Editorial

In With the Good Air

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The almost continuous reconstruction of healthcare facilities challenges the safety of patients because of the continual occupancy of hospitals. Traditional safety measures during construction have focused on avoiding hazards such as fire, mineral dust, and chemical aerosols. Since the development of transplant technology and other immunosuppressive therapies, opportunistic pathogens have become more frequent nosocomial pathogens. Immunocompromised patients are often devastated by infections, which can result in death. The removal of existing buildings to make way for new healthcare facilities and the renovation of existing buildings can result in aerosolization of such pathogens. In this issue of *Infection Control and Hospital Epidemiology*, Srinivasan et al.[1] describe the generation of a tremendous dust cloud caused by explosive demolition. Their article provides data verifying that safety measures worked during a massive potential exposure to airborne contaminants.

Before this demolition project, Thio et al.[2] had described an outbreak of aspergillosis due to deficiencies in building ventilation systems at the same institution. Correcting these deficiencies was paramount to ensuring air quality during this subsequent demolition. In 1983, Streifel et al.[3] described an explosive demolition at the University of Minnesota in preparation for renewal of the old hospital. The 1983 protective measures involved ventilation manipulation and building protection for areas housing immunocompromised patients. Srinivasan et al. used ventilation management methods that required continuous operation of ventilation systems so as to ensure building pressure. Except for smoke management, the importance of building depressurization was relatively unknown in 1983. Building depressurization seems to be an undiscovered problem in healthcare facilities and is dependent on continuous air balance considerations for mechanical ventilation. For example, it is easier to add exhaust systems to a building than to increase the supply air. This fact has contributed to the tendency of buildings to become depressurized, making it easier for unfiltered air to enter.

Since 1947, hospitals have been required to meet ventilation standards set forth in the Hill Burton Act, which distributed funds to assist in the construction of hospitals. Since then, the ventilation parameters have been developed to provide guidance to enhance the comfort and safety of the occupants of healthcare facilities. Currently, the American Institute of Architects (AIA) provides the design guidelines for construction in healthcare facilities.[4] These guidelines address filter efficiency, air exchanges, and pressure management as factors necessary for the control of air quality. They are used by more than 40 states in developing design criteria for construction projects. Since 1996, the construction section of these guidelines has required the incorporation of features that facilitate infection control. Prior to 1996, construction management and design concerns were largely associated with controlling odors and mineral dust and engineering design concepts were associated with temperature and humidity control. The guidelines for construction in healthcare facilities provide a focus on the construction and ventilation management specifications for general and specific hospital mechanical systems.

In another article in this issue of *Infection Control and Hospital Epidemiology*, Hahn et al.[5] describe the addition of high-efficiency particulate air (HEPA) filters for preventing aspergillosis. Although HEPA filters are important, their installation is relatively complex and requires extensive engineering design for appropriate control of fungal spores. To install HEPA filters, it is necessary to increase fan size to drive the increase in static pressure due to an increase in filter efficiency. For example, in the outbreak described by Thio et al., the healthcare facility had been using HEPA filters, but the lack of building pressurization circumvented their value by allowing unfiltered air to enter the building through pathways other than the intakes of the air handling system.[2] Therefore, it would be prudent for a protective environment (PE) to be pressurized in order to prevent the infiltration of unwanted airborne particles into susceptible patient care areas. The AIA has identified special ventilation (SPV) areas requiring specific pressurization, air exchanges, and filtration for infection control as special ventilation rooms, including airborne infection iso-

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lation (AII) and PE rooms. Building pressurization requirements have not been considered. Twelve air exchanges are recommended per hour. In addition, HEPA filtration is necessary for the supply air in the PE rooms or if the exhaust air from an AII room is recirculated. These SPV rooms require air pressure for airflow into or out of them with at least 0.01 inch of water gauge (2.5 Pa) pressure differential. This means that the airflow has a velocity of 400 linear feet per minute (2.03 m/s). These ventilation parameters are important for the management of airborne infectious disease risks in hospitals. It is my professional experience that these critical ventilation parameters are often deficient because of minimal maintenance of healthcare mechanical systems. Unfortunately, such deficiencies are often discovered as the result of an outbreak of opportunistic airborne fungal infections.[2,6-8]

Srinivasan et al. provided a proactive level of care, which included pre-demolition planning to provide an infection control risk assessment. The risk management group analyzed the coming event with the construction issues related to infection control and made key decisions to protect the facility and its occupants. The expedient removal (ie, implosion) of buildings can shorten the construction–demolition time considerably; additionally, the efforts to protect the buildings can be intensified for that relatively short period of time.[3] The article by Srinivasan et al. describes efforts to maintain building pressure, anticipate window leakage, control traffic, and provide appropriate special ventilation in critical areas. Such a "heads up" approach can protect high-risk patients during demolition and construction projects. All hospitals are certainly not equal in building management for a variety of reasons. The largest and most progressive healthcare systems have likely placed patients at greater risk because of their continual upgrades of utilities and replacement of buildings. Such facilities often have patients undergoing immunosuppressive therapy and several have had aspergillosis outbreaks. What has been lacking is hard evidence that the mechanical and operational factors are necessary for the prevention of opportunistic airborne fungal disease. When design guidelines are followed, the ventilation parameters of PE rooms are substantially different from those of regular patient rooms. The guidelines specify increased air exchange rates, specific pressure differentials, and highly efficient filtration; however, for these parameters to work, windows must be sealed, doors must be self-closing, and surfaces must be clean so as not to harbor fungal spores.

Published reports of outbreaks have emphasized the use of air sampling[6,7] to help manage the environment. The air sampling effort provides valuable information for ventilation performance, especially before patients occupy the SPV area; however, it does little during construction to prevent infections if the ventilation system is not working correctly. The emphasis should instead be on providing real-time data to confirm that the air in PE rooms is clean and pressurized appropriately.[9] Ensuring specified ventilation and appropriate procedural practice is critical for the management of air quality. If the areas housing immunosuppressed patients are properly designed and maintained, the testing of ventilation parameters should indicate the lowest counts of non-viable particles and airborne fungi. In addition, the room air exchanges should be greater than 12 and the room pressure greater than 0.01 inch water gauge, which should be sufficient for keeping airborne particles out of the protected environment. If these data are collected as part of an epidemiologic evaluation, the ventilation systems could be ruled out as a source because they are operating as designed, especially if pre-occupancy baseline data are available for comparison. Of course, unscheduled power outages, even if only for a short period, may also contribute to ventilation deficiencies. Fire alarms can result in fans being automatically turned off and can thus contribute to short-term building depressurization.

Srinivasan et al. used cultures and real-time air quality analysis to monitor the dust cloud. The use of dust that can be respired as an indicator should be questioned for healthcare applications. The current Occupational Safety and Health Administration permissible exposure level for respirable dust is 5.0 mg/m^3. It is possible to see dust at approximately 0.4 mg/m^3. The difficulty comes with knowing when to react. Fine particle analysis with optical or condensation particle counters provides a sensitive real-time parameter for evaluation, but the current standards are associated with clean room technologies and are difficult to interpret for health care due to the many sources of locally generated noninfectious airborne particles. The value of environmental analysis comes with the pre-planning for projects, regardless of whether they involve explosive demolition, excavation, or internal demolition followed by renovation. Pre-construction analysis of the ventilation parameters of the air handling system allows for the recognition of deficiencies and their correction before a problem arises. Depending on the circumstances, any disruption of the environment close to an immunocompromised patient could result in exposure. For example, the attachment of spores to the clothing of clinicians or visitors may result in indirect exposure to such dust clouds in the rooms of immunocompromised patients.[10,11] Ensuring the requisite number of air exchanges, proper filtration, and relative pressures will help to dilute and remove any incoming infectious agents shed from clothes and other items brought into patient rooms.

Filter checks in air handling systems are cumbersome using culture methods due to sampling limitations in an area with high-velocity airflow. Particle counters are capable of documenting satisfactory filter installation by measuring atmospheric particle levels before and after filtration. The number of particles in filtered environments should be substantially smaller unless filters have been improperly installed. The advantage of real-time analysis is the immediate availability of the results in order to correct the deficiency before the risk increases during external construction. The disadvantage of using a particle counter is believing what you are seeing during the comparison analysis. This uncertainty can be resolved by using appropriate controls. During implosion demolition, the concern is about protecting critical areas from the uncertain direction of movement of the dust cloud. Determining the critical building preparations before initiating an external project was described by Srinivasan et al. Real-time data are useful, but repeated analyses should be conducted to provide data demonstrating consistent deficiencies (ie, as compared with other filter systems with the same filtration). These evaluations can help find holes in filters, worn gaskets, or improperly installed filters. I was involved with a recent investigation of an outbreak of aspergillosis that compared the filter efficiencies of several air handling systems. Remarkable differences were found in particle removal efficiency among the systems, with the areas experiencing cases of aspergillosis having the most inefficient systems. An inspection of the deficient filter banks revealed corrosion of the fastening clips on the filters and leaks in the filter gaskets. In addition, the windows at that institution were operable and many in the affected area were defective and would not close. The area was an intensive care unit housing patients who had received solid organ transplants. If excavation or other airborne aerosol had occurred outside that hospital, airborne spores could easily have entered that transplant ward.

To promote the appropriate management of airborne infectious diseases, the Environment of Care (EC) section of the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) has provided language to stimulate healthcare institutions to assess their special ventilation environments in sections EC1.7 and EC3.2.1 of the JCAHO compliance guidance manual.[12] These sections encourage preventive maintenance of utility systems so as to reduce the potential for nosocomial illness. Standard EC1.7 suggests that healthcare facilities establish criteria for identifying, evaluating, and taking inventory of critical operating components as part of an infection control–directed utility management program. As hospitals plan physical plant renovation or new construction, potential risks to building occupants must be identified. Standard EC3.2.1 states that when construction is planned, the ". . . organization conducts a proactive risk assessment using risk criteria to identify hazard. . . . The criteria should address the impact that demolition, renovation or new construction activities have on air quality requirements, infection control . . . and emergency procedures." The intent of these JCAHO standards is to encourage the organization to implement proper controls to reduce risk and minimize the impact of the activities. Is this happening?

Many healthcare facilities are interested in methods to control construction, especially costs. The development of transplant technologies and treatment for oncologic and immunosuppressive diseases has created an increasing number of patients at risk for opportunistic infection. Healthcare facilities should ensure safety by providing infection control mechanisms to minimize exposure to such pathogens. The inclusion of ventilation parameters is critical. Since September 11, 2001, we have also been concerned about what would happen if our healthcare facilities were subjected to horrific exposures to external airborne contaminants, internal airborne contaminants, or both. What is explosive demolition but a biological cloud of contamination? The use of proactive risk assessment and engineering controls will help to keep infectious agents away from susceptible patients. Likewise, thoughtful management of the ventilation in healthcare facilities will limit their vulnerability to airborne spread of infectious or chemical contaminants. A recently released document regarding the protection of buildings from nuclear, biological, and chemical exposures stressed the importance of filtration, air exchanges, and pressure management.[13]

Particle counts and microbial levels often vary in different areas of a healthcare facility because of the design and operational status of each area. Planned preventive measures must be emphasized for ventilation systems. Infection control professionals must join with hospital managers to ensure that budgets include essential review and correction of mechanical system defects. Mechanical priorities must be established and disruption of building systems recognized as a risk for some patient groups. Stable ventilation parameters that include air exchanges, pressurization, and proper filtration will help maintain safe indoor air quality. Although aspergillosis does not affect large numbers of patients, it does represent a deadly disease for those at risk receiving costly healthcare resources.

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