

[Topic A6: Health and indoor air epidemiology](#)

INDOOR DAMPNES AND MOLD AS INDICATORS OF RESPIRATORY HEALTH RISKS, PART 1: DEVELOPING EVIDENCE TO SUPPORT PUBLIC HEALTH POLICY ON DAMPNES AND MOLD

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SUMMARY

While current evidence suggests that prevention and remediation of indoor dampness and dampness-related agents are likely to reduce health risks, evidence is not yet available to support quantitative guideline levels for specific indoor microbiologic concentrations. This paper recommends approaches for developing evidence to support *quantitative* health-protective guidelines for indoor dampness and dampness-related agents. These approaches include better assessment of environmental factors related to health effects, for factors ranging from crude indicators like visible water damage or mold odor, to slightly more quantitative metrics for measured material moisture levels, to highly quantitative microbial assays. Example research strategies are described for measured indoor moisture and health effects.

INTRODUCTION

Current evidence on health effects of indoor dampness, mold, and dampness-related agents has documented consistent associations between qualitative, subjectively assessed indoor dampness or mold and respiratory or allergic health effects (Fisk et al., 2007; WHO, 2009; Fisk et al., 2010; Mendell et al., 2011). Because dampness and mold are common in buildings in the U.S. and worldwide (Mudarri and Fisk, 2007), an important proportion of currently observed respiratory and allergic disease is attributable to indoor dampness and mold (Mudarri and Fisk, 2007). Causal links remain unclear, however, and objectively measured microorganisms or their components or products have shown little consistent relationship with health outcomes (Mendell et al., 2011).

One important reason that dampness and mold are still common, despite links to substantial adverse effects, is that limited scientific knowledge is available to support evidence-based health-protective policies. The best current public health advice is to use subjective, qualitative observations of dampness or mold to guide remedial actions; however, acceptable levels of these cannot yet be specified, other than saying that more evident dampness or mold seems to increase risks. Guidelines more quantitative than this are needed. This paper briefly outlines a set of approaches for developing evidence to support *quantitative* health-protective guidelines or other policies for indoor dampness and dampness-related agents.

METHODS

This paper summarizes recommended strategies based on the past and current research and planned efforts of the Indoor Air Quality Section (IAQS) within the California Department of Public Health (CDPH), a group focused on research useful for public health policy in the area of Indoor Air Quality.

RESULTS AND DISCUSSION

Based on results of prior efforts – e.g., (Fisk et al., 2007; Fisk et al., 2010; Mendell et al., 2011) – and an initial evaluation of current dampness/mold-related U.S. policies (<http://www.eli.org/sites/default/files/eli-pubs/2014-mold-database.pdf>), we recommend the following approaches to develop support for evidence-based, quantitative, health-protective guidelines for indoor dampness and mold (Figure 2):

1. Review current knowledge on indoor dampness or mold factors and health
2. Summarize current health-protective policies on indoor dampness and mold, limitations in the current policies, and the key new scientific evidence needed to support improved health-protective policies.
3. Perform research to produce key missing evidence, focused on specific policy needs.
 - a. Better quantify relationships of *subjective, qualitative environmental indicators* (e.g., visible water damage, visible moisture, visible mold, mold odor) with health effects as feasible, using available data and new research findings (e.g., as done for new asthma and rhinitis (Quansah et al., 2012; Jaakkola et al., 2013)), identifying any dose-response relations identified.
 - b. Quantify relationships of *measured building moisture* with health effects (using: existing published data on measured moisture, new analyses of available data on moisture; conversion of available findings on moisture content estimated as “% wood moisture equivalent” (% WME) to “water activity” (A_w) and for other building materials; and field research to produce new data on measured moisture or water activity and health.
 - c. Quantify relationships of *measured microorganisms* or other bioactive microbial compounds with health effects, to support prevention strategies and also to identify specific dampness-related causal agents (Kawaguchi et al., 2014).
 - d. Define *environmental conditions that allow growth of microorganisms*, either per species or per groups with similar requirements (Li and Wadsö, 2013) – e.g., water activity or moisture by material and temperature; because the health effects of specific indoor microorganisms are not yet established, this effort may only support guidelines for the maximum material moisture levels that do not support amplification of “suspect” microbial groups.
 - e. Identify the *specific biologic mechanisms* by which some or all fungi/bacteria (or other dampness-related agents, microbial or other) cause health effects, to help identify specific causal agents.
4. Combine approaches 3a—2e iteratively as input into a risk management process, to support initial health-protective guidelines on indoor dampness and mold based on available evidence, and to guide additional research to provide information needed to further refine the initial guidelines.

As an example, a recommended set of research strategies focused on item 3b above (Figure 1) would include the following:

- Synthesize available published data on measured indoor moisture and health effects;
- Analyze any other existing epidemiologic data on measured indoor moisture and health effects to better quantify relationships;
- Investigate and validate portable A_w sensors, only recently available;
- Collect and synthesize data, available and newly generated, on the equivalency of %WME and A_w in gypsum board and other common building materials, using different measurement instruments;
- Conduct additional epidemiologic studies in multiple geographic locations to characterize relationships of %WME or of A_w with key health effects;
- Combine findings on measured indoor moisture and health with relevant findings from other research, such as on specific microorganisms, their moisture requirements, and their health effects.

The IAQS/CDPH is currently working on multiple aspects of the relationships between measured indoor moisture and health, as reported in six other papers at the current conference (Chen et al., 2014; Kawaguchi et al., 2014; Macher et al., 2014a; Macher et al., 2014b; Mendell, 2014; Mendell et al., 2014).

Findings on this topic to date at IAQS/CDPH included the following: Two available studies in the UK, using the same moisture meters, found strong positive, dose-related relationships between measured home moisture in gypsum plaster walls and asthma exacerbation (Mendell et al., 2014). In a California study, measured wall moisture was higher in perimeter than in interior walls, in bedroom than in living room walls, and in homes with more subjective indicators of dampness or mold (Macher et al., 2014b). In a chamber at moisture and temperature equilibrium at sequentially increasing levels of air relative humidity (RH, 11-99%), measurements were made in gypsum board allowing comparisons/conversions between gravimetrically measured moisture content, moisture content (as %WME) assessed by pin-less and two-pin moisture meters, and A_w assessed by a water activity sensor (Macher et al., 2014a). A computerized simulation, using a Combined Heat, Air, Moisture, and Pollutant Simulation program (CHAMPS) to predict the %WM, and equilibrium RH (or A_w) of gypsum board under various relative humidity levels at steady-state conditions, captured well the overall trend of the experimental results and predicted the moisture parameters in the correct order of magnitude, suggesting the usefulness of such models in this area of research (Chen et al., 2014). A literature review on microbial volatile organic compounds (MVOCs) suggested that measurement of specific MVOCs may improve detection of dampness or mold in a quantitative and objective manner, as compared with subjective visual or olfactory evidence (Kawaguchi et al., 2014).

Ultimately, the most effective public health prevention of adverse effects from indoor dampness and dampness-related agents may come from identifying specific dampness-related causal agents, quantifying their relationships with health effects, and setting acceptable limits in guidelines or standards. However, public health prevention can and should always proceed with the best available information, and then advance further as improved information continues to be developed.

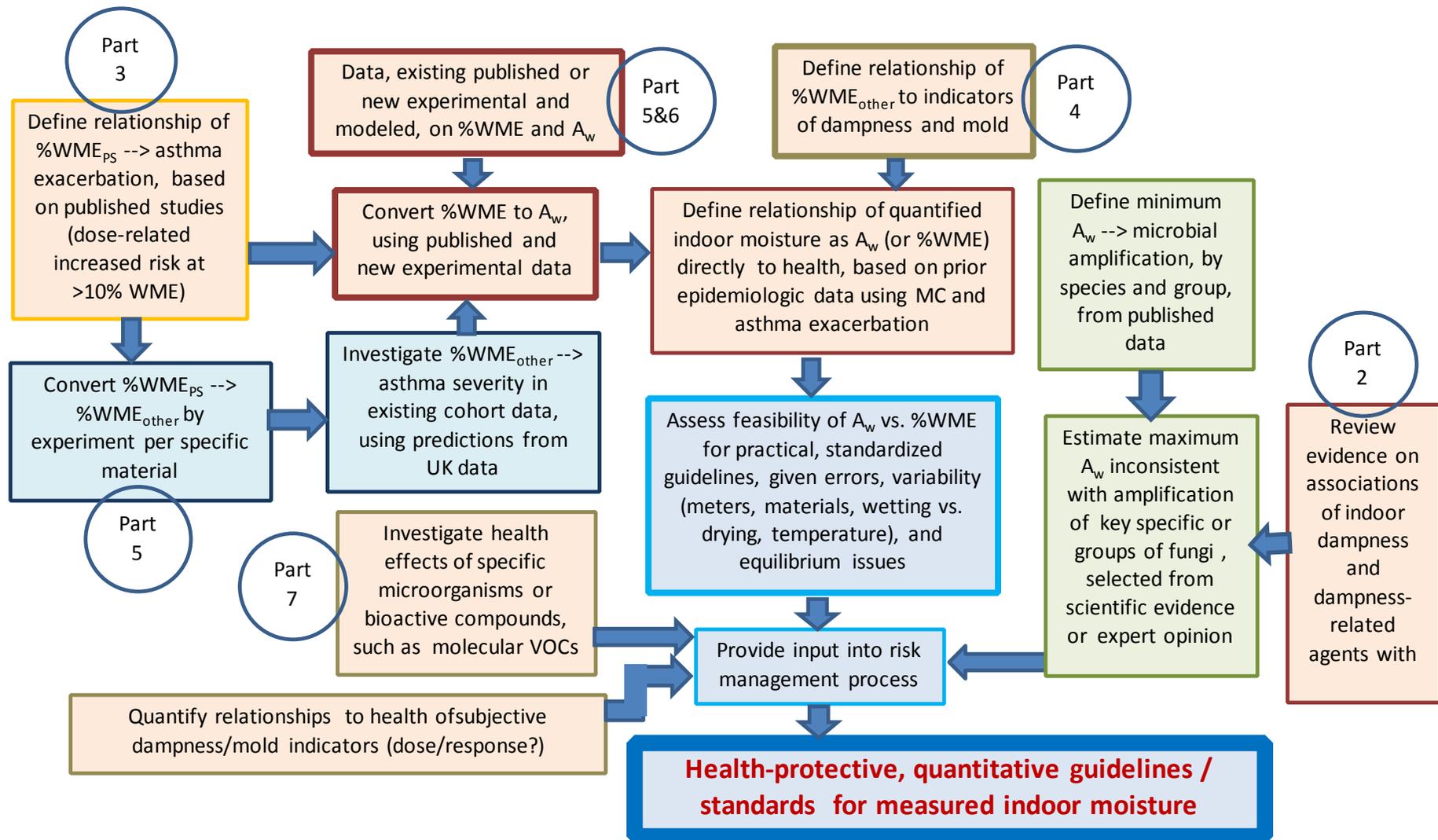


Figure 1. Diagram of approaches, including developing evidence on measured moisture and health, to support health-protective public policies for indoor dampness and mold (Parts 2-7 in circles refer to related research reports presented at this conference, listed in References (Abbreviations: A_w , water activity; other, other moisture meters; PS, Protimeter SurveymasterTM; WME, wood moisture equivalent)

CONCLUSIONS

While prevention and remediation of indoor dampness and dampness-related agents are likely to reduce health risks to occupants, available evidence cannot yet support quantitative guidelines for indoor microbiologic concentrations. A variety of simultaneous approaches is recommended *to develop evidence* that can support quantitative health-protective guidelines for indoor dampness and dampness-related agents, even before successful identification of specific dampness-related causal agents. Based on work in our group and by others, several approaches to characterization of environmental predictors of dampness-related health effects seem promising, including quantifying material moisture as %WME or A_w .

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