Literature review of current research on health effects and accepted guidelines for the management of indoor mould and water damage in the built environment

Article · December 2013

CITATION
1

READS
320

1 author:

Cedric D Cheong
Greencap
68 PUBLICATIONS **67** CITATIONS

SEE PROFILE

Literature review of current research on health effects and accepted guidelines for the management of indoor mould and water damage in the built environment

Cedric D Cheong, M.Sc., B.Env.Sc, TAE 40110

Affiliation: Mycologia Pty Ltd, Department of Research and Development, Osborne Park, Western Australia, 6017, cedric.cheong@mycologia.com.au

Abstract: Extensive research studies have documented a strong association between exposure to dampness and amplified growth of mould and mycotoxins (including ochratoxin, aflatoxin and trichothecene) in water damaged and damp indoor environments and the incidence of respiratory symptoms, asthma, hypersensitivity pneumonitis, rhino-sinusitis, bronchitis and respiratory infections. Living in a water damaged and mouldy property is linked with poor physical health outcomes and the continual cycle of illness could eventually lead to anxiety and depression. This paper reviews the many position statements, alerts, advisory notes, guidelines and white paper documents of various cognizant international health authorities and available current scientific research on the health effects, assessment, prevention and remediation of indoor mould and water damage in the built environment.

BACKGROUND

It is estimated that 50% of illnesses are caused by indoor air pollution, of which water and mould damage are a significant contributor to adverse health effects[1,2,3]. It is estimated that one in three homes in Australia are water and mould damaged and in the US, it is reported that one in two homes have dampness and mould issues[4].

Cognizant international health authorities and strong, credible scientific research have confirmed associations and links between health problems (including asthma and upper respiratory problems) with indoor dampness and mould. These organisations have issued position statements/documents, alerts, advisory notes, guidelines and white paper documents stating their respective positions (Table 1).

INTRODUCTION

Fungi/mould are ubiquitous in the indoor and outdoor environments, existing naturally in air, soil and water. It is estimated that we are routinely exposed to around 200 types of moulds[3]. The majority of fungi are saprotropic and depend on an external source of organic material for growth.

The indoor built environment contains many of the components required for mould growth, such as oxygen, organic based nutrient sources, moisture and an acceptable temperature range. When humidity and moisture within the built environment are not effectively controlled or managed, persistent dampness and water damage can occur, leading to material damage, corrosion, structural decay and microbial growth (fungi and bacteria)[7].

Persistent dampness, water damage and microbial growth within the built environment should be avoided or minimised[2] as health authorities have established an association between damp buildings, mould growth and the increased potential for adverse health effects[7]. Furthermore, there is a correlation between the length of time dampness and water damage exists in the built environment and increased damage and deterioration of building components[3,17].

ORGANISATION	DOCUMENT	DATE
World Medical Association (**WMA**)	WMA Statement on Fungal Disease Diagnosis and Management[5]	October 2013
American Industrial Hygiene Association (**AIHA**)	Position Statement on Mould and Dampness in the Built Environment[6]	March 26, 2013
American Society of Heating, Refrigerating and Air-Conditioning Engineers (**ASHRAE**)	ASHRAE Position Document on Limiting Indoor Mold and Dampness in Buildings[7]	January 29, 2013
American Lung Association (**ALA**)	Standard of Care for the New Hampshire Mould Industry[8]	December 2012
Specialised Cleaning & Restoration Industry Association (**SCRIA**)	Draft Australian Water Damage Restoration Guidelines[9]	July 2012 **currently being reviewed for 2014 re-release*
National Collaborating Centre for Environmental Health (**NCCEH**)	Health Effects from Mould Exposure or Dampness in Indoor Environments[10]	July 2012
National Institute for Occupational Safety and Health (NIOSH) & Centre for Disease and Prevention (**CDC**)	Preventing Occupational Respiratory Disease from Exposure caused by Dampness in Office Buildings, Schools, and Other Nonindustrial Buildings[11]	November 2012
Global Indoor Health Network (**GIHN**)	Common Toxins in Our Homes, Schools and Workplaces[12]	December 17, 2012
Mycologia	AMG-2010 Australian Mould Guideline[13]	August 2010 **currently being reviewed for 2014 re-release*
New York State (Mould Task Force)	Final Report to the Governor and Legislature[14]	2010
World Health Organisation (**WHO**)	WHO guidelines for indoor air quality: dampness and mould[2]	2009
Institute of Inspection Cleaning and Restoration Certification (**IICRC**)	BSR-IICRC S520 Standard and Reference Guide for Professional Mold Remediation[15]	2008 **currently being reviewed for 2013/2014 re-release*
Institute of Inspection Cleaning and Restoration Certification (**IICRC**)	ANSI/IICRC S500 Standard and Reference Guide for Professional Water Damage Restoration[16]	2006 **currently being reviewed for 2013/2014 re-release*
Institute of Medicine (**IOM**)	Damp Indoor Spaces and Health[3]	2004

Table 1: List of organisations and released documents

HEALTH EFFECTS

Extensive research studies have documented that exposure to dampness and amplified growth of mould and mycotoxins (including ochratoxin, aflatoxin and trichothecene) in water damaged and damp indoor environments has been associated with the onset of respiratory symptoms, asthma, hypersensitivity pneumonitis, rhino-sinusitis, bronchitis and respiratory infections[2,18-21]. Chronic exposure can then lead to inflammation and oxidative stress[22-35]. Individuals with asthma or hypersensitivity pneumonitis may be at risk for progression to more severe diseases if the relationship between illness and exposure to the damp building is not recognised and exposure continues[3,11].

The following list of verified health effects and symptoms are associated with mould exposure in damp and water damaged built environments[18,36-38].

- Asthma exacerbation, new onset asthma, upper respiratory tract (sore throat, conjunctivitis, allergic rhinitis, nasal congestion, runny nose), cough, wheeze, hypersensitivity pneumonitis in sensitive individuals, dyspnea (shortness of breath), respiratory infections, bronchitis, eczema, common cold and allergy/atopy.

Airborne exposure (inhalation) is the most significant mechanism of exposure to indoor mould in water damaged and damp indoor built environments, followed by transdermal (absorption) and foodborne (ingestion) exposure. Hyphae, spores, fungal fragments, and mycotoxins (macrocyclic trichothecenes, T2 mycotoxins) can be inhaled when fungal propagules are aerosolized. Transdermal exposure most often occurs when contaminated items and belongings are brought to new locations, resulting in cross-contamination and continued exposure. Foodborne exposure occurs through the ingestion of food contaminated by spores, mycotoxins and hyphae[22,39-42].

continued next page

from page 11

Current research has not determined conclusively the causal relationship and exact mechanism by which mould in the indoor environment causes health effects, but is likely to be from one or more of the following mechanisms: allergic and inflammatory responses (allergens), systemic infections (pathogens), or acute and chronic toxicity (toxins)[2,18,43,44].

Longer term mental health effects have also been studied, with results showing occupants in water damaged buildings (WDB) who are exposed to toxigenic moulds are prone to cognitive impairment due to the damage to neurological tissue. A study of children exposed to indoor mould for more than 2 years showed statistically significant reduction of 10 points in their IQ. For longer term exposures, the risk for low IQ scores was tripled[45-49].

In other studies, strong associations with depressive symptoms, with reports of emotional distress, were noted in individuals living in WDB. The associations were independent of individual and housing characteristics. Exposure to toxigenic moulds and conditions in WDB is thought to dysregulate emotions through a hypo-activation of the frontal cortex. Further compounding of stress can also be attributed to the stress of chronic illness as a result of exposure to mould and the stress of dealing with mouldy conditions in the building[47,48,50-54]. Other reported symptoms include problems with physical energy, sleep and social isolation[55-57]. Living in a water damaged and mouldy property is linked with poor physical health outcomes (respiratory problems, asthma exacerbation, new onset asthma, diarrhoea, nausea, headaches) and the continual cycle of illness may eventually lead to anxiety and depression[57-60].

FUNGAL DISEASE DIAGNOSIS AND MANAGEMENT

The treatment of fungal diseases and illness can be difficult as many mechanisms are interacting at any given time, thus requiring a comprehensive and multi-faceted approach focussed on treating the fungal infection, removing oxidative stress in the body and instituting treatments which focus on countering oxidative stress[12,61,62].

Complete removal of the individual from exposure to indoor mould, dampness and water damage and from contaminated items are critical in reducing exposure. However, this may not be enough for some individuals to regain their health. Continual persistence of symptoms and ill health may continue after exposure, likely due to genetic and nutritional factors as well as the initial severity, duration of exposure and continual exposure through cross-contamination[12,63]. The development of new onset chemical sensitivity (previously commonly known as multiple chemical sensitivity), can often occur after exposure[62].

Available treatment approaches include the use of sequestering agents[64-70], intake and support of anti-oxidants[61,62,71,72], systemic, nebulised and intranasal glutathione[107,108], gastrointestinal probiotics[73-76], nutritional support[77-85], and the immediate treatment of persistent fungal infections or symptomatic colonisation[86].

Further epidemiologic studies and research on the burden of fungal disease, illness and treatment options is needed and such research needs to be made available to physicians. As further knowledge and understanding of the best treatment approaches for fungal diseases and illness increases, this will help physicians to provide optimal care for patients[5,12,86].

ASSESSMENT

There are no recommended quantitative/numerical, health-based exposure guidelines or thresholds for acceptable levels of contamination by microorganisms[3,6,7,11,87]. Many authorities have previously published guidelines, but many have since retracted them and the current acceptable approach is that any visible mould growth indoors, regardless of species or amount, is a cause for immediate concern and needs to be removed.

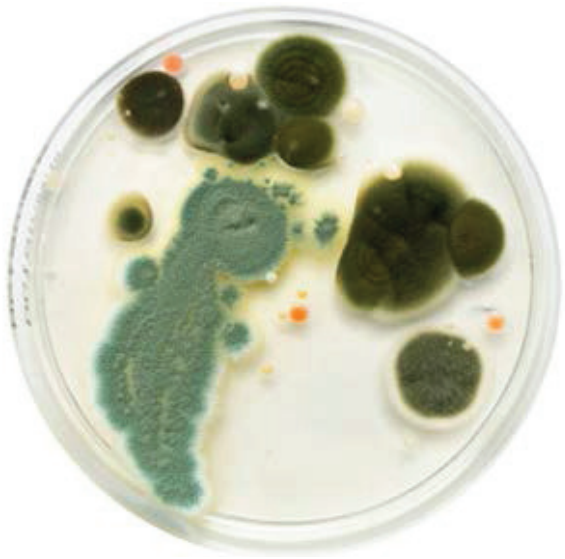
If visible mould is not detected after a thorough inspection but is suspected, microbial air and surface sampling in combination with moisture measurements from affected building materials may be carried out according to guidance documents[88-90]. Sampling and measurements are used to defend a hypothesis about the nature of the contamination, 'hidden' sources of contamination (behind wall or in cavities), and whether or not the indoor air is similar to outdoor air[6,89,91].

Assessments should be conducted by qualified and experienced investigators, with resultant reports providing useful information for the development of an action plan for remediation and rehabilitation of the affected area, a basis for protection of occupants and remediation workers and be useful for public health officials and treating physicians. Field notes should be sufficiently detailed, clear and concise to allow field work and sampling to be interpreted, verified and repeated ensuring quality assurance[6,8,88].

A complete holistic assessment of the indoor built environment incorporating a health and risk assessment should include the use of semi-quantitative estimates of the extent of visible mould and moisture damage (in the form of mould and dampness indices), complimented by data on the ventilation and air flow status, indoor air quality parameters, types of reservoirs present, medical practitioner diagnoses, HVAC hygiene status, air and surface sampling (where required), building investigation photo log, occupant behaviour and building history data sets[88,87,92-95].

PREVENTION

Building materials that have become damp or water damaged, are at a high risk of fungal growth if combined with an organic nutrient source, resulting in health problems experienced by occupants and the eventual deterioration of the building[96]. It is therefore critical that building designers and architects choose materials that are appropriate to the environmental conditions and occupant use. For the control of mould in buildings, materials which are less susceptible to fungal growth (e.g., glass fibre instead of wallpaper) should be chosen and manufacturers of building materials



encouraged to develop non-toxic, fungus or water-resistant materials[96].

The water activity (aw) of a building material is a key determining factor for fungal growth and varies with the temperature and the type of material[97]. The longer a material's aw is over 0.75, the greater the risk of fungal growth[98], as high levels of water activity allow fungi to obtain moisture from the material for growth resulting in potential damage to the material. A definitive aw threshold does not exist for fungal growth as different fungi have different aw preferences[99]. The key is to ensure the aw of building materials is lower than the requirements for fungal growth and thus prevent colonisation from occurring[100].

Two other important physical factors in the indoor environment that can affect the water requirements of fungi are temperature and the type of nutrients present on the surface. For fungal growth to occur, there is an optimal temperature range for particular species of fungi. Outside of that optimal temperature range, more water is necessary for growth. Similarly, if the nutrient source is not something the fungi normally would grow on in nature, more water is required for growth. This is because fungi are natural decomposers and break down organic compounds, thus fungi tend to grow more frequently and quickly on plant-derived or organic materials, such as wood and paper. When building materials are inorganic and do not come from a plant origin, or have been altered in some way, fungi require more water in order to grow[97].

REMEDIATION

If visible mould is present, it should be remediated, regardless of mould species. This helps to reduce the risk of new onset asthma, and result in savings in health care costs and public health improvements[2,6]. Repair and remediation of the conditions that lead to the adverse exposure should be given priority to prevent additional loads to populations who are already immunocompromised and stressed by the increased burden of disease[2,95].

The end goal of the remediation is that no further health symptoms are experienced by occupants upon re-habitation of the property and that further exposure and damage to building materials and furnishings are prevented[11,95,101]. Remediation and the removal of water and mould damaged materials should be conducted by qualified personnel as improper efforts could result in cross-contamination of microbes, spores, fragments, and toxins throughout the entire building structure[102,103].

Remediation protocols should include the use of proper containment procedures and personal protective equipment (including respirators) as the action of removing and handling contaminated material will result in increased aerosolisation of spores and fungal fragments containing mycotoxins, which can be dangerous to human health when inhaled[2,11,41,43,102].

The use of biocides, antimicrobials, sterilisers and disinfectants are often un-necessary in the remediation process and could pose further health problems for remediation workers and leave residual chemicals that may affect occupants upon re-habitation. Such products should only be used in appropriate situations such as those involving contaminated water (Class 2 & 3)[15,16]. Biocides and disinfectants cannot be used as a substitute for mould removal[2,101]. Appropriate PPE, operator experience and ventilation and exhaust protocols should be in place when using such products[9,15,16,104].

Physical removal of all mould including active mould growth, mould laden dust, physical components, mycotoxins and fungal propagules is necessary as exposure to dead or inactivated mould or its components can still result in adverse health effects[12,13]. This is due to the structure of fungi, which incorporates an epoxide ring, thus making non-viable fungal spores, fragments and mycotoxins extremely hard to destroy[105]. A study of common chemical based building remediation treatments (peroxide, hot air, flaming, two boron-based chemicals, drying, steam, UV light, ammonium chloride or sodium-hypochlorite based chemicals) found that no remediation treatment eliminated all the mycotoxins from the building materials[106].

SUMMARY AND CONCLUSION

Cognisant international health authorities and current scientific research have established an association between damp buildings, mould growth and the increased potential for adverse health effects. Persistent dampness, water damage and microbial growth within the built environment should be avoided or minimised.

There are no recommended quantitative/numerical, health-based exposure guidelines or thresholds for acceptable levels of mould contamination in the built environment. The current acceptable approach is that any visible mould growth indoors, regardless of species or amount, is a cause for immediate concern and needs to be removed.

Repair and remediation of the conditions that have led to the adverse exposure should be given priority to prevent further health effects. The end goal of the remediation is that occupants who return to their property experience no further health

continued next page

from page 13

symptoms and there is no damage to building materials and furnishings.

Further epidemiologic studies and research on the burden of fungal disease, illness and treatment options is needed and such research needs to be made available to physicians to assist them in providing optimal care for their patients.

Cedric Cheong is trainer, speaker and researcher at Mycologia. Cedric was the co-host of the internationally acclaimed TV show, "Is Your House Killing You?" which highlights dangers within Australian homes. Cedric contributed to the development of the SCRIA Draft Australian Water Damage Restoration Guidelines in 2013 and the AIRAH HVAC Hygiene Guidelines in 2010 and has written over 45 publications in peer reviewed scientific journals as well as recent articles in AIHE and FM magazines. Cedric has recently released the Mycologia Position Statement on Indoor Mould and Water Damage in the Built Environment.

Cedric was an Associate Lecturer at Murdoch University and Notre Dame University in the field of Health and the Environment. Cedric has completed training in the area of microbial sampling and HVAC investigations in Phoenix, Arizona and has visited various research centres in the Netherlands, Finland, Singapore, Canada and the USA as part of his research on indoor fungi, mould remediation, cleaning and indoor air. Cedric holds current IICRC certification for water damage restoration and applied microbial remediation and has also completed training in Friable and Non-Friable Asbestos remediation.

References

1. Commonwealth of Massachusetts, "Special Legislative Committee on Indoor Air Pollution, Indoor Air Pollution in Massachusetts," April 1989.

2. World Health Organisation (WHO), 2009. WHO guidelines for indoor air quality: dampness and mould.

3. Institute of Medicine, Committee on Damp Indoor Spaces and Health. Damp indoor spaces and health. Washington, DC: National Academies Press; 2004. Available from: http://www.nap.edu/openbook.php?isbn=0309091934.

4. Spengler J., Neas L., Nakai S., Dockery D., Speizer F., Ware J., and Raizenne. 1994 respiratory Symptoms and housing characteristics. Indoor air , 4: 72-82.

5. World Medical Association (WMA). "WMA Statement on Fungal Disease Diagnosis and Management". 64th WMA General Assembly, Fortaleza, Brazil, 16-19th October, 2013.

6. American Industrial Hygiene Association (AIHA)– March 26, 2013. Position Statement on Mould and Dampness in the Built Environment

7. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) – January 29, 2013. ASHRAE Position Document on Limiting Indoor Mold and Dampness in Buildings

8. American Lung Association (ALA). Standard of Care for the New Hampshire Mould Industry. The American Lung Association in New Hampshire's Mold task Force. December 2012

9. Specialised Cleaning & Restoration Industry Association (SCRIA) – July 2012. Draft Australian Water Damage Restoration Guidelines, currently being reviewed for 2014 re-release.

10. National Collaborating Centre for Environmental Health (NCCEH) - July 2012. Health Effects from Mould Exposure or Dampness in Indoor Environments.

11. National Institute for Occupational Safety and Health (NIOSH) & Centre for Disease and Prevention (CDC), November 2012. Preventing Occupational Respiratory Disease from Exposure caused by Dampness in Office Buildings, Schools, and Other Nonindustrial Buildings.

12. Global Indoor Health Network (GIHN), December 17, 2012. Common Toxins in Our Homes, Schools and Workplaces

13. Mycologia, August 2010. AMG-2010 Australian Mould Guideline – currently being reviewed for 2014 re-release.

14. New York State (Mould Task Force), 2010. Final Report to the Governor and Legislature.

15. Institute of Inspection Cleaning and Restoration Certification (IICRC), 2008. BSR-IICRC S520 Standard and Reference Guide for Professional Mold Remediation, currently being reviewed for 2013/2014 re-release.

16. Institute of Inspection Cleaning and Restoration Certification (IICRC), 2006. ANSI/IICRC S500 Standard and Reference Guide for Professional Water Damage Restoration, currently being reviewed for 2013/2014 re-release.

17. Zielinska-Jankiewicz K, Kozajda A, Piotrowska M, Szadkowska-Stanczyk I. Microbiological contamination with moulds in work environment in libraries and archive storage facilities. Ann Agric Environ Med. 2008;15(1):71-8.

18. Fisk, WJ, Lei-Gomez Q, Mendell MJ. Meta-analyses of the associations of respiratory health effects with dampness and mold in homes. Indoor Air 2007; 17: 284–296.

19. D.Mudarri and W. J. Fisk, "Public health and economic impact of dampness and mold," Indoor Air, vol. 17, no. 3, pp. 226–235, 2007.

20. J. J. K. Jaakkola, B. F.Hwang, andN. Jaakkola, "Home dampness and molds, parental atopy, and asthma in childhood: a sixyear population-based cohort study," Environmental Health Perspectives, vol. 113, no. 3, pp. 357–361, 2005.

21. K. Karvala, H. Nordman, R. Luukkonen et al., "Occupational rhinitis in damp and moldy workplaces," American Journal of Rhinology, vol. 22, no. 5, pp. 457–462, 2008.

22. T. L. Brasel, J. M. Martin, C. G. Carriker, S. C. Wilson, and D. C. Straus, "Detection of airborne Stachybotrys chartarum macrocyclic trichothecene mycotoxins in the indoor environment," Applied and Environmental Microbiology, vol. 71, no. 11, pp. 7376–7388, 2005.

23. D. C. Straus and S. C. Wilson, "Respirable trichothecene mycotoxins can be demonstrated in the air of Stachybotrys chartarum-contaminated buildings," Journal of Allergy and Clinical Immunology, vol. 118, no. 3, p. 760, 2006.

24. J. D.Thrasher, M. R. Gray, K. H. Kilburn, D. P. Dennis, and A. Yu, "A water-damaged home and health of occupants: a case study," Journal of Environmental and Public Health, vol. 2012, Article ID 312836, 10 pages, 2012.

25. J. L. Richard, R. D. Plattner, J. May, and S. L. Liska, "The occurrence of Ochratoxin A in dust collected from a problem household," Mycopathologia, vol. 146, no. 2, pp. 99–103, 1999.

26. D. G. Hooper, V. E. Bolton, F. T. Guilford, and D. C. Straus, "Mycotoxin detection in human samples frompatients exposed to environmental molds," International Journal of Molecular Sciences, vol. 10, no. 4, pp. 1465–1475, 2009.

27. T. L. Brasel, A. W. Campbell, R. E. Demers et al., "Detection of trichothecene mycotoxins in sera from individuals exposed to Stachybotrys chartarum in indoor environments," Archives of Environmental Health, vol. 59, no. 6, pp. 317–323, 2004.

28. M. J. Hodgson, P. Morey, W. Y. Leung et al., "Building associated pulmonary disease from exposure to Stachybotrys chartarum and Aspergillus versicolor," Journal of Occupational and Environmental Medicine, vol. 40, no. 3, pp. 241–249, 1998.

29. S. Engelhart, A. Loock, D. Skutlarek et al., "Occurrence of toxigenic Aspergillus versicolor isolates and sterigmatocystin in carpet dust from damp indoor environments," Applied and Environmental Microbiology, vol. 68,no. 8, pp. 3886–3890, 2002.

30. J. Liu, Y. Wang, J. Cui et al., "Ochratoxin A induces oxidative DNA damage and G1 phase arrest in human peripheral blood mononuclear cells in vitro," Toxicology Letters, vol. 211, no. 2, pp. 164–171, 2012.

31. K. Doi and K. Uetsuka, "Mechanisms of mycotoxin-induced neurotoxicity through oxidative stress-associated pathways," International Journal of Molecular Sciences, vol. 12, no. 8, pp. 5213–5237, 2011.

32. A. Bouslimi, Z. Ouannes, E. E. Golli, C. Bouaziz, W. Hassen, and H. Bacha, "Cytotoxicity and oxidative damage in kidney cells exposed to the mycotoxins Ochratoxin A and citrinin: individual and combined effects," Toxicology Mechanisms and Methods, vol. 18, no. 4, pp. 341–349, 2008.

33. Z. Islam, C. J. Amuzie, J. R. Harkema, and J. J. Pestka, "Neurotoxicity and inflammation in the nasal airways of mice exposed to the macrocyclic trichothecene mycotoxin roridin A: kinetics and potentiation by bacterial lipopolysaccharide coexposure," Toxicological Sciences, vol. 98, no. 2, pp. 526–541, 2007.

34. J.-H. Park, J. M. Cox-Ganser, K. Kreiss, S. K. White, and C. Y. Rao, "Hydrophilic fungi and ergosterol associated with respiratory illness in a water-damaged building," Environmental Health Perspectives, vol. 116, no. 1, pp. 45–50, 2008.

35. J. Jussila, H. Komulainen, V.M. Kosma, A. Nevalainen, J. Pelkonen, and M. R. Hirvonen, "Spores of Aspergillus versicolor isolated from indoor air of a moisture-damaged building provoke acute inflammation in mouse lungs," Inhalation Toxicology, vol. 14, no. 12, pp. 1261–1277, 2002.

36. Simon-Nobbe B, Denk U, Pöll V, Rid R, Breitenbach M. The spectrum of fungal allergy. Int Arch Allergy Immunol. 2008; 145(1):58-86.

37. Sahakian NM, Park JH, Cox-Ganser JM. Dampness and mold in the indoor environment: implications for asthma. Immunol Allergy Clin North Am 2008 Aug; 28(3):485-505

38. Seltzer JM, Fedoruk MJ. Health effects of mold in children. Pediatr Clin North Am 2007 Apr; 54(2):309-33, viii-ix. http://pediatrics.aappublications.org/cgi/reprint/118/6/2582

39. American Environmental and Health Foundation, 26th Annual International Symposium on Man and his Environment in Health and Disease Hidden Connections for Chronic Diseases, vol. 1, 2008.

40. W. G. Sorenson, D. G. Frazer, and B. B. Jarvis, "Trichothecene mycotoxins in aerosolized conidia of Stachybotrys atra," Applied and Environmental Microbiology, vol. 53, no. 6, pp. 1370–1375, 1987

41. R. G´orny and T. Reponen, "Fungal fragments as indoor air biocontaminants," Applied and Environmental Microbiology, vol. 68, no. 7, pp. 3522–3531, 2002

42. E. Karunasena, M. D. Larra´naga, J. S. Simoni, D. R. Douglas, and D. C. Straus, "Building-associated neurological damage modeled in human cells: a mechanism of neurotoxic effects by exposure to mycotoxins in the indoor environment," Mycopathologia, vol. 170, no. 6, pp. 377–390, 2010

43. J D Thrasher, D P K Kilburn and N Immers. Indoor environment resulting from water intrusion. Part 1. November 2006.

44. J. H. Park and J. M. Cox-Ganser, "Mold exposure and respiratory health in damp indoor environments," Frontiers in Bioscience, vol. 3, pp. 757–771, 2011.

45. W. Jedrychowski, U. Maugeri, F. Perera et al., "Cognitive function of 6-year old children exposed to mold-contaminated homes in early postnatal period. Prospective birth cohort study in Poland," Physiology & Behavior, vol. 104, no. 5, pp. 989–995, 2011.

46. W. A. Gordon, J. B. Cantor, E. Johanning et al., "Cognitive impairment associated with toxigenic fungal exposure: a replication and extension of previous findings," Applied Neuropsychology, vol. 11, no. 2, pp. 65–74, 2004.

47. K. H. Kilburn, "Indoor mold exposure associated with neurobehavioral and pulmonary impairment: a preliminary report," Archives of Environmental Health, vol. 58, no. 7, pp. 390–398, 2004.

48. J. V. Baldo, L. Ahmad, and R. Ruff, "Neuropsychological performance of patients following mold exposure," Applied Neuropsychology, vol. 9, no. 4, pp. 193–202, 2002.

49. B. R. Crago, M. R. Gray, L. A. Nelson, M. Davis, L. Arnold, and J. D. Thrasher, Psychological, neuropsychological, and electrocortical effects of mixed mold exposure," Archives of Environmental Health, vol. 58, no. 8, pp. 452–463, 2003.

50. Crago BR, Gray MR, Nelson LA, Davis M, Arnold L, Thrasher JD. Pscyhological, neuropsychological, and electrocortical effects of mixed mold exposure. Arch Environ Health. 2003;58:452–463.

51. Edmond D. Shenassa, ScD, Constantine Daskalakis, ScD, Allison Liebhaber, BA, Matthias Braubach, MPH, and MaryJean Brown, ScD, RN. Dampness and Mold in the Home and Depression: An Examination of Mold-Related Illness and Perceived Control of One's Home as Possible Depression Pathways. American Journal of Public Health. October 2007, Vol 97, No. 10. 1893

52. Bandura A. Self-Efficacy: The Exercise of Control. New York, NY: WH Freeman; 1997.

53. Griffin JM, Fuhrer R, Stansfeld SA, Marmot M. The importance of low control at work and home on depression and anxiety: do these effects vary by gender and social class? Soc Sci Med, 2002;54:783–798.

54. Brown GW, Moran PM. Single mothers, poverty and depression. Psychol Med. 1997;27:21–33.

55. Hyndman SJ. Housing dampness and health amongst British Bengalis in east London. Soc Sci Med. 1990;30:131–41.

56. Martin CJ, Platt SD, Hunt SM. Housing conditions and ill

health. BMJ (Clin Res Ed). 1987;294:1125–1127

57. Packer CN, Stewart-Brown S, Fowle SE. Damp housing and adult health: results from a lifestyle study in Worcester, England. J Epidemiol Community Health. 1994;48:555–559.

58. Hyndman SJ. Housing dampness and health amongst British Bengalis in east London. Soc Sci Med. 1990;30:131–41.

59. Zock JP, Jarvis D, Luczynska C, Sunyer J, Burney P. Housing characteristics, reported mold exposure, and asthma in the European Community Respiratory Health Survey. J Allergy Clin Immunol, 2002;110:285–292.

60. Dales RE, Burnett R, Zwanenburg H. Adverse health effects among adults exposed to home dampness and molds. Am Rev Respir Dis. 1991;143:505–509.

61. L. Alpsoy, A. Yildirim, and G. Agar, "The antioxidant effects of vitamin A, C, and e on aflatoxin B 1-induced oxidative stress in human lymphocytes," Toxicology and Industrial Health, vol. 25, no. 2, pp. 121–127, 2009.

62. A. Yenilmez, B. Isikli, E. Aral, I. Degirmenci, E. Sutken, and C. Baycu, "Antioxidant effects of melatonin and coenzyme Q10 on oxidative damage caused by single-dose Ochratoxin A in rat kidney," Chinese Journal of Physiology, vol. 53, no. 5, pp. 310–317, 2010.

63. A. England, A. M. Valdes, J. L. Slater-Jefferies et al., "Variants in the genes encoding TNF-, IL-10, and GSTP1 influence the effect of -tocopherol on inflammatory cell responses in healthy men,"The American Journal of Clinical Nutrition, vol. 95, no. 6, pp. 1461–1467, 2012.

64. C. Bishop, V. M. Hudson, S. C. Hilton, and C. Wilde, "A pilot study of the effect of inhaled buffered reduced glutathione on the clinical status of patients with cystic fibrosis," Chest, vol. 127, no. 1, pp. 308–317, 2005

65. A. Roth, K. Chakor, E. E. Creppy, A. Kane, R. Roschenthaler, and G. Dirheimer, "Evidence for an enterohepatic circulation of Ochratoxin A in mice," Toxicology, vol. 48, no. 3, pp. 293–308, 1988.

66. K. A. Coddington, S. P. Swanson, A. S. Hassan, andW. B. Buck, "Enterohepatic circulation of T-2 toxin metabolites in the rat," Drug Metabolism and Disposition, vol. 17, no. 6, pp. 600–605, 1989.

67. J. J. Boylan, J. L. Egle, and P. S. Guzelian, "Cholestyramine: use as a new therapeutic approach for chlordecone (Kepone) poisoning," Science, vol. 199, no. 4331, pp. 893–895, 1978.

68. W. J. Cohn, J. J. Boylan, and R. V. Blanke, "Treatment of chlordecone (Kepone) toxicity with cholestyramine. Results of a controlled clinical trial,"The New England Journal ofMedicine, vol. 298, no. 5, pp. 243–248, 1978.

69. S. Takenaka, K. Morita, H. Tokiwa, and K. Takahashi, "Effects of rice bran fibre and cholestyramine on the faecal excretion of Kanechlor 600 (PCB) in rats," Xenobiotica, vol. 21,no. 3, pp. 351– 357, 1991.

70. S. Tonstad, J. Knudtzon, M. Sivertsen, H. Refsum, and L. Ose, "Efficacy and safety of cholestyramine therapy in peripubertal and prepubertal children with familial hypercholesterolemia," Journal of Pediatrics, vol. 129, no. 1, pp. 42–49, 1996.

71. H. Malekinejad, A. A. Farshid, and N. Mirzakhani, "Liquorice plant extract reduces Ochratoxin A-induced nephrotoxicity in rats," Experimental and Toxicologic Pathology, vol. 63, no. 1-2, pp. 125–130, 2011.

72. M. Sirajudeen, K. Gopi, J. S. Tyagi, R. P.Moudgal, J.Mohan, and R. Singh, "Protective effects ofmelatonin in reduction of oxidative damage and immunosuppression induced by aflatoxin B1- contaminated diets in young chicks," Environmental Toxicology, vol. 26, no. 2, pp. 153–160, 2011.

73. K. Doi and K. Uetsuka, "Mechanisms of mycotoxin-induced neurotoxicity through oxidative stress-associated pathways,"International Journal of Molecular Sciences, vol. 12, no. 8, pp. 5213–5237, 2011.

74. R. Zajtchuk, "Medical aspects," in Medical Aspects of Chemical and BiologicalWarfare, Office ofThe SurgeonGeneral at TMM Publications,Washington, DC, 1997.

75. V. Iebba, M. Nicoletti, and S. Schippa, "Gut microbiota and the immune system: an intimate partnership in health and disease," International Journal of Immunopathology and Pharmacology, vol. 25, no. 4, pp. 823–833, 2012.

76. J. L. Round and S. K. Mazmanian, "The gutmicrobiota shapes intestinal immune responses during health and disease," Nature Reviews Immunology, vol. 9, no. 5, pp. 313–323, 2009.

77. K. Gross-Steinmeyer, P. L. Stapleton, J. H. Tracy, T. K. Bammler, S. C. Strom, and D. L. Eaton, "Sulforaphane- and phenethyl isothiocyanate-induced inhibition of aflatoxin B1-mediated genotoxicity in human hepatocytes: role of GSTM1 genotype and CYP3A4 gene expression," Toxicological Sciences, vol. 116, no. 2, pp. 422–432, 2010.

78. T. W. Kensler, J.-G. Chen, P. A. Egner et al., "Effects of glucosinolate-rich broccoli sprouts on urinary levels of aflatoxin-DNAadducts and phenanthrene tetraols in a randomized clinical trial in He Zuo Township, Qidong, People's Republic of China," Cancer Epidemiology Biomarkers and Prevention, vol. 14, no. 11 I, pp. 2605–2613, 2005.

79. L. Tang, H. Guan, X. Ding, and J. S. Wang, "Modulation of aflatoxin toxicity and biomarkers by lycopene in F344 rats," Toxicology and Applied Pharmacology, vol. 219, no. 1, pp. 10–17, 2007.

80. S. Gao, X. Y. Chen, R. Z. Zhu, B.-M. Choi, S. J. Kim, and B. R. Kim, "Dual effects of phloretin on aflatoxin B1 metabolism: activation and detoxification of aflatoxin B1," BioFactors, vol. 38, no. 1, pp. 34–43, 2012.

81. F. L. P. Soares, R. de Oliveira Matoso, L. G. Teixeira et al., "Gluten-free diet reduces adiposity, inflammation and insulin resistance associated with the induction of PPAR-alpha and PPAR-gamma expression," The Journal of Nutritional Biochemistry, 2012.

82. J. R. Jackson, W. W. Eaton, N. G. Cascella, A. Fasano, and D. L. Kelly, "Neurologic and psychiatric manifestations of celiac disease and gluten sensitivity," The Psychiatric Quarterly, vol. 83, no. 1, pp. 91–102, 2012.

83. A. Kheder, S. Currie, C. Romanowski, and M. Hadjivassiliou, "Progressive ataxiawith palatal tremor due to gluten sensitivity," Movement Disorders, vol. 27, no. 1, pp. 62–63, 2012.

84. Y. Zhang, D. L. Menkes, and D. S. Silvers, "Propriospinal myoclonus associated with gluten sensitivity in a young woman," Journal of the Neurological Sciences, vol. 315, no. 1-2, p. 141, 2012.

85. M. Pietzak, "Celiacdisease,wheat allergy, andglutensensitivity: when gluten free is not a fad," Journal of Parenteral and Enteral Nutrition, vol. 36, no. 1, supplement, pp. 68S–75S, 2012.

86. Hope, J. 2013. A review of the mechanism of injury and treatment approaches for illness resulting from exposure to water damaged buildings, mold and mycotoxins. The Scientific World Journal, 2013, 20.

87. Health Canada. Fungal contamination in public buildings: Health effects and investigation methods. Ottawa, ON: Health Canada, Environmental and Workplace Health.2004.

88. AIHA 2008. Recognition, evaluation and control of indoor mould, By Prezant, B., Weekes, D.M., Miller, J.D., eds. Fairfax, VA: American Industrial Hygiene Association.

89. Hung, L.L., J.D. Miller, and K.H. Dillon (eds.): Field Guide for the Determination of Biological Contaminants in Environmental Samples, 2nd edition. Fairfax, VA: AIHA, 2005.

90. American Industrial Hygiene Association (AIHA): "Facts about Mold." December 2011. Available at http://www.aiha.org/newspubs/ [Accessed February 12, 2013.]

91. Horner, W.E., C. Barnes, R. Codina, and E. Levetin: Guide for interpreting reports from inspections/investigations of indoor mold. J. Allergy Clin. Immunol. 121:592-97 (2008).

92. Quansah, R., M.S. Jaakkola, T.T. Hugg, S.A. Heikkinen, and J.J. Jaakkola: Residential dampness and molds and the risk of developing asthma: a systematic review and meta-analysis. PLoS One. 7(11):e47526 (2012).

93. Dales, R., L. Liu, A.J. Wheeler, and N.L. Gilbert: Quality of indoor residential air and health. Can. Med. Assoc. J. 179:147-52 (2008).

94. Park, J.H., P.L. Schleiff, M.D. Attfield, J.M. Cox-Ganser, and K. Kreiss: Building-related respiratory symptoms can be predicted with semi-quantitative indices of exposure to dampness and mold. Indoor Air 14: 425-33 (2004).

95. Kemp, P. and Neumeister-Kemp, HG. 2010. Australian Mould Guideline. AMG-2010. The EnviroTrust. Osborne Park, WA.

96. Andersen, B., Frisvad, J.C., Sondergaard, Ib, Rasmussen, Ib S. and Larsen, L.S. 2011. Associations between fungal species and water damaged building materials. Applied and environmental microbiology, 77(12), 4180-4188.

97. Nielsen K. F., Holm G., Uttrup L. P., Nielsen P. A. 2004. Mould growth on building materials under low water activities. Influence of humidity and temperature on fungal growth and secondary metabolism. Int. Biodeterior. Biodegradation 54:325–336.

98. Viitanen H., et al. 2010. Moisture and bio-deterioration risk of building materials and structures. J. Build. Phys. 33:201–224.

99. Grant C., Hunter C. A., Flannigan B., Bravery A. F. 1989. The moisture requirements of moulds isolated from domestic dwellings. Int. Biodeterior. 25:259–284.

100. American Conference of Governmental Industrial Hygenists (ACGIH): Bioaerosols: Assessment and Control, Macher, J. (ed). Cincinnati, OH: ACGIH, 1999.

101. Palaty, C. 2010. Mould remediation in indoor environments – review of guideleines and evidence. Metaphase. National Collaborating Centre for Environemtnal health. Vancouver, BC. 2010.

102. New York City Department of Health and Mental Hygiene. Guidelines on Assessment and Remediation of Fungi in Indoor Environments. [Online] November 2008 [cited 2009 May 11]; newsroom/Documents/Facts%20About%20 Mold%20December%202011.pdf.

103. Shoemaker, R. Step by step treatment. Surviving Mold, n.d. Web. Sept 2011.

104. Environmental Protection Agency. Mold Remediation in Schools and Commercial Buildings. 2001. Available at: http://www.epa.gov/mold/mold remediation.html (Accessed March 4, 2010).

105. G. Schatzmayr, F. Zehner, M. T¨aubel et al., "Microbiologicals for deactivating mycotoxins," Molecular Nutrition and Food Research, vol. 50, no. 6, pp. 543–551, 2006.

106. M. Peitzsch, E. Bloom, R. Haase, A. Must, and L. Larsson, "Remediation of mould damaged building materials—efficiency of a broad spectrum of treatments," Journal of Environmental Monitoring, vol. 14, no. 3, pp. 908–915, 2012.

107. J. Prousky, "The treatment of pulmonary diseases and respiratory-related conditions with inhaled (nebulized or aerosolized) glutathione," Evidence-Based Complementary and Alternative Medicine, vol. 5, no. 1, pp. 27–35, 2008.

108. J.K.Kern, D. A. Geier, J. B. Adams, C. R. Garver,T. Audhya, and M. R. Geier, "A clinical trial of glutathione supplementation in autism spectrum disorderss," Medical Science Monitor, vol. 17, no. 12, pp. CR677–CR682, 2011.