This is the second in a two-part series on designing healthcare settings to improve patient safety. Part I addressed concepts of error theory and evidence-based practice as they relate to planning safe care environments (Sheridan-Leos, 2008). Part II describes the design and planning of oncology care settings to prevent fungal infections and improve provider handwashing.

There is currently an explosion of healthcare construction and remodeling in the United States; as the oncology population will soon be increasing, oncology care settings are part of the building boom. Given the number of organizations that are adding or planning to add care facilities, the time is now for nursing’s input into the design of healthcare facilities.

The design of healthcare facilities has an impact on patient safety issues relating to nosocomial infection. A white paper on nursing-sensitive patient outcomes published by the Oncology Nursing Society recognizes prevention of infection as an important safety outcome that is sensitive to nursing interventions (Given & Sherwood, 2005). Additionally, 3 of the 15 outcomes endorsed by the National Quality Forum (2007) as nursing-sensitive performance measures are related to infection. Oncology nurses need to be part of the planning, design, and demolition phases of constructing and remodeling healthcare facilities to mitigate risks for patients with cancer. The objectives of this article are to: (a) describe the impact of healthcare-associated infections on patients with cancer and (b) describe evidence-based design of healthcare environments to prevent fungal infections and promote handwashing.

The Impact of Healthcare-Associated Infections

Klevens et al. (2007) estimated that approximately 1.7 million healthcare-associated infections occurred in U.S. hospitals in 2002, and the infections were associated with approximately 99,000 deaths. Factors that have led to the increasing infection rate are: (a) low handwashing rates by staff between patient contacts, (b) patients who are sicker and immunocompromised, (c) infrastructure repairs and renovations of aging hospitals, and (d) new construction on existing campuses creating the risk of airborne fungal disease (Joseph, 2006). Emerging evidence in healthcare design indicates that if infectious environmental transmission routes are considered in the design of healthcare facilities, healthcare-acquired infections can be reduced (Joseph).

If a patient acquires a healthcare-associated infection, the additional cost of treating the infection will no longer be paid by Medicare, effective October 1, 2008. The specific healthcare-associated infections that no longer will be covered by Medicare include vascular catheter-associated infection and catheter-associated urinary tract infections (unless they were present on admission). Instead, charges will have to be absorbed by the organization and the organization will not be allowed to charge the patient the additional cost of treatment (Paddock, 2007).

Reducing the Risk of Infection by Preconstruction Planning

The importance of containing airborne and surface contaminants during new construction and remodeling projects is now better understood. The American Institute of Architects ([AIA], 2006), the Centers for Disease Control and Prevention (2003), and the Joint Commission (2003) have published guidelines for the design and construction of hospitals...
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...and ambulatory care settings. The safety issues become even more evident when one considers that almost 75% of all construction projects in health care involve an expansion or renovation of an existing healthcare structure while it is still occupied by patients (Newton, 2003). Although the cost of properly conducting a construction project to avoid spreading contaminants can be significant, the initial cost can be minimized with proper planning and education of healthcare staff and construction contractors at the planning stages of a project (Kidd, Buttner, & Kressel, 2007). Projects that do not address infection control early in the planning phase may face costly changes and potential project delays (Newton), as well as injury to patients.

The Infection Control Risk Assessment (ICRA) was introduced as a requirement for patient areas affected by construction projects in the 2001 edition of the AIA Guidelines for the Design and Construction of Health Care Facilities. This requirement was then referenced and made mandatory by the Joint Commission in the Environment of Care Standard EC 1.7. The ICRA is a strategic plan that identifies and mitigates the potential risks for transmission of disease-carrying agents that can be transported or spread during a construction project. The process for implementing the ICRA should start early in the design and planning stages of a project. A multidisciplinary panel should address the impact that a particular construction project will have on an organization’s patient population. In general, the plan should address design risks from infections transmitted by air, water, or the environment (Noskin & Peterson, 2001). Because patients with cancer are at increased risk for construction-related infections, oncology nurses, with their unique understanding of patient care issues, should be present during this phase of the project. For the immunosuppressed and nonimmunosuppressed oncology populations, this determination can not be taken lightly.

The following is a list of issues the ICRA should specifically address as they relate to construction activities within a facility (Newton, 2003).

- The impact of disrupting essential services for patients and staff
- The need for patients to relocate during the project
- What measures will need to be taken to protect patients, staff, visitors, and contractors from contaminants during the project
- Measures to maintain internal air quality
- A plan for environmental monitoring.

The plan that is adopted by the ICRA panel is meant to be a living document that should be updated through each phase of the project (Newton, 2003). During the actual construction, rounds should be completed at least weekly and large projects should be visited daily (Kidd et al., 2007). The single most important measure to avoid the spread of airborne contaminants from a construction area is to ensure that the construction area remains under negative pressure (Newton). The ICRA should address which areas will be affected by the construction and to what extent. Any major renovation project most likely will require that the construction area be sealed from the remainder of the facility and maintained at negative pressure relative to adjacent areas (Newton). Specific measures to consider during construction and demolition to reduce the spread of airborne pathogens are using portable high-efficiency particulate air (HEPA) filters, installing barriers between the patient care and construction areas, using negative air pressure in the construction areas relative to the patient care areas, and sealing patient windows (Joseph, 2006).

**Fungal Infections: A Special Risk for Patients With Cancer**

Fungal infections are among the most serious complications in patients with cancer. The complications can occur in neutropenic patients (Gardner, 2007), in those with hematologic or solid malignancies (Ohmagari, Raad, Hachem, & Kontoyiannis, 2004), in non-neutropenic patients treated with steroids (Cornillet et al., 2006), and in critically ill patients without malignancy (Meersseman et al., 2004). A study by Martin, Mannino, Eaton, and Moss (2003) of the epidemiology of sepsis revealed that the annual number of cases of sepsis caused by fungal organisms increased 207% from 1979–2000.

**Candidiasis**

Candidiasis is an infection caused by a group of microscopic fungi or yeast. More than 20 species of Candida exist, the most common being *C. albicans*. Candidemia is considered to be a nosocomial infection. *Candida* species are the most prevalent cause of fungal infections in hospitalized patients (Gardner, 2007). A retrospective study by Zaoutis et al. (2005) estimated the incidence of candidemia in hospitalized adults and children in the United States during 2000. The authors indicated a frequency of 43 cases per 100,000 pediatric admissions and 30 cases per 100,000 adult admissions. In pediatric patients, candidemia was associated with a 10% increase in mortality, a mean 21-day increase in length of stay, and a mean increase in total per-patient...
Charges of $92,266. In adult populations, candidemia was associated with a 14.5% increase in mortality, a mean 10-day increase in length of stay, and a mean increase in hospital charges of $39,351.

**Aspergillosis**

*Aspergillus* is a fungus found in soil, decaying vegetation, and dust. The principal host defense against *Aspergillus* infections is alveolar macrophages, which target inhaled spores. Impairment of the cellular defenses by cytotoxic chemotherapy, corticosteroids, and hematologic malignancies increases the risk of infection (Hahn et al., 2002). If the spores are left undisturbed, they are not a threat to immunosuppressed patients. However, new construction and renovation projects often are associated with dissemination of *Aspergillus* spores (Kidd et al., 2007). *Aspergillus* spores are easily suspended in the air and can survive for prolonged periods. Because of their size, they are easily inhaled, which can lead to invasive infection of the upper and lower respiratory tracts of susceptible hosts. Aspergillosis represents 57% of nosocomial fungal infections and is the second most common opportunistic fungal infection in patients with hematologic malignancies (Lee et al., 2007). In a systematic review of 53 studies, Vonberg and Gastmeier (2006) reported that the species most commonly identified was *A. fumigatus* (43%).

A major impediment to successful treatment of *Aspergillus* infections is the difficulty in establishing early diagnosis. Many times, the infections are diagnosed late or at postmortem examination. Thus, outbreaks often are underestimated or go unnoticed because of low rates of positive cultures of tissue and sputum samples (Hahn et al., 2002).

**The Role of the Healthcare Environment**

Ulrich, Quan, Zimring, Joseph, and Choudhary (2004) identified several studies that linked increased levels of dust and fungal spores during renovation and construction activities with healthcare-associated infections in immunocompromised patients. A systematic review by Vonberg and Gastmeier (2006) suggested that construction and renovation activities often are considered to be the main cause of nosocomial *Aspergillus* outbreaks. The authors recommended several measures to prevent invasive *Aspergillus* nosocomial infections (see Figure 1). The authors stated that concentrations of *Aspergillus* species even below one colony forming unit/m² were sufficient to cause infection in high-risk patients. Even smaller concentrations of spores have been associated with outbreaks from *A. fumigatus* and *A. flavus*.

**Preventing Aspergillosis by Filtering**

Providing clean, filtered air and controlling indoor air pollution through ventilation are key aspects to maintaining air quality (Joseph, 2006). HEPA filters are 99.97% effective in removing particles that are 0.3 μm. *Aspergillus* spores are 2.5–3.0 μm in diameter (Joseph). The Centers for Disease Control and Prevention and the Healthcare Infection Control Practices Advisory Committee recommend HEPA filters for healthcare facilities (CDC, 2003). However, HEPA filters cost more than the typical 90% efficient filters, are more expensive to maintain, and cost more to operate (Joseph).

A study by Lee et al. (2007) examined the impact of cleaning and directional air flow on environmental contamination with *Aspergillus* species in HEPA-filtered hospital rooms that housed patients with hematologic malignancies. Of a total of 1,258 surface samples, 3.3% were positive for the *Aspergillus* species. No significant difference was found in the density of *Aspergillus* species between rooms with negative airflow and rooms with positive airflow. The study also found that concentration of bioaerosolized contamination with *Aspergillus* species was increased in rooms sampled one hour after cleaning compared with rooms sampled before cleaning. This suggests a possible correlation between bioaerosols (*Aspergillus* species suspended in the air because of cleaning activity in the room) and the risk of nosocomial aspergillosis. Contamination was more likely to occur in the summer. The authors concluded that a multifaceted approach may be best to reduce the incidence of *Aspergillus* infections. The approach should focus on (a) the environment, (b) engineering controls, and (c) the relationship between the patient and the environment.

**Reducing Infections by Handwashing**

Although infections caused by airborne transmission are a cause for concern, most infections acquired in clinical settings are via the contact pathway (Institute of Medicine, 2004). Such infections are not transmitted directly from environmental surfaces to patients. Rather, the environmental surfaces harbor contaminants that are passed from caregivers’ hands to patients. Multiple well-designed studies have proven that handwashing is one of the most effective ways to prevent infection by the contact pathway (Zitiella et al., 2006). The importance of handwashing is well known; however, the handwashing rates of various healthcare staff are low and represent a serious safety issue. In observational studies of healthcare workers’ hand hygiene adherence, hand hygiene procedures have been poor, with mean baseline rates of 5%–81% (CDC, 2002). Ulrich et al. (2004) found that compliance rates in the range of 15%–30% are typical. Handwashing rates are lowest among physicians and nursing assistants; rates are lower in units that are understaffed, have a high patient census, or have high bed-occupancy rate. Educational programs have not been successful in increasing handwashing or have produced only transient increases in handwashing.

**Avoid nonemergent admissions during peak construction times.**

**House high-risk patients as far away as possible from construction and demolition areas.**

**Seal off patient care areas with barriers and keep doors and windows closed.**

**Verify that high-efficiency particulate air filtration is sufficient.**

**When transporting patients, take routes that are farthest away from construction zones.**

**Wet-clean care areas without raising dust.**

**Surveil patients who are at increased risk.**

![Figure 1. Measures to Prevent Invasive Aspergillus Nosocomial Infections](image-url)

*Note.* Based on information from Vonberg & Gastmeier, 2006.
Hospital staffs have reported several reasons for poor handwashing: inconvenient sink location, shortage of sinks, lack of time, lack of soap or paper towels, and forgetfulness. These factors speak to facility design (Joseph, 2006). Easy access to hand-hygiene supplies (sinks, soap, and medicated detergent or alcohol-based hand-rub solution) is essential for optimal adherence to hand-hygiene recommendations (CDC, 2002). The time required for nurses to leave the bedside, go to a sink, and wash and dry their hands before attending to the next patient is a deterrent to frequent handwashing (CDC, 2002).

Environmental designs that make handwashing practices easier and more convenient may be more effective in producing sustained increases in handwashing compliance (Joseph, 2006). Ulrich et al. (2004) identified six studies that examined whether handwashing rates improved when healthcare settings increased the ratio of sinks or hand-cleaner dispensers to the number of beds. Some evidence showed that numerous conveniently located dispensers and sinks can increase handwashing compliance. Ulrich et al. identified three studies suggesting that providing single-bed rooms with conveniently located sinks reduces nosocomial rates in intensive care units.

**Summary**

Evidence-based design is a new term in the planning, design, and construction of healthcare facilities. No randomized, controlled clinical trials have researched the impact of different healthcare designs on the prevention of nosocomial infections. Randomized, controlled clinical trials likely will not occur because of enormous variations in design and construction techniques. However, a growing body of research indicates that the design of a healthcare setting and planning for construction can have an effect on healthcare-associated infections (see Figure 2). Because such infections can be deadly for patients with cancer, oncology nurses, as the major providers of bedside care, should be a part of the design, planning, construction, and demolition processes. Oncology nurses have a specialized knowledge of the unique needs of patients with cancer and should be “at the table” during all phases of the current and future healthcare building boom.

- Standardization in room size and layout (Reiling et al., 2003)
- In-room sinks for staff handwashing that are visible and convenient (Rashid, 2006; Reiling et al., 2003; Ulrich et al., 2004)
- Sink placement that is optimally close to the entrance of the room and large enough to prevent splashing (Noskin & Peterson, 2001)
- Private rooms (Rashid, 2006; Reiling et al., 2003; Ulrich et al., 2004)
- Storing of patient supplies in patient rooms (Reiling et al., 2003)
- Waste disposal facilities in patient rooms (Noskin & Peterson, 2001; Rashid, 2006)
- High-efficiency particulate air (HEPA) filters (Joseph, 2006)
- HEPA filters for immunocompromised patients with hematologic malignancies to control outbreaks of Aspergillus (Hahn et al., 2002)
- Microbes can survive on carpeting (Noskin & Peterson, 2001), so avoid the use of carpeting where spills are likely to occur and in high-risk patient areas.
- Use vacuum cleaners fitted with HEPA filters (Joseph, 2006).
- Avoid acoustical tiles in high-risk areas; walls and ceilings should have smooth, impervious surfaces (Noskin & Peterson, 2001).
- Auto-sensors in patient rooms can provide light immediately when someone enters, reducing surface-borne pathogens by eliminating the need to touch light switches (Eagle, 2005).
- Bacteria-killing ultraviolet lights in the air-handling system (Eagle, 2005)
- Maintain negative pressure in construction areas to decrease the spread of airborne contaminates (Joseph, 2006; Newton, 2003).
- Measures to consider during demolition and construction to reduce airborne pathogens: HEPA filters at sites, barriers between patient care areas and construction areas, and sealing of patient windows (Joseph, 2006).

**Figure 2. Design Features Relating to Preventing Nosocomial Infections**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
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<tbody>
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<tr>
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**References**


