

REVIEW

Adverse Health Effects of Indoor Molds

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Abstract

Purpose: *It has long been known that eating moldy food is hazardous, and airborne Aspergillus and other fungi can cause life-threatening illnesses in immunocompromised patients. However, the possible health risks of indoor mold exposure in immunocompetent humans are controversial. This literature review examines the health effects of indoor airborne exposure to mold.*

Design: *Literature review.*

Materials and Methods: *This review was conducted by searching PubMed and other medical databases, as well as reading recent conference reports.*

Results: *Many studies link exposure to damp or moldy indoor conditions to increased incidence and/or severity of respiratory problems such as asthma, wheezing and rhinosinusitis. Stachybotrys produces trichothecenes and other mycotoxins, which can inhibit protein synthesis and induce hemorrhaging disorders. Indoor mold exposure can alter immunological factors and produce allergic reactions. Several studies have indicated that indoor mold exposure can alter brain blood flow, autonomic nerve function, brain waves and worsen concentration, attention, balance and memory. Failure to perform the appropriate objective evaluations on patients may account for the commonly held belief that indoor mold exposure poses no significant health risks to immunocompetent humans.*

Conclusions: *Exposure to high levels of indoor mold can cause injury to and dysfunction of multiple organs and systems, including respiratory, hematological, immunological, and neurological systems, in immunocompetent humans.*

Keywords: *mold, fungi, mycotoxin, allergy, indoor air quality, asthma, neurotoxicity, lung hemorrhage, Aspergillus, Penicillium, Cladosporium, Alternaria, Stachybotrys.*

INTRODUCTION

In recent years, public attention has become increasingly focused on human health concerns linked with mold (fungi) inside homes and workplaces. Indoor airborne mold exposure has been associated with adverse human health effects in multiple organs and body systems, including respiratory, nervous, immune, hematological and dermatological systems. Indoor mold exposure can also lead to life-threatening systemic infections in immunocompromised patients.

A qualitative systematic literature review was undertaken in order to examine and

appraise the current state of knowledge about indoor mold-linked health effects, and to summarize the available evidence for the use by health professionals. Physicians, in particular, may encounter patients with common symptoms occurring in particular environments, and understanding the potential for mold-related health effects is key to the complete investigation of those environments. Physicians and industrial hygienists may be asked to contribute reports to assist the courts in settling suits. In 2002, an estimated 10,000 mold-related cases were pending in US courts [1]. Also in 2002, the insurance industry paid out \$2 billion in mold-related claims in Texas alone [2].

Literature was reviewed using the peer-reviewed database, and from recent conferences on indoor molds. The levels of evidence available for each topic varied from level I (from at least one properly randomized controlled trial) through level II (from trials without randomization, exceptionally convincing uncontrolled experiments, cohort or case-control studies), to level III (opinion of respected authorities based on clinical experience, descriptive studies, or reports of expert committees) [3].

MOLDS IN THE INDOOR ENVIRONMENT

Fungi (or molds) are ubiquitous in both indoor and outdoor environments and are frequently dispersed by airborne spores. Mold and mold spores require moisture and a food source, such as cellulose or decaying food, to grow [4]. As mold spores swell with water and grow, they elongate, forming balloon-like protuberances (hyphae), which secrete digestive enzymes and mycotoxins. The fungi then digest the food source to support their growth.

About 100,000 fungal species have already been identified; in fact, fungi are estimated to comprise an astounding 25% of the world's biomass [5]. Various surveys of homes in North America and Europe have reported that visible mold and/or water damage are common, found in 23–98% of all homes examined [6–9]. There are no official standards at this time for indoor airborne fungi concentrations. However, indoor fungal levels above a range of 150–1000 colony-forming units per cubic meter of air (cfu m^{-3}) are considered to be sufficient to cause human health problems [7, 10–12]. Numerous reports have documented that indoor air can be contaminated with fungal spore levels well in excess of 1000 cfu m^{-3} [13–20]. The most common indoor fungal genera collected are *Cladosporium*, *Aspergillus* and *Penicillium* [13–20]. *Alternaria*, *Stachybotrys*, *Rhizopus*, *Mucor*, *Wallemia*, *Trichoderma*, *Chaetonium*, yeasts, *Botrytis*, *Epicoccum* and *Fusarium* species are often found indoors as well [13–20].

MOLD-RELATED HEALTH SYMPTOMS

Patients have been reporting multiple ill health effects linked to exposures to mold. Studies of more than 1600 patients suffering ill effects associated with fungal exposure were presented at one meeting in Dallas in 2003 (21st Annual Symposium of Man and His Environment, Dallas, Texas, 19–22 June 2003) [21–25].

To cite a few studies: Lieberman [21] examined 48 heavily mold-exposed patients who had the following health problems: muscle and/or joint pain (71%), fatigue/weakness (70%), neurocognitive dysfunction (67%), sinusitis (65%), headache (65%), gastrointestinal problems (58%), shortness of breath (54%), anxiety/depression/irritability (54%), vision problems (42%), chest tightness (42%), insomnia (40%), dizziness (38%), numbness/tingling (35%), laryngitis (35%), nausea (33%), skin rashes (27%), tremors (25%) and heart palpitations (21%). Rea *et al.*'s study [23] of 150 heavily indoor mold-exposed patients found the following health problems: fatigue (100%), rhinitis (65%), memory loss and other neuropsychiatric problems (46%), respiratory problems (40%), fibromyalgia (29%), irritable

bowel syndrome (25%), vasculitis (4.7%) and angioedema (4.0%). These clinical reports suggest that there can be multisystem adverse effects of airborne mold. All reported cases had environmental mold exposure consistent with toxic mold exposure.

MECHANISMS OF MOLD-RELATED HEALTH EFFECTS

Fungi can exert ill health effects by three major mechanisms: allergy, toxicity, and infection.

Allergy and Irritation

At least 70 allergens have been well characterized from spores, vegetative parts and small particles from fungi (0.3 µm and smaller) [26, 27]. A review of 17 studies revealed that 6–10% of the general population and 15–50% of atopics had immediate skin sensitivity to fungi [28]. Fungi produce beta glucans, which have irritant properties [29].

Toxicity

Fungi produce a wide variety of toxic chemicals called mycotoxins [4, 30, 31]. Some common mycotoxins include: aflatoxins—very potent carcinogens and hepatotoxins, produced by some *Aspergillus* species; ochratoxins—nephrotoxic and carcinogenic, produced by some *Aspergillus* and *Penicillium*; sterigmatocystin—immunosuppressive and a liver carcinogen, produced by *Aspergillus* species, especially *A. versicolor*; trichothecenes—produced primarily by *Stachybotrys* and *Fusarium* species and have been reported to inhibit protein synthesis and cause hemorrhage and vomiting. Fungi also produce beta glucans, which have immunological effects [32]. The smell of molds comes primarily from volatile organic compounds [33].

Adverse human and animal effects from mycotoxin-contaminated foodstuffs have been well recognized since the early twentieth century [30, 34], but the pathway of mycotoxin injury through inhalation is questioned [35]. Because it is unethical to conduct controlled studies on humans with inhaled mycotoxin exposure, only controlled animal exposures and human cohort and case-control studies can be carried out. The literature reveals that significant amounts of mycotoxins (including ochratoxin, sterigmatocystin and trichothecenes) are present in indoor dust [36–39] and dust or fungal particles less than 10 µm in diameter are respirable, thus allowing absorption of mycotoxins through the lungs [31, 34, 40, 41].

Patients exposed to indoor *Stachybotrys* have been found to have measurable blood levels of the *Stachybotrys* hemorrhagic toxin stachylysin [42]. Levels of trichothecene mycotoxins in urine have also been found in significantly higher levels in patients exposed to high indoor fungal levels as opposed to an unexposed control group [43].

Blood ochratoxin levels have been found to be significantly higher in food industry workers exposed to airborne ochratoxin vs. unexposed controls [39]. These findings support an inhalation pathway for entry of mycotoxins into the body.

Infection

Fungi such as *Candida*, *Histoplasmosis*, *Cryptococcus*, *Blastomyces* and *Coccidioides* can infect immunocompetent people [44]. Fungi such as *Trichophyton*, *Candida* and *Malassezia* commonly cause minor skin infections in immunocompetent humans [45].

Serious infections by such fungi as *Candida*, *Aspergillus* and *Pneumocystis* mostly involve severely immunocompromised patients [45–47]. In recent years, the incidence of life-threatening infections in immunocompromised patients from *Aspergillus* and other common

fungi has been growing rapidly [48, 49]. Invasive aspergillosis is very common among immunocompromised patients, with the following reported incidence rates: lung transplants: 17–26%; allogenic bone marrow transplants: 5–15%; acute leukemia: 5–24%; heart transplants: 2–13% [50–51]. Even with strong anti-fungal drugs and intense hospital treatment, mortality rates from invasive aspergillosis range from 50 to 99% in the immunocompromised [52, 53].

SAMPLING FOR MOLD EXPOSURE

Indoor fungal sampling is most commonly performed by measuring airborne levels of viable (culturable) or total (viable and non-viable) spores [54, 55]. Some of the airborne viable sampling methods, such as Andersen samplers, collect air for only a few minutes. Settle plates are an inexpensive method to obtain a semi-quantitative measure of indoor airborne fungi levels. Viable and non-viable airborne spore counts can vary considerably over a period of minutes, so air sampling over several periods of time may be necessary to accurately characterize airborne fungal spore levels [54, 55]. However, airborne fungi measurements fail to take into consideration mold contamination in dust or surfaces (often visible to the naked eye) and mycotoxins in air, dust and on surfaces [54, 56]. Therefore, testing settled dust for fungi and mycotoxins has been recommended [54, 55]. Other techniques, such as polymerase chain reaction (PCR), enzyme-linked immunosorbent assay (ELISA), and measurement of fungal volatile organic compounds, polysaccharides, ergosterol and beta glucans, have also been found to be useful in assaying indoor environments for molds, their allergens and mycotoxins [54].

INDOOR MOLD EXPOSURE AND HEALTH EFFECTS IN BODY SYSTEMS

Respiratory System

Many epidemiological studies have noted that residential exposure to molds and/or chronic dampness can increase asthma/wheezing incidence or morbidity in both children and adults [7–9, 57–70]. Asthma and related conditions are very common in the USA, with an overall prevalence of about 5.4% among all age groups and incidences as high as 27% in inner city children [71]. Studies with infants have reported that higher fungal exposures are associated with more wheezing, coughing and respiratory illness [72, 73]. Higher indoor beta glucan levels have been associated with significantly higher levels of chest tightness and joint pain [74]. Non-industrial occupational mold exposure has been reported to be associated with significantly higher levels of asthma, sinusitis, irritated skin and eyes, and chronic fatigue [75–79]. One study found that patients exposed to high indoor fungal levels had significantly lower lung function than unexposed controls [24]. Higher outdoor fungal concentrations have been linked to higher asthma death rates [80] and higher asthma incidence [81–83] in children or young adults. Challenge exposures with *Penicillium* and *Alternaria* extracts equivalent to high outdoor levels of fungi were noted to severely lower lung function in asthmatics [84]. Skin sensitivity to *Alternaria* has been linked to much higher risk (odds ratio 190, 95% confidence interval 6.5–6.536, $p < 0.0001$) of respiratory arrest [85]. Various epidemiological studies have associated skin sensitivity to common indoor fungi and higher asthma incidence or severity [86–90] and higher rates of sinusitis [91].

Airborne fungal exposure is known to cause bronchopulmonary aspergillosis and hypersensitivity pneumonitis, and can cause sinusitis [92, 93]. An estimated 14% of the US population suffers from rhinosinusitis and related conditions [94]. Allergic fungal sinusitis was diagnosed on the basis of fungal growth in nasal secretions and the presence of allergic mucin in 93% of 101 consecutive patients undergoing sinus surgery [94]. Another study was

able to recover and culture fungi from the sinuses of 56% of 45 patients undergoing endoscopic sinus surgery for chronic rhinosinusitis [95]. A long-term cohort study of 639 patients with allergic fungal sinusitis demonstrated that remedial steps taken to reduce fungal exposure (by utilizing, for example, air filters, ionizers, moisture control and antimicrobial nasal sprays) significantly reduced rhinosinusitis and improved nasal mucosa morphology [22]. This study concluded that failure to reduce airborne fungi levels to less than four per hour on a settle plate failed to resolve the sinusitis [22]. Although, historically, anti-fungal drugs have generally not been recommended for the treatment of fungal sinusitis [92, 93], recent observational studies have found beneficial effects of oral and nasal medication for sinusitis patients [22, 96]. Several studies have linked residential exposure to various fungi with hypersensitivity pneumonitis [97–99].

Hematological Effects

Exposure to high indoor levels of *Stachybotrys*, *Aspergillus* and other fungi has been epidemiologically associated with infant lung hemorrhage [100–104]. Although questions were raised after this association was discovered [105], it meets many epidemiological criteria for causality [106]. Acute infant pulmonary hemorrhage can be rapidly fatal; when the infant survives, lung blood vessel damage is present and deposits of hemosiderin will remain in the lung macrophages and can be seen in tissue obtained during bronchoscopy [101]. *Stachybotrys* fungi produce a wide range of trichothecene mycotoxins (including satratoxins and T2), several roridin epimers, verrucarins J and B and hemolysin [31, 103]. A hemorrhagic protein called stachylysin has been isolated from *Stachybotrys* collected from homes of infants with lung hemorrhage [107, 108] and from serum of patients with residential *Stachybotrys* exposure [42]. It is hypothesized that infants with their rapidly growing lungs are more susceptible to the toxic effects of *Stachybotrys* mycotoxins [109]. Studies with *Stachybotrys*-exposed adults have noted a significantly higher incidence of health conditions such as wheezing, skin and eye irritation, 'flu-like symptoms and chronic fatigue [110]. *Stachybotrys* has been isolated from the lungs of a child with pulmonary hemosiderosis [111].

A case study was presented of 16-month-old twins in a mold-infested home, one of whom died of pulmonary hemosiderosis [112]. High levels of trichothecene mycotoxins were found in the lungs and liver of the dead infant, while high IgG levels to *Stachybotrys* and IgM levels to satratoxin and trichothecenes were found in the serum of the surviving infant. Environmental sampling in the twins' home found high levels of satratoxin as well as high levels of spores from *Stachybotrys*, *Aspergillus versicolor* and *Penicillium* [112].

Immune System

Some studies have reported that indoor fungi-exposed patients have higher serum levels of IgG, IgA and IgM antibodies to common fungi, trichothecenes and satratoxins [113–115]. IgG antibodies to nine common indoor fungi were significantly higher in subjects with sinusitis vs. non-sinusitis subjects in a moldy school [116]. Other studies have noted no significant increases in fungal IgG [117, 118] or fungal IgE [113] in fungi-exposed patients. Indoor fungal exposure has been associated with altered levels of T4, T8 and natural killer cells and higher levels of autoantibodies [23, 25, 119, 120]. Occupants of homes with high Indoor glucan exposure had a lower proportion of cytotoxic t-cells (CD8+SF61+) and higher secretion of tumor necrosis factor than occupants of homes with lower levels of beta glucans [121]. Studies of animals given such common mycotoxins as aflatoxins, ochratoxins and trichothecenes orally showed considerable immune impairment, including depression of T cells, B cells and macrophages [122]. Human cell line studies have also found that

many mycotoxins can suppress T-cell, B-cell and natural killer cell activity at serum concentrations similar to those found in indoor mold-exposed patients [123].

Central Nervous System

Two case series of 48 and 150 mold-exposed patients found significant fatigue and weakness in 70–100% of cases, and neurocognitive dysfunction including memory loss, irritability, anxiety and depression in over 40% of the patients [21, 23]. Numbness, tingling and tremor were also found in a significant number of patients [21, 23]. These signs and symptoms have been described as classic manifestations of neurotoxicity [124].

A study of 43 mold-exposed patients found that they performed significantly worse than 202 controls on many neuropsychiatric tests, including balance sway speed, blinking reflex, color perception, reaction times and left grip strength ($p < 0.0001$) [125]. Quantitative electroencephalogram (qEEG) studies in 182 patients with documented mold exposure also noted significant alterations in brain waves, including hypoactivation of the frontal cortex and narrowed frequency bands [126]. Higher levels of mold exposure (longer time in mold-infested area, presence of *Stachybotrys* or higher cfu m⁻³ air) were associated with significantly more abnormal qEEGs as well as significantly worse scores of concentration and motor and verbal skills in these 182 patients [126]. A triple-headed SPECT brain scan revealed neurotoxic patterns in 26 of 30 (87%) mold-exposed patients [127]. An iriscorder study of autonomic nervous function in 60 mold-exposed patients found that 95% had abnormal autonomic responses of the pupil compared with the population reference range [23]. Visual contrast sensitivity studies were often abnormal in indoor mold-exposed patients [23]. Additional studies have reported that mold-exposed patients do significantly worse on tests of attention, balance, reaction time, verbal recall, concentration, memory, and finger tapping compared with the general population reference range [24, 128, 129]. Most of these patients also experienced many health problems, including chronic fatigue, headaches, insomnia and decreased balance, concentration and attention. Studies of indoor mold-exposed children and adults found significantly more neurophysiological abnormalities vs. controls, including abnormal EEGs and abnormal brainstem, visual and somatosensory evoked potentials [25, 130, 131].

Lieberman [21] presented a case series of 12 patients who developed tremors following documented heavy indoor mold exposure. Numerous articles have reported domestic dogs developing tremors following ingestion of moldy food [132–134]. Territrem b, a mycotoxin produced by the common fungus *Aspergillus terreus*, has been shown to be an irreversible binder and inhibitor of acetylcholinesterase [135].

Renal System

It is known that ochratoxin-contaminated food is nephrotoxic [136, 137]. Indoor airborne exposure to ochratoxin may also be nephrotoxic. In a case report of a family presenting with increasing thirst/urination, lethargy, and skin rash, a considerable amount of ochratoxin was found in their house dust. The family recovered after moving to another home [36].

Reproductive System

The literature suggests a relationship between heavy airborne fungal exposure and reproductive dysfunction. Kristensen *et al.* [138, 139] reported that airborne mycotoxin exposures in Norwegian grain farmers was significantly related to higher rates of pre-term deliveries, late-term miscarriages and higher rates of endometrial and ovarian

endocarcinoma. The veterinary literature finds a strong association between mycotoxins in feedstuffs and reproductive problems [140].

Diabetes

There is a great deal of evidence that links environmental factors to the triggering of type 1 diabetes. Exposure to viruses, bacteria and mycotoxins such as alloxan, streptozotocin and L-asparaginase has been linked to the development of type 1 diabetes in animals and humans [141–143]. Lieberman [21] reported that in a single year, five of his patients developed type 1 diabetes following documented heavy indoor mold exposure.

DIAGNOSIS AND MANAGEMENT OF POTENTIALLY MOLD-RELATED HEALTH PROBLEMS

A careful medical and environmental history is an essential first step in evaluating a patient for mold-related health problems [144–147]. Particular attention should be paid to any history of exposure to visible mold and/or water damage at the home or workplace. Environmental sampling for viable spores, total spores, and mycotoxins in the air and dust can provide important exposure information. For a helpful overview of sampling methods, see references [54, 148, 149]. For an informative guide to the classification, identification and biology of common indoor fungi, see reference [4]. Several good guides exist for the prevention and remediation of indoor fungi problems [144, 148–151].

For patients suspected of having substantial fungal exposure, a battery of sophisticated laboratory tests has been developed: a basic metabolic panel to test for several important parameters (including electrolytes, blood sugar, liver and kidney status); measurement of antibodies to molds and mycotoxins in serum [113, 114]; immune tests for autoantibodies, complement, gamma globulins and lymphocyte panels [120]; urine and blood testing for mycotoxins [43]; visual contrast sensitivity tests; and pupillometry and heart rate variation to assist in the evaluation of autonomic nervous system function. The use of standard neuropsychological test batteries [23, 128–130], EEG and brain imaging techniques such as SPECT and magnetic resonance imaging (MRI) can be very helpful tools in documenting neurological damage [25, 125, 127, 131, 145]. Pulmonary function tests are also useful for patients with respiratory symptoms [24, 124]. Failure to perform objective evaluations to assess system or organ dysfunction account for the presently accepted position that airborne mold exposures have no significant adverse effects [35]. If end-stage organ damage is suspected, consultation with a specialist may be useful.

Other common indoor environmental exposures should also be considered as a potential source of health problems. Common non-fungal indoor environmental factors include poor ventilation, carbon monoxide from faulty heat sources, leaking natural gas, pesticides, wood smoke, second-hand tobacco smoke, petrochemicals, such as cleaners/building materials/solvents, formaldehyde from outgassing carpets, building materials, bacteria, and allergens from the fur, feathers, saliva and excrement of common household animals such as cockroaches, dust mites, cats, dogs, mice, rats, caged birds, and pigeons. Exposure to ozone, second-hand tobacco smoke, cockroach allergens, formaldehyde, and viral infections have been noted to have a synergistic effect with fungal exposure to worsen asthma and rhinitis [152–156].

The most important part of treatment for mold-exposed patients, symptomatic or not, is avoidance of fungal exposure and remediation of mold contamination in the home and workplace. Any water leaks and damage from flooded or damp areas should be rectified immediately. Non-porous surfaces such as floors and walls that have visible mold growth should be cleaned. Porous waterlogged materials like carpet and furniture should be discarded. Control of humidity is important to control mold growth. The use of air

conditioners and dehumidifiers can significantly reduce summertime indoor airborne mold concentrations [13, 157]. HEPA air filters can also significantly reduce indoor airborne fungi concentrations [158]. For cleaning severe indoor water or mold problems, the use of protective equipment like face masks and/or the use of a professional remediation firm may be essential [148–151].

Environmental control plays a key role in preventing *Aspergillus* infections. Several studies have linked hospital construction work to increased rates of invasive aspergillosis [159–162]. Environmental controls such as using HEPA filters, sealing rooms, regular cleaning of rooms, and using anti-fungal copper-8-quinolate paint have been shown to both significantly reduce airborne levels of *Aspergillus* and significantly reduce rates of invasive aspergillosis in immunocompromised hospital patients [158, 160–165]. Other recent research has indicated that a large number of *Aspergillus* spores can spread through water supplies [166] and that cleaning shower facilities can significantly lower airborne levels of *Aspergillus* [167].

Use of sublingual or fungal immunotherapy by injection has been shown to be beneficial to some patients sensitized to common indoor molds such as *Alternaria* and *Cladosporium herbarium* [168, 169]. Some studies with laboratory animals suggest that a high-quality diet with adequate antioxidant vitamins, selenium, phytochemicals, methionine and total protein can reduce the harmful effects of food mycotoxins [170, 171].

SUMMARY

There is an accumulated weight of evidence linking indoor airborne mold and/or mycotoxin exposures to multisystem adverse human health effects. A history of new neurocognitive symptoms occurring in patients soon after heavy mold exposure, accompanied by objective neuropsychological findings in such patients, adds considerably to the weight of evidence from animal studies, epidemiological research, and case series.

Health care professionals, building managers, homeowners and the general public need to be much more aware of the potential adverse health effects of high indoor fungal exposures and the need for proper building construction, maintenance, and remediation of dampness to prevent such effects. Potentially mold-related illnesses need to be considered in differential diagnoses, and careful exposure histories taken. Prompt removal from exposure to fungal contamination remains the treatment of choice, with some evidence that immunotherapy and nutritional support are also useful. Indoor airborne mold particles can be irritative to the respiratory tract, and fungal spores, antigens, volatile organic compounds, and mycotoxins can be absorbed through the respiratory route to provoke injury by the mechanisms of allergy, toxicity, and infection.

REFERENCES

- [1] Umberger M. The start that upstaged the economy. Chicago Tribune, 13 January 2002, available at WL 2612028, database ALLNEWS.
- [2] Mold claims hit \$4 billion in Texas, Insurance Journal, 27 May 2003 (<http://insurancejournal.com>).
- [3] The Canadian Task Force on the Periodic Health Examination. The Canadian Guide to Clinical Preventative Health Care. Ottawa: Supply and Services Canada, 1994.
- [4] Samson R, Hoekstra E, Frisvad J, Filtenborg O. Introduction to Food and Airborne Fungi. Utrecht: Centraalbureau voor Schimmelcultures, 2000.
- [5] Miller JD. Fungi as contaminants of indoor air. Atmos Environ 1992; 26A(12): 2162–72.
- [6] Presternon DR. Perceived moisture problems in Iowa homes. Technical note. Forest Products J 1991; 41(6): 47–48.
- [7] Platt S, Martin C, Hunt S, Lewis C. Damp housing, mould growth and symptomatic health state. Br Med J 1989; 298: 1673–8.

- [8] Brunekreef B, Dockery D, Speizer FE. Home dampness and respiratory morbidity in children. *Am Rev Dis* 1989; 140: 1363–7.
- [9] Dales R, Zwanenburg H, Burnett R, Franklin C. Respiratory health effects of home dampness and molds among Canadian children. *Am J Epidemiol* 1991; 134(2): 196–203.
- [10] Etzel R. Indoor air pollutants in homes and schools. *Pediatr Clin North Am* 2001; 48(5): 1153–65.
- [11] Flannigan B, McCabe E, McGarry F. Allergic and toxigenic microorganisms in houses. *J Appl Bacteriol* 1991; 70: 61S–73S.
- [12] Dhillon M. Current status of mold immunotherapy. *Ann Allergy* 1991; 66: 385.
- [13] Curtis L, Ross M, Persky V *et al.* Bioaerosol concentrations in the Quad Cities 1 year after the 1993 Mississippi River floods. *Indoor Built Environ* 2000; 9: 35–43.
- [14] Shelton B, Kirkland K, Flanders WD, Morris G. Profiles of airborne fungi in buildings and outdoor environments in the United States. *Appl Environ Microbiol* 2002; 68(4): 1743–53.
- [15] Ren P, Jankun T, Leaderer B. Comparisons of seasonal fungal prevalence in indoor and outdoor air and in house dwellings in one Northeast American county. *J Exposure Anal Environ Epidemiol* 1999; 9: 560–8.
- [16] Pei-Chih W, Huey-Jen S, Chia-Yin L. Characteristics of indoor and outdoor airborne fungi at suburban and urban homes in two seasons. *Sci Total Environ* 2000; 253: 111–8.
- [17] Li CS, Kuo YM. Characteristics of airborne microfungi in subtropical homes. *Sci Total Environ* 1994; 155(3): 267–71.
- [18] Ebner E, Hasselwandter K, Frank A. Indoor and outdoor incidence of airborne fungal allergens at low and high alpine environments. *Mycol Res* 1992; 97: 117–24.
- [19] Solomon WR. A volumetric study of winter fungus prevalence in the air of midwestern homes. *J Allergy Clin Immunol* 1976; 57(1): 46–55.
- [20] Beaumont F, Kauffman HF, Sluiter HJ, DeVries K. A volumetric-aerobiological study of seasonal fungus prevalence inside and outside dwellings of asthmatic patients living in northeast Netherlands. *Ann Allergy* 1984; 53(6): 486–92.
- [21] Lieberman A. Explosion of mold cases in homes, workplaces and occupational medicine practices. Presented at the 21st Annual Symposium on Man and His Environment in Health and Disease, Dallas, Texas, 19–22 June 2003.
- [22] Dennis D. Chronic sinusitis: defective T-cells responding to superantigens, treated by reduction of fungi in the nose and air. *Arch Environ Health* 2003; 58(7): 433–41.
- [23] Rea WJ, Didriksen N, Simon TR, Pan Y, Fenyves EJ, Griffiths B. Effects of toxic exposure to molds and mycotoxins in building-related illnesses. *Arch Environ Health* 2003; 58(7): 399–405.
- [24] Kilburn KH. Indoor mold exposure associated with neurobehavioral and pulmonary impairment: a preliminary report. *Arch Environ Health* 2003; 58(7): 390–8.
- [25] Campbell A, Thrasher J, Madison R, Vojdani A, Gray M, Johnson A. Neural autoantibodies and neurophysiologic abnormalities in patients exposed to molds in water damaged buildings. *Arch Environ Health* 2003; 58(8): 464–78.
- [26] Kurup V, Shen HD, Vijay H. Immunobiology of fungal allergens. *Int Arch Allergy Immunol* 2002; 129: 181–8.
- [27] Gorny RL, Reponen T, Willeke K *et al.* Fungal fragments as indoor air contaminants. *Appl Environ Microbiol* 2002; 68: 3522–31.
- [28] Institute of Medicine. Clearing the Air. Asthma and Indoor Exposures. Institute of Medicine. [2]
- [29] Korpi A, Kasanen JP, Kosma VM, Rylander R, Pasanen AL. Slight respiratory irritation but not inflammation in mice exposed to (1>3)-beta-D-glycan aerosols. *Mediat Inflamm* 2003; 12(3): 139–46.
- [30] Etzel R. Mycotoxins. *J Am Med Assoc* 2002; 287(4): 425–7.
- [31] Nielsen KF. Mycotoxin production by indoor molds. *Fungal Genet Biol* 2003; 39: 103–17.
- [32] Rylander R. Indoor air-related effects and airborne (1>3)-beta-D-glucan. *Environ Health Perspect* 1999; 107(Supplement 3): 501–3.
- [33] Wilkins K, Larsen K, Simkus M. Volatile metabolites from mold growth on building materials and synthetic media. *Chemosphere* 2000; 41(3): 437–46.
- [34] Bennett J, Klich M. Mycotoxins. *Clin Microbiol Rev* 2003; 16(3): 497–516.
- [35] Hardin B, Kelman B, Saxon A. ACOEM evidence base statement. Adverse health effects associated with molds in the indoor environment. *J Occup Environ Med* 2003; 45(5): 470–8.
- [36] Richard J, Plattner R, May J, Liska S. The occurrence of ochratoxin A in dust collected from a problem household. *Mycopathologica* 1999; 146(2): 99–103.
- [37] Smoragiewicz W, Cossette B, Boutard A, Krystyniak K. Trichothecene mycotoxins in the dust of ventilation systems in office buildings. *Int Arch Occup Environ Health* 1993; 65(2): 113–7.
- [38] Engelhart S, Loock A, Skutlarek D *et al.* Occurrence of toxigenic *Aspergillus versicolor* isolates and sterigmatocystin in carpet dust from damp indoor environments. *Appl Environ Microbiol* 2002; 68(8): 3886–90.
- [39] Iavicoli I, Brera C, Carelli G, Caputi R, Marinaccio A, Miraglia M. External and internal dose in subjects occupationally exposed to ochratoxin A. *Int Arch Occup Environ Health* 2002; 75(6): 381–6.

- [40] Fischer G, Dott W. Relevance of airborne fungi and their secondary metabolites for environmental, occupational and indoor hygiene. *Arch Microbiol* 2003; 179: 75–82.
- [41] Sorenson WG. Fungal spores: hazardous to health? *Environ Health Perspect* 1999; 107 (Supplement 3): 469–72.
- [42] Van Emon J, Reed A, Yike I, Vesper S. ELISA measurement of stachylysin in serum to quantify human exposures to the indoor mold *Stachybotrys charatarum*. *J Occup Environ Med* 2003; 45: 582–91.
- [43] Croft W, Jastromski BM, Croft AL, Peters HA. Clinical confirmation of trichothecene mycotoxicosis in patient urine. *J Environ Biol* 2002; 23(3): 301–20.
- [44] Johnson P, Sarosi G. Community acquired fungal pneumonias. *Semin Resp Infect* 1989; 4(1): 56–63.
- [45] Tierney L, McPhee S, Papadakis M. *Current Medical Diagnosis and Treatment*. New York: Lange Medical Books, 2003.
- [46] Nicod L, Pache J, Howarth N. Fungal infections in transplant recipients. *Eur Resp J* 2001; 17(1): 133–40.
- [47] Garber G. An overview of fungal infections. *Drugs* 2001; 61(Supplement 1): 1–12.
- [48] Groll AH, Shah PM, Mentzel C, Schneider M, Just-Nuebling G, Huebner K. Trends in the postmortem epidemiology of invasive fungi at a university hospital. *J Infect* 1996; 33: 23–32.
- [49] Husain S, Alexander BD, Munoz P *et al*. Opportunistic mycelial fungal infections in organ transplant recipients: emerging importance of non-*Aspergillus* fungi. *Clin Infect Dis* 2003; 37(2): 221–9.
- [50] Denning D. Report on a European Science Foundation Workshop on Invasive Aspergillosis, 21–22 October 1998, University of Manchester, Manchester.
- [51] Kontoyiannis D, Bodey G. Invasive aspergillosis in 2002: an update. *Eur J Clin Microbiol Infect Dis* 2002; 21: 161–72.
- [52] Denning D. Therapeutic outcome in invasive aspergillosis. *Clin Infect Dis* 1996; 23(3): 608–15.
- [53] Lin S, Schranz J, Teutsch S. Aspergillosis case-fatality rate: systemic review of the literature. *Clin Infect Dis* 2001; 32(3): 358–66.
- [54] Pasanen AL. A review: fungal exposure assessment in indoor environments. *Indoor Air* 2001; 11: 87–98.
- [55] Dillon HK, Miller JD, Sorenson WG, Douwes J, Jacobs R. Review of methods applicable to the assessment of mold exposure in children. *Environ Health Perspect* 1999; 107(Supplement 3): 473–80.
- [56] Tiffany J, Bader H. Detection of *Stachybotrys charatarum*: the effectiveness of culturable-air sampling and other methods. *Environ Health* 1999; 2000: 9–11.
- [57] Gent J, Ren P, Belanger K *et al*. Levels of household mold associated with respiratory symptoms in the first year of life in a cohort at risk for asthma. *Environ Health Perspect* 2002; 110(12): A781–6.
- [58] Dales R, Burnett R, Zwanenburg H. Adverse health effects among adults' exposures to home dampness and molds. *Am Rev Resp Dis* 1991; 143: 505–9.
- [59] Ostro B, Lipsett M, Mann J, Braxton-Owens H, White M. Air pollution and exacerbation of asthma in African-American children in Los Angeles. *Epidemiology* 2001; 12: 200–8.
- [60] Zock J, Jarvis D, Lucynska G, Sunyer J, Burney P. Housing characteristics, reported mold exposure, and asthma in the European Community Respiratory Health Survey. *J Allergy Clin Immunol* 2002; 110(2): 285–92.
- [61] Williamson I, Martin C, McGill G. Damp housing and asthma: a case control study. *Thorax* 1997; 52: 229–34.
- [62] Verhoeff AP, Van Strien RT, Van Wijnen JH, Brunekreef B. Damp housing and household respiratory symptoms: the role of sensitization to dust mites and molds. *Am J Epidemiol* 1995; 141: 103–10.
- [63] Strachan DP, Flannigan B, McCabe E, McGarry F. Quantification of airborne moulds in the homes of children with and without wheeze. *Thorax* 1990; 45: 382–7.
- [64] Brunekreef B. Damp housing and adult respiratory symptoms. *Allergy* 1992; 47: 498–502.
- [65] Waegemaekers M, Van Wageningen N, Brunekreef B, Boleij JS. Respiratory symptoms in damp homes. A pilot study. *Allergy* 1989; 44: 192–8.
- [66] Jedrychowski W, Flak E. Separate and combined effects of the indoor and outdoor air quality on chronic respiratory symptoms adjusted for allergy among preadolescent children. *Int J Occup Med Environ Health* 1998; 11: 19–35.
- [67] Hu FB, Persky V, Flay BR, Richardson J. An epidemiological study of asthma prevalence and related factors among young adults. *J Asthma* 1997; 34(1): 67–76.
- [68] Jaakkola J, Jaakkola N, Ruotsalainen R. Home dampness and molds as determinants of respiratory symptoms and asthma in pre-school children. *J Exposure Anal Environ Epidemiol* 1993; 3(Supplement 1): 126–42.

3

- [69] Slezak J, Persky V, Kviz F, Ramakrishnan V, Byers C. Asthma prevalence and risk factors in selected Head Start sites in Chicago. *J Asthma* 1998; 35(2): 203–12.
- [70] Lee YL, Lin YC, Hsiue TR, Hwang BF, Guo YL. Indoor and outdoor environmental exposures, parental atopy and physician diagnosed asthma in Taiwanese schoolchildren. *Pediatrics* 2003; 112(5): e389–95.
- [71] Sly RM. Changing prevalence of allergic rhinitis and asthma. *Ann Allergy Asthma Immunol* 1999; 82(3): 233–48.
- [72] Belanger K, Beckett W, Triche E *et al.* Symptoms of wheeze and persistent cough in the first year of life: associations with indoor allergens, air contaminants, and maternal history of asthma. *Am J Epidemiol* 2003; 158: 195–202.
- [73] Stark PC, Burge HA, Ryan LM, Milton DK, Gold DR. Fungal levels in the home and lower respiratory tract illness in the first year of life. *Am J Resp Crit Care Med* 2003; 168(2): 232–7.
- [74] Thorn J, Rylander R. Airways inflammation and glucan in a rowhouse area. *Am J Resp Crit Care Med* 1998; 157: 1798–803.
- [75] Chao HJ, Schwartz J, Milton DK, Burge HA. The work environment and workers' health in 4 large office buildings. *Environ Health Perspect* 2003; 111(9): 1242–8.
- [76] Pirhonen I, Nevalainen A, Husman T. Home dampness, moulds and their influence on respiratory infections in Finland. *Eur Resp J* 1996; 9: 2618–22.
- [77] Koskinen OM, Husman TM, Meklin TM. The relationship between mould and moisture observations in houses and state of health of their occupants. *Eur Resp J* 1999; 14: 1363–7.
- [78] Ruotsalainen R, Jaakola N, Jaakola J. Dampness and molds in day-care centers as an occupational health care problem. *Int Arch Occup Environ Health* 1995; 66: 369–74.
- [79] Wan GH, Li CS. Dampness and airway inflammation and systemic conditions in office building workers. *Arch Environ Health* 1999; 54: 58–63.
- [80] Targonski P, Persky V, Ramakrishnan V. Effect of environmental molds on risk of death from asthma during the pollen season. *J Allergy Clin Immunol* 1995; 95(5 Part 1): 955–61.
- [81] Neas LM, Dockery DW, Burge H, Koutrakis P, Speizer FE. Fungus spores, air pollutants, and other determinants of peak expiratory flow rates in children. *Am J Epidemiol* 1996; 143(8): 797–807.
- [82] Delfino RJ, Zeiger RS, Seltzer JM *et al.* The effect of outdoor fungal spore concentrations on daily asthma severity. *Environ Health Perspect* 1997; 105(6): 622–35.
- [83] Dales RE, Cakmak S, Judek S *et al.* Influence of outdoor aeroallergens on hospitalization for asthma in Canada. *J Allergy Clin Immunol* 2004; 113: 303–6.
- [84] Liccorish K, Novey H, Kozak P, Fairshter R, Wilson A. Role of *Alternaria* and *Penicillium* spores in the pathogenesis of asthma. *J Allergy Clin Immunol* 1985; 76(6): 819–25.
- [85] O'Halloren M, Yungiger J, Offord K *et al.* Exposure to an aeroallergen as a possible precipitating factor in respiratory arrest in young patients with asthma. *N Engl J Med* 1991; 324(6): 359–63.
- [86] Zureik M, Neukirch C, Leynaert B, Laird R, Bousquet J. Sensitization to airborne moulds and severity of asthma: cross sectional study from European Community Respiratory Health Survey. *Br Med J* 2002; 325(7361): 411–4.
- [87] Gergen PJ, Turkeltaub PC. The association of individual allergen reactivity with respiratory disease in a national sample: data from the second National Health and Nutrition Examination Survey, 1976–1980 (NHANES II). *J Allergy Clin Immunol* 1992; 90(4 Pt 1): 579–88.
- [88] Tariq SM, Matthews SM, Stevens M, Hakim EM. Sensitization to *Alternaria* and *Cladosporium* by the age of 4 years. *Clin Exp Allergy* 1996; 26(7): 794–8.
- [89] Perzanowski MS, Sporik R, Squillance SP *et al.* Association of sensitization to *Alternaria* allergens with asthma among school aged children. *J Allergy Clin Immunol* 1998; 101(5): 626–32.
- [90] Nelson RP, DiNiccolo R, Fernandez-Caldas E, Seleznick MJ, Lockey R, Good RA. Allergen specific IgE levels and mite allergen exposure in children with acute asthma first seen in an emergency department and in nonasthmatic control subjects. *J Allergy Clin Immunol* 1996; 98(2): 382–8.
- [91] Lander F, Meyer HW, Norn S. Serum IgE specific to indoor moulds, measured by basophil histamine release, is associated with building-related symptoms in damp buildings. *Inflamm Res* 2001; 50: 227–31.
- [92] Schubert M. Medical treatment of allergic fungal sinusitis. *Ann Allergy Asthma Immunol* 2000; 85(2): 90–101.
- [93] Greenberger P. Allergic bronchopulmonary aspergillosis, allergic fungal sinusitis and hypersensitivity pneumonitis. *Clin Allergy Immunol* 2002; 16: 449–68.
- [94] Ponikau JU, Sherris R, Kern EB. The diagnosis and incidence of allergic fungal sinusitis. *Mayo Clinic Proc* 1999; 74: 877–84.
- [95] Lebowitz R, Waltzman M, Jacobs J, Pearlman A, Tierno P. Isolation of fungi by standard laboratory methods in patients with chronic rhinosinusitis. *Laryngoscope* 2002; 112(12): 2189–91.
- [96] Rains BM, Mineck CW. Treatment of allergic fungal sinusitis with high-dose itraconazole. *Am J Rhinol* 2003; 17(1): 1–8.

- [97] Apostolakos M, Rossmore H, Beckett W. Hypersensitivity pneumonitis from ordinary residential exposures. *Environ Health Perspect* 2001; 109(9): 979–81.
- [98] Kita T, Nishi K, Fujimura M *et al.* A case of hypersensitivity pneumonitis caused by *Humicola fuscoatra*. *Respirology* 2003; 8: 95–8.
- [99] Ando M, Yoshida K, Soda K, Araki S. Specific bronchoalveolar lavage IgA antibody in patients with summer type hypersensitivity pneumonitis induced by *Trichosporon cutaneum*. *Annu Rev Resp Dis* 1986; 134: 177–9.
- [100] Centers for Disease Control (CDC): Pulmonary hemorrhage/hemosiderosis among infants, Cleveland, Ohio, 1993–6. *MMWR* 1997; 46: 33–5.
- [101] Montana E, Etzel R, Allan T, Horgan T, Dearborn D. Environmental risk factors associated with pediatric idiopathic pulmonary hemorrhage and hemosiderosis in a Cleveland community. *Pediatrics* 1997; 99: 117–24.
- [102] Etzel R, Montana E, Sorenson W *et al.* Acute pulmonary hemorrhage in infants associated with exposure to *Stachybotrys atra* and other fungi. *Arch Pediatr Adolesc Med* 1998; 152: 757–62.
- [103] Vesper S, Dearborn D, Yike I, Sorenson W, Haugland R. Hemolysis, toxicity and randomly amplified polymorphic DNA analysis of *Stachybotrys chartarum* strains. *Appl Environ Microbiol* 1999; 65(7): 3175–81.
- [104] Dearborn D, Smith P, Dahms B *et al.* Clinical profile of 30 infants with acute pulmonary hemorrhage in Cleveland. *Pediatrics* 2002; 110(3): 627–37.
- [105] Center for Disease Control and Prevention (CDC). Update: Pulmonary hemorrhage/hemosiderosis among infants, Cleveland, Ohio 1993–6. *MMWR* 2000; 49: 18–184. 4
- [106] Etzel T. *Stachybotrys*. *Curr Opin Pediatr* 2003; 15(1): 103–6.
- [107] Vesper S, Magnuson M, Dearborn D, Yike I, Haugland R. Initial characterization of the hemolysin stachylysin from *Stachybotrys chartarum*. *Infect Immun* 2001; 69(2): 912–6.
- [108] Vesper S, Vesper MJ. Stachylysin may be a cause of hemorrhaging in humans exposed to *Stachybotrys chartarum*. *Infect Immun* 2002; 70(4): 2065–9.
- [109] Yike I, Allan T, Sorenson W, Dearborn D. Highly sensitive protein translation assay for trichothecene toxicity in airborne particulates: comparison with cytotoxicity assays. *Appl Environ Microbiol* 1999; 65(1): 88–94.
- [110] Johanning E, Biagini R, Hull D, Morey P, Jarvis B, Landsbergis P. Health and immunology study following exposure to toxigenic fungi (*Stachybotrys chartarum*) in a water-damaged office environment. *Int Arch Environ Health* 1996; 68: 207–18.
- [111] Elidemir O, Colasurdo G, Rossmann S, Fan L. Isolation of *Stachybotrys* from the lung of a child with pulmonary hemosiderosis. *Pediatrics* 1999; 104(4 Part1): 964–6.
- [112] Hooper D. Molecular evaluation for autopsy and clinical tissue in patients. Presented at the 22nd Annual Symposium on Man and His Environment in Health and Disease, Dallas, Texas, 27 June 2004.
- [113] Vojdani A, Campbell A, Kashanian A, Vojdani E. Antibodies against molds and mycotoxins following exposure to toxigenic fungi in water-damaged building. *Arch Environ Health* 2003; 58(6): 324–36.
- [114] Vojdani A, Thrasher J, Madison R, Gray M, Heuser G, Campbell A. Antibodies to molds and satratoxin individuals in a water-damaged building. *Arch Environ Health* 2003; 58(7): 421–32.
- [115] Savilahti R, Uitti J, Laippala P, Hussman T, Reiman M. Immunoglobulin G antibodies of children exposed to microorganisms in a water-damaged school. *Pediatr Allergy Immunol* 2002; 13(6): 438–42.
- [116] Patovirta RL, Reiman M, Husman T, Haverinen U, Toivola M, Nevalainen A. Mould specific IgG antibodies connected with sinusitis in teachers of a mould damaged school: a 2 year follow up study. *Int J Occup Med Environ Health* 2003; 16(3): 221–30.
- [117] Taskinen TM, Laitinen S, Nevalainen A *et al.* Immunoglobulin G antibodies to moulds in school-children from moisture problem schools. *Allergy* 2002; 57(1): 9–16.
- [118] Malkin R, Martinez K, Marinovich V, Wilcox T, Wall D, Biagini R. The relationship between symptoms and IgG and IgE antibodies in an office environment. *Environ Res* 1998; 76(2): 85–93.
- [119] Dales R, Miller D, White J, Dulberg C, Lazarovitis A. Incidence of residential fungal contamination on peripheral blood lymphocyte populations in children. *Arch Environ Health* 1998; 53(3): 190–5.
- [120] Vojdani A. Health effects and immunotoxicology of toxigenic molds and mycotoxins. Presented at the 21st International Symposium of Man and His Environment in Health and Disease, Dallas, Texas, 20 June 2003.
- [121] Beijer L, Thorn J, Rylander R. Mould exposure at home relates to inflammatory markers in blood. *Eur Resp J* 2003; 21(2): 317–22.
- [122] Bondy G, Pestka J. Immunomodulation by fungal toxins. *J Toxicol Environ Health B* 2000; 3(2): 109–43.
- [123] Berek L, Petri IB, Msterhazy A, Teren J, Molnar J. Effects of mycotoxins on human immune functions in vitro. *Toxicol In Vitro* 2001; 15(1): 25–30.

- [124] Singer R. Neurotoxicity Guidebook. New York: Van Nostrand Reinold, 1990.
- [125] Gray M, Kilburn K, Crago R. Molds, mycotoxins and public health: summary of 195 patients treated collaboratively. Presented at the American Public Health Association (APHA) Meeting, Philadelphia, Pennsylvania, 11 November 2002.
- [126] Crago BR, Gray M, Nelson L, Davis M, Arnold L, Thrasher J. Psychological, neuropsychological and electrocortical effects of mixed mold exposure. *Arch Environ Health* 2003; 58(8): 452–63.
- [127] Simon T. Neurotoxicity—mold exposure versus all causes. Presented at the 21st Annual Symposium on Man and His Environment in Health and Disease, Dallas, Texas, 19–22 June 2003.
- [128] Gordon W, Johanning E, Haddad L. Cognitive impairment associated with exposure to toxigenic fungi. Presented at the 3rd International Conference on Fungi, Mycotoxins and Bioaerosols, Saratoga Springs, New York, 23–25 September 1998. In: *Bioaerosols, Fungi and Mycotoxins: Health Effects, Assessments, Prevention and Control*. Albany, New York: Eastern New York Center for Environmental and Occupational Health, 1999.
- [129] Didricksen N. Neurocognitive deficits in individuals exposed to toxigenic molds. Presented at the 21st Annual Symposium on Man and His Environment in Health and Disease, Dallas, Texas, 19–22 June 2003.
- [130] Baldo JV, Ahmad L, Ruff R. Neuropsychological performance of patients following mold exposure. *Appl Neuropsychol* 2002; 9(4): 193–202.
- [131] Anyanwu E, Campbell A, Vojdani A. Neurophysiological effects of chronic indoor environmental toxic mold exposure on children. *Sci World J* 2003; 3(4): 281–90.
- [132] Boysen SR, Rozanski EA, Chan DL, Grobe TL, Fallon MJ, Rush J. Tremorgenic mycotoxicosis in four dogs from a single household. *J Am Vet Med Assoc* 2002; 221(10): 1441–4.
- [133] Young DL, Villar D, Carson TL, Ierman PM, Moore RA, Bottoff MR. Tremorgenic mycotoxin intoxication with penitrem A and roquefortine in two dogs. *J Am Vet Med Assoc* 2002; 222(1): 52–3.
- [134] Naude TW, O'Brien OM, Rundberget T, McGregor AD, Roux C, Flaoyen A. Tremorgenic neuromycotoxicosis in 2 dogs ascribed to ingestion of penitrem A and possibly roquefortine in rice contaminated with *Penicillium crustosum*. *J S Afr Vet Assoc* 2002; 73(4): 211–5.
- [135] Chen JW, Luo YL, Hwang MJ, Peng FC, Ling KH, Territrem B. A tremorgenic mycotoxin that inhibits acetylcholinesterase with a noncovalent yet irreversible binding mechanism. *J Biol Chem* 1999; 274(49): 34916–23.
- [136] Krogh P, Hald B, Pedersen J. Occurrence of ochratoxin A and citrinin in cereals associated with mycotoxic porcine nephropathy. *Acta Path Micro Scand* 1973; 81 Sect B: 689–95.
- [137] Castegnaro M, Plestina R, Dirheimer O, Chernosemsky IN, Barsch H. Mycotoxins, endemic nephropathy and urinary tract tumors. *IARC Sci Pub* 1991; 115: 1–340.
- [138] Kristensen P, Irgens L, Andersen A, Bye AS, Sundheim L. Gestational age, birth weight, and perinatal death among births to Norwegian farmers, 1967–1991. *Am J Epidemiol* 1997; 146: 329–38.
- [139] Kristensen P, Andersen A, Irgens L. Hormone-dependent cancer and adverse reproductive outcomes in farmers families—effects of climatic conditions favoring fungal growth in grain. *Scand J Work Health* 2000; 26(4): 331–7.
- [140] Diekman M, Green M. Mycotoxins and reproduction in domestic livestock. *J Anim Sci* 1992; 70: 1615–27.
- [141] Cotran RS. *Robbins Pathologic Basis of Disease*, 5th edn. New York: WB Saunders, 1994, p. 914.
- [142] Cheta D. Animal models of type 1 (insulin-dependent) diabetes mellitus. *J Pediatr Endocrinol Metab* 1998; 11(1): 11–9.
- [143] Hoffmeister PA, Storer BE, Sanders JE. Diabetes mellitus in long-term survivors of pediatric hematopoietic cell transplantation. *J Pediatr Hematol Oncol* 2004; 26(2): 81–90.
- [144] Eggleston PA. Environmental control for fungal allergen exposure. *Curr Allergy Asthma Rep* 2003; 3(5): 424–9.
- [145] Heuser G, Axelrod P, Heuser S. Defining chemical injury: a diagnostic protocol and profile of chemically injured civilians, industrial workers and Gulf War veterans. *Int Perspect Public Health* 2000; 13: 1–16.
- [146] Marshall L, Weir E, Abelsohn A, Sanborn MD. Identifying and managing adverse environmental effects: 1) taking an exposure history. *Can Med Assoc J* 2002; 166(8): 1049–55.
- [147] Dales RE, Miller D, McMullen E. Indoor air quality and health: validity and determinants of reported home dampness and molds. *Int J Epidemiol* 1997; 26: 120–4.
- [148] Macher J (ed.) *Bioaerosols: Assessment and Control*. American Conference of Governmental and Industrial Hygienists (ACGIH), Cincinnati, Ohio, 1999.
- [149] Portnoy JM, Barnes CS, Kennedy K. Sampling for indoor fungi. *J Allergy Clin Immunol* 2004; 113: 189–98.
- [150] Institute of Medicine Committee on the Health Effects of Indoor Allergens: Engineering Control

- Strategies. Allergens: Assessing and Controlling Adverse Health Effects. Engineering Control Strategies. Washington, DC: National Academy Press, 1993, 206–32.
- [151] Institute for Inspection, Cleaning and Restoration. IICRC S520 Standard and reference guide for professional mold remediation. Vancouver, Washington: IICRC Press, 2003.
- [152] Higgins BG, Francis HC, Yates G *et al.* Environmental exposure to air pollution and allergens and peak flow changes. *Eur Resp J* 2000; 16(1): 61–6.
- [153] Thorn J, Brisman J, Toren K. Adult-onset asthma is associated with self-reported mold or environmental tobacco smoke in the home. *Allergy* 2001; 56: 287–92.
- [154] Chen WY, Tseng HI, Wu MT *et al.* Synergistic effect of multiple indoor allergen sources on atopic symptoms in primary school children. *Environ Res* 2003; 93(1): 1–8.
- [155] Skoner DP. Viral infection and allergy: lower airway. *Allergy Asthma Proc* 2002; 23(4): 229–32.
- [156] Fireman P. Virus-provoked rhinitis in patients who have allergies. *Allergy Asthma Proc* 2002; 23(2): 99–102.
- [157] Hirsch D, Hirsch R, Kalbfleish S. Effect of central air-conditioning and meteorological factors on indoor spore counts. *J Allergy Clin Immunol* 1978; 62(1): 22–6.
- [158] Sheretz RJ, Belani A, Kramer BS *et al.* Impact of air filtration on nosocomial *Aspergillus* infections. *Am J Med* 1987; 83(4): 709–18.
- [159] Panackal A, Dahlman A, Keil K *et al.* Outbreak of invasive aspergillosis among renal transplant patients. *Transplantation* 2003; 75(7): 1050–3.
- [160] Oren I, Haddad N, Finkelstein R, Rowe J. Invasive pulmonary aspergillosis in neutropenic patients during hospital construction: before and after chemoprophylaxis and institution of HEPA filters. *Am J Hematol* 2001; 66(4): 257–62.
- [161] Loo V, Bertrand C, Dixon C *et al.* Control of construction-associated nosocomial aspergillosis in an antiquated hematology unit. *Infect Control Hosp Epidemiol* 1996; 17(6): 360–4.
- [162] Iwen P, Davis J, Reed EC, Winfield BA, Hinrichs SH. Airborne fungal spore monitoring in a protective environment during hospital construction, and correlation with outbreak of invasive aspergillosis. *Infect Control Hosp Epidemiol* 1994; 15(5): 303–6.
- [163] Hahn T, Cummings K, Michalek AM, Lipman B, Segel B, McCarthy P. Efficacy of high-efficiency particulate air filtration in preventing aspergillosis in immunocompromised patients with hematologic malignancies. *Infect Control Hosp Epidemiol* 2002; 23(9): 525–31.
- [164] Cornet M, Levy V, Fleury L *et al.* Efficacy of prevention by high-efficiency particulate air filtration or laminar airflow against *Aspergillus* airborne contamination during hospital renovation. *Infect Control Hosp Epidemiol* 1999; 20(7): 508–13.
- [165] Withington S, Chambers ST, Beard ME *et al.* Invasive aspergillosis in severely neutropenic patients over 18 years: impact of intranasal amphotericin B and HEPA filtration. *J Hosp Infect* 1998; 38(1): 11–8.
- [166] Annaisie EJ, Stratton SL, Dignani MC *et al.* Pathogenic *Aspergillus* species recovered from a hospital water system: a 3 year prospective study. *Clin Infect Dis* 2002; 34(6): 780–9.
- [167] Annaisie EJ, Stratton SL, Dignani MC *et al.* Cleaning patient shower facilities: a novel approach to reducing patient exposure to aerosolized *Aspergillus* species and other opportunistic molds. *Clin Infect Dis* 2002; 35(8): E86–8.
- [168] Bernardis P, Agnoletto M, Puccinelli P, Parmiani S, Pozzan M. Injective versus sublingual immunotherapy in *Alternaria tenuis* allergic patients. *J Invest Allergol Clin Immunol* 1996; 6(1): 55–62.
- [169] Helbling A, Reimers A. Immunotherapy in fungal allergy. *Curr Allergy Asthma Rep* 2003; 3(5): 447–53.
- [170] Galvano F, Piva A, Ritieni A, Galvano G. Dietary strategies to counteract the effects of mycotoxins: a review. *J Food Protect* 2001; 64(1): 120–31.
- [171] Atroshi F, Rizzo A, Westermarck, Ali-Vehmas T. Antioxidant nutrients and mycotoxins. *Toxicology* 2002; 180(2): 151–67.

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