WORLD HEALTH ORGANIZATION
EUROPE

WHO GUIDELINES FOR INDOOR AIR QUALITY – DAMPNESS AND MOULD

Executive Summary

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Executive Summary

This document presents World Health Organization (WHO) guidelines for the protection of public health from health risks due to dampness, associated microbial growth and contamination of indoor spaces. The guidelines are based on a comprehensive review and evaluation of the accumulated scientific evidence by a multidisciplinary group of experts studying health effects of indoor air pollutants as well as those specialized in identification of the factors that contribute to microbial growth indoors.

Problems of indoor air quality are recognized as important risk factors for human health in both low-income and middle- and high-income countries. Indoor air is also important because populations spend a substantial fraction of time within buildings. In residences, day-care centres, retirement homes and other special environments, indoor air pollution affects population groups that are particularly vulnerable due to their health status or age. Microbial pollution involves hundreds of species of bacteria and fungi that grow indoors when sufficient moisture is available. Exposure to microbial contaminants is clinically associated with respiratory symptoms, allergies, asthma and immunological reactions.

The microbial indoor air pollutants of relevance to health are widely heterogeneous, ranging from pollen and spores of plants coming mainly from outdoors, to bacteria, fungi, algae and some protozoa emitted outdoors or indoors. They also include a wide variety of microbes and allergens that spread from person to person. There is strong evidence regarding the hazards posed by several biological agents that pollute indoor air; however, the WHO working group convened in October 2006 concluded that the individual species of microbes and other biological agents that are responsible for health effects cannot be identified. This is due to the fact that people are often exposed to multiple agents simultaneously, to complexities in accurately estimating exposure and to the large numbers of symptoms and health outcomes due to exposure. The exceptions include some common allergies, which can be attributed to specific agents, such as house-dust mites and pets.

The presence of many biological agents in the indoor environment is due to dampness and inadequate ventilation. Excess moisture on almost all indoor materials leads to growth of microbes, such as mould, fungi and bacteria, which subsequently emit spores, cells, fragments and volatile organic compounds into indoor air. Moreover, dampness initiates chemical or biological degradation of materials, which also pollutes indoor air. Dampness has therefore been suggested to be a strong, consistent indicator of risk of asthma and respiratory symptoms (e.g. cough and wheeze). The health risks of biological contaminants of indoor air could thus be addressed by considering dampness as the risk indicator.

Health hazards result from a complex chain of events that link penetration of water indoors, excessive moisture to biological growth, physical and chemical degradation, and emission of hazardous biological and chemical agents. The review of scientific evidence that supports these guidelines follows this sequence of events. The issues related to building dampness and its effect on indoor exposure to biological and non-biological pollutants are summarized in Chapter 2, which also addresses approaches to exposure assessment. An important determinant of dampness and biological growth in indoor spaces is ventilation, and this issue is discussed in Chapter 3. The evidence for the health effects of indoor exposure is presented in Chapter 4, based on a

review of epidemiological studies and of clinical and toxicological research on the health effects of dampness and mould. The results of the epidemiological and toxicological studies are summarized in the appendices.

The background material for the review was prepared by invited experts and discussed at a WHO working group meeting, convened in Bonn, Germany, 17–18 October 2007. The conclusions of the working group discussion are presented in Chapter 5 and are reproduced in this executive summary, as follows.

- Sufficient epidemiological evidence is available from studies conducted in different countries and under different climatic conditions to show that the occupants of damp or mouldy buildings, both houses and public buildings, are at increased risk of respiratory symptoms, respiratory infections and exacerbation of asthma. Some evidence suggests increased risks of allergic rhinitis and asthma. Although few intervention studies were available, their results show that remediation of dampness can reduce adverse health outcomes.
- There is clinical evidence that exposure to mould and other dampness-related microbial agents increases the risks of rare conditions, such as hypersensitivity pneumonitis, allergic alveolitis, chronic rhinosinusitis and allergic fungal sinusitis.
- Toxicological evidence obtained in vivo and in vitro supports these findings, showing the occurrence of diverse inflammatory and toxic responses after exposure to microorganisms isolated from damp buildings, including their spores, metabolites and components.
- While groups such as atopic and allergic people are particularly susceptible to biological and chemical agents in damp indoor environments, adverse health effects have also been found in nonatopic populations.
- The increasing prevalences of asthma and allergies in many countries increase the number of people susceptible to the effects of dampness and mould in buildings.

The conditions that contribute to the health risk were summarized as follows.

- The prevalence of indoor dampness varies widely within and among countries, continents and climate zones. It is estimated to affect 10–50% of indoor environments in Europe, North America, Australia, India and Japan. In certain settings, such as river valleys and coastal areas, the conditions of dampness are substantially more severe than the national averages for such conditions.
- The amount of water on or in materials is the most important trigger of the growth of microorganisms, including fungi, actinomycetes and other bacteria.
- Microorganisms are ubiquitous. Microbes propagate rapidly wherever water is available. The dust and dirt normally present in most indoor spaces provide sufficient nutrients to support extensive microbial growth. While mould can grow on all materials, selection of appropriate materials can prevent dirt accumulation, moisture penetration and mould growth.
- Microbial growth may result in greater numbers of spores, cell fragments, allergens, mycotoxins, endotoxins, β-glucans and volatile organic compounds in indoor air. The causative agents of adverse health effects have not been identified conclusively, but an excess level of any of these agents in the indoor environment is a potential health hazard.
- Microbial interactions and moisture-related physical and chemical emissions from

building materials may also play a role in dampness-related health effects.

- Building standards and regulations with regard to comfort and health do not sufficiently emphasize requirements for preventing and controlling excess moisture and dampness.
- Apart from its entry during occasional events (such as water leaks, heavy rain and flooding), most moisture enters a building in incoming air, including that infiltrating through the building envelope or that resulting from the occupants' activities.
- Allowing surfaces to become cooler than the surrounding air may result in unwanted condensation. Thermal bridges (such as metal window frames), inadequate insulation and unplanned air pathways, or cold water plumbing and cool parts of air-conditioning units can result in surface temperatures below the dew point of the air and in dampness.

On the basis of this review, the following guidelines were formulated.

- Persistent dampness and microbial growth on interior surfaces and in building structures should be avoided or minimized, as they may lead to adverse health effects.
- Indicators of dampness and microbial growth include the presence of condensation on surfaces or in structures, visible mould, perceived mouldy odour and a history of water damage, leakage or penetration. Thorough inspection and, if necessary, appropriate measurements can be used to confirm indoor moisture and microbial growth.
- As the relations between dampness, microbial exposure and health effects cannot be quantified precisely, no quantitative health-based guideline values or thresholds can be recommended for acceptable levels of contamination with microorganisms. Instead, it is recommended that dampness and mould-related problems be prevented. When they occur, they should be remediated because they increase the risk of hazardous exposure to microbes and chemicals.
- Well-designed, well-constructed, well-maintained building envelopes are critical to the prevention and control of excess moisture and microbial growth, as they prevent thermal bridges and the entry of liquid or vapour-phase water. Management of moisture requires proper control of temperatures and ventilation to avoid excess humidity, condensation on surfaces and excess moisture in materials. Ventilation should be distributed effectively throughout spaces, and stagnant air zones should be avoided.
- Building owners are responsible for providing a healthy workplace or living environment free of excess moisture and mould, by ensuring proper building construction and maintenance. The occupants are responsible for managing the use of water, heating, ventilation and appliances in a manner that does not lead to dampness and mould growth. Local recommendations for different climatic regions should be updated to control dampness-mediated microbial growth in buildings and to ensure desirable indoor air quality.
- Dampness and mould may be particularly prevalent in poorly maintained housing for low-income people. Remediation of the conditions that lead to adverse exposure should be given priority to prevent an additional contribution to poor health in populations who are already living with an increased burden of disease.

The guidelines are intended for worldwide use, to protect public health under various environmental, social and economic conditions, and to support the achievement of optimal indoor air quality. They focus on building characteristics that prevent the occurrence of adverse health effects associated with dampness or mould. The guidelines pertain to various levels of economic development and different climates, cover all relevant population groups and propose

feasible approaches for reducing health risks due to dampness and microbial contamination. Both private and public buildings (e.g. offices and nursing homes) are covered, as dampness and mould are risks everywhere. Settings in which there are particular production processes and hospitals with high-risk patients or sources of exposure to pathogens are not, however, considered.

While the guidelines provide objectives for indoor air quality management, they do not give instructions for achieving those objectives. The necessary action and indicators depend on local technical conditions, the level of development, human capacities and resources. The guidelines recommended by WHO acknowledge this heterogeneity. In formulating policy targets, governments should consider their local circumstances and select actions that will ensure achievement of their health objectives most effectively.