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Controlling Hospital-Acquired Infections

Role of Industrial Hygienists

Om Malik, PhD, CIH, ROH; Hamid Arabzadeh, CIH, CSP, CHMM, REA; and Jas Singh, PhD, CIH

Data released by the U.S. National Nosocomial Infections Surveillance System show that every year nearly 2 million patients in North America contract an infection in a hospital and about 100,000 die as a result of their infection.

Several outbreaks of hospital-acquired mold infections have been linked with hospital construction, renovation and maintenance, activities that allow mold spores to become airborne. Fungal infections account for 9 percent of all nosocomial infections. Health Canada has carried out an extensive review of literature of nosocomial infections over a 20-year period (1978–1998) and found numerous nosocomial outbreaks related to construction or renovation projects. The NNIS data also show increasing trends in nosocomial fungal infection rates for urinary tract and bloodstream infections and pneumonia in intensive care units.

The incidence of infections in hospitals and other health care facilities caused by mold has risen dramatically in recent years and needs the awareness of the hygiene community. The issue is even more serious in developing countries.

Mold and Its Health Effects

For most healthy individuals, breathing ambient concentrations of airborne mold results in no adverse effects on health. However, hospitalized immunocompromised patients are susceptible to infections from naturally occurring airborne fungi that can grow at body temperature. Clinical manifestations of mold-related infections include an allergic syndrome, fungus ball formation in pre-existing lung cavities and invasive pulmonary disease. Proteins in the mold particles can cause an overreaction of the immune system and affect the respiratory system and skin resulting in asthma, hypersensitivity pneumonitis, allergic rhinitis (hay fever) and dermatitis. Hypersensitivity pneumonitis (nonbacterial pneumonia) results from fungal invasion of hyphae into the lung tissue. From the lung, the fungus may disseminate through the bloodstream to the brain, kidney, liver, heart and other sites.

The steady rise in hospital-acquired infections, including those caused by fungal agents, may be due to several factors. With increasing medical costs, there has been a major focus on reducing hospital stays for most patients—with the result that hospitals seem to becoming more and more like intensive care units as the proportion of sicker patients rises. This, coupled with the increased use of antibiotics and chemotherapy, has contributed to the rising trend of mold-related nosocomial infections, as have the advent of routine organ transplants, the introduction of methods for advanced life support and the management of diseases such as AIDS.

Emerging Infectious Fungal Pathogens Impacting Nosocomial Infections

The pathogens most associated with such infections are opportunistic yeasts (e.g., Candida albicans) or filamentous mold (e.g., Aspergillus fumigatus and A. flavus). According to NNIS data, the most common molds associated with nosocomial infections were Candida spp. (85.6 percent), followed by Aspergillus spp. (1.3 percent). In addition, molds such as Fusarium, Zygomycetes, Acremonium, Chrysosporium, Fusarium, Mucor, Paecilomyces, Penicillium, Scedosporium, Scopulariopsis, Trichoderma, Malassezia and Trichosporone (previously considered nonpathogenic for humans or only occasionally associated with human disease) are increasingly being reported as nosocomial fungal pathogens. In highly immunocompromised hosts, these pathogens carry a risk of high morbidity and mortality. The crude mortality from fungal infections exceeds 50 percent in most studies and has been reported as high as 95 percent in bone marrow transplant patients with Aspergillus spp. infections.

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As stated above, the predominant etiologic agent is Aspergillus. In particular, Aspergillus fumigatus, A. flavus, A. niger and A. terreus have been repeatedly documented. Aspergillus is found ubiquitously in soil and decaying vegetation; its spores (conidia) are small (2.5–3.5 µm), can remain viable for months in relatively dry locations and are considered transient colonizers in humans. Aspergillus conidia bypass the host defenses of the upper airway and can reach the pulmonary alveolar spaces because of their small size. When these spores reach the lungs, they can result in infection, colonization or hypersensitivity.

The resulting disease manifestations are largely dependent on the individual response. Healthy hospital staff may become sensitized to Aspergillus, but there is only a small risk of infection, whereas it can be life-threatening for patients who are severely immunosuppressed. The resulting disease, aspergillosis, is difficult to diagnose at an early stage because early signs are nonspecific, and the rate of isolation of Aspergillus in sputum cultures is low. Therefore, it is important that preventive measures be taken to reduce or eliminate exposure to Aspergillus spores. Understanding the relation between these organisms and construction and renovation activities leads to a better understanding of the need for preventive measures.

Construction- and Renovation-Related Sources of Nosocomial Infections

Most construction and renovation activities generate dust to varying degrees depending on the type of activity, ranging from inspection and noninvasive activities that produce very little dust to major demolition and renovation projects that are a major source of dust generation. Based on a review of literature on reported outbreaks of infections during or as a result of construction and renovations, the infection-causing agents have been identified to be mold, dust or soil contaminated with fungal spores or bacteria. They have been reported entering hospitals through (1) open or improperly sealed windows due to infiltration from adjacent patient care areas where no or improper barriers had been erected, (2) defective ventilation systems allowing unfiltered air from an adjacent construction area, (3) incorrect air pressurization in patient care areas allowing airflow from dirty areas to clean areas, (4) inadequate air exchange rate, or (5) improper maintainance of filters (especially HEPA filters) and othe HVAC components.

Once fine dust and spores enter the patient area, they settle very slowly; for example, Aspergillus spores will probably settle at a rate of 0.03 cm per second. Fine dust and spores can therefore remain suspended in air for a prolonged period, thus increasing the likelihood of being inhaled or contaminating horizontal surfaces by settling. It is therefore prudent to devise strategies to prevent dust and mold spores from entering the occupied space.

A proactive approach to eliminating Aspergillus infections is to minimize the dust generated during the construction activity and to prevent dust infiltration into patient care areas adjacent to construction. Prevention of nosocomial diseases has historically been the responsibility of infection control personnel. However, a multidisciplinary team, including occupational hygienists, is needed to ensure that the preventive measures are effective. The role of the team is to identify and quantify the risk factors, develop a preventive strategy, implement control measures, carry out monitoring and supervision during the project and provide clearance at the end of all construction activity.

Infection Prevention and Control

Strategies: An Example

Health Canada adopted the Infection Control Construction Permit developed by Virginia Kennedy, formerly from St. Luke's Episcopal Hospital, Houston, and suggested a Risk Assessment and Preventive Measures Checklist be used during the design process. The checklist describes four levels of construction activity that may occur within a health care facility and four risk groups, ranging from lowest to highest risk. It further describes a Construction Activity and Risk Group Matrix and recommends four levels of protective measures for appropriate infection prevention.

Risk Factors: Exposure to Construction

As described above, several studies have shown that hospitalization during construction activity is an independent risk factor for development of invasive nosocomial fungal infections. The risk due to construction is divided into four types.

- Type A: Inspection and noninvasive activities such as removal of ceiling tiles, painting (but not sanding), electrical trim work and other maintenance activities that do not generate dust.

• Type B: Small-scale, short-duration activities that create minimal dust such as activities that require access to chase spaces, cutting of walls or ceilings where dust migration can be controlled for installation/ repairs of minor electrical work.

• Type C: Any work that generates a moderate to high level of dust or requires demolition or removal of any fixed building components or assemblies (e.g., countertops, cupboards, sinks) including activities that require sanding of walls, removal of floor coverings, new wall construction, minor duct work, etc.

• Type D: Major demolition, construction and renovation projects such as heavy demolition or removal of a complete cabling system and new construction requiring consecutive work shifts to complete.

Risk Factors: Patient Characteristics

The underlying medical conditions of certain patients put them at increased risk for construction-related nosocomial infections. Health Canada created four population and geographic risk groups:

• Group 1: Lowest risk—examples include office areas, unoccupied wards, public areas.

• Group 2: Medium risk—examples include outpatient clinics (except for oncology and surgery), admission/discharge.

• Group 3: Medium to high risk—examples include emergency rooms, radiology/MRI, post-anesthesia care units.

• Group 4: Highest risk—examples include ICUs, all operating rooms, labor and delivery operating rooms.

Risk Management: Prevention and Controls

In their model adapted from Kennedy's permit, Health Canada has classified control measures into four classes. These classes are based on assessed risk using the risk factors matrix. The stringency of controls increases from Class I to Class IV. Class I controls may be simply a drop sheet, whereas for Class IV there is a requirement for complete containment and negative air machines, air and patient monitoring and other dust suppression techniques.

Air sampling is very important in the identification of the offending mold species. Air sampling should be carried out before, during and at the end of the project. In a hospital-like setting, baseline data are very important in case there is an outbreak during or after the project. All baseline samples should be taken by a technique that allows the analyst to provide results to the species level.

Samples taken during the project can be analyzed to the genus level because it normally takes two to three weeks for speciation. These samples are taken primarily to check the integrity of containment and effectiveness of dust control measures. The clearance samples once again must be speciated.

Hospital-acquired infections are a major health issue that result in many deaths every year and add considerably to health care costs in North America. It would be naïve to assume that industrial hygienists can play a lead role in this health issue, but as is evident from the above, with their expertise in controlling molds, industrial hygienists can make a difference.

Malik is president of OHM Inc. in Toronto. He can be reached at drommalik@hotmail.com.

Arabzadeh is a health and safety manager and a volunteer faculty at the University of California at Irvine's College of Medicine. He can be reached at hamid@hracih.com.

Singh is with Diagnostic Laboratory Services Inc., Honolulu. He can be reached at mjassingh@aol.com.

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