficient expertise, or do not disclose conflicts of interest. Such shortcomings can lead to biased opinions, misinterpretations of evidence, or flawed

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assessments, ultimately impacting the fairness of the trial. Lawyers' highest duty is to their clients, and conflicts of interest are widely condemned for the harm they can inflict on the attorney-client relationship and the legal profession [120-124]. A conflict of interest occurs when an individual's interests could compromise their impartiality or judgment. In the context of court experts, these conflicts can arise if they have financial, professional, or personal ties to the parties involved in the case. Such conflicts can bias their evaluations and testimony, undermining the integrity of the judicial process. Identifying and resolving these conflicts is vital to maintaining fairness in legal proceedings [125, 126]. If a court expert fails to disclose a conflict of interest, it can raise questions regarding the credibility and reliability of their testimony. Nondisclosure may lead to legal challenges, including motions to exclude the expert's testimony. It could also serve as grounds for an appeal if it is determined that the lack of disclosure affected the trial's outcome. For instance, in the case of Mickens v. Taylor, the Supreme Court addressed issues related to conflicts of interest and their impact on legal proceedings [127-129]. Court experts must be transparent about potential conflicts of interest to uphold the justice system's integrity and ensure fair outcomes in mold-related litigation. Evidence exists for the causality of these buildings' moisture-induced indoor moulds and severe health threats. Indoor mold induced by moisture damage and its effects on pulmonary and extrapulmonary diseases should not be ignored. The health and economic implications of these attitudes are apparent [130].

Conclusion

Moisture-induced mold significantly threatens public health and causes economic challenges in Europe and the USA. The widespread mold problems caused by moisture emphasize the need for effective moisture control and building maintenance to reduce mold-associated health risks. There is evidence that indoor mold is strongly associated with severe disease. Methods to detect the root cause of hidden and visible mold are available. Combining different approaches is necessary. Epidemiological studies have established a strong association between indoor mold exposure and respiratory infections, allergic rhinitis and conjunctivitis, asthma exacerbation, hypersensitivity pneumonitis, and aspergillosis. Laboratory tests for diagnosing indoor mold-associated disease should be interpreted cautiously alongside clinical symptoms, environmental exposure history and other diagnostic findings. The significance of mycotoxins produced by indoor molds and possible health effects has been demonstrated by studies.

Various health authorities implemented preventive measures and legal frameworks to mitigate associated diseases. However, inconsistent enforcement of guidelines, missing standards and federal regulations, insufficient public awareness and variability in medical education are challenges for public health authorities. Local state health authorities are tasked to conduct thorough investigations whenever there is a suspicion of mold contamination in medical facilities and may enforce remediation. However, despite the guidelines, the public health office may not be aware of the threat. Mold prevention failures often stem from industry and real estate shortcomings in the construction and maintenance of buildings. Legal action may arise when indoor mold results in health problems and property damage, and court experts get involved. Court experts may cause challenges in case of lack of impartiality, insufficient expertise, biased opinion, misinterpretation of evidence and flawed assessment. A conflict of interest may exist when court experts have financial, professional, or personal ties to the parties. Identifying and resolving these conflicts is vital to maintaining fairness and trust in legal proceedings. Nondisclosure of conflict of interest upholds the justice system's integrity. In summary, protection by the state healthcare system against indoor moisture and mold is limited. Despite numerous expert reports on moisture and mold caused by construction and maintenance defects, the protective measures stipulated in the guidelines and standards may not be observed without the necessary sanctions.

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