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HEALTHCARE ACQUIRED INFECTION

A healthcare or hospital acquired infections (HAI), also called a nosocomial infection is the result of treatment in a hospital or healthcare service unit, whereas the patient acquires an infection that he/she did not have prior to being admitted to the hospital. An HAI is determined based on appearing 48 hours or more after admission or within 30 days of discharge. HAI affects an estimated two million patients in the United States each year with 90,000 or more ending in death. HAI kills more people each year than breast cancer, prostate cancer and AIDS combined. From a cost perspective, HAI in the United States results in millions of extra hospital days; and an estimated cost of $30 billion due to multiple drug regimens, additional medical care and loss of productivity (Graves, 2004). In a study reported by the Pennsylvania Health Care Cost Containment Council, the average number of HAI reported was 17.7 per 1,000 patients with a mortality rate of 12.2%. The average length of stay attributed to HAI was 19.7 days with a cost per patient of $191,872 (Wilderman, 2009). HAI occur in about 20% of very low birth weight infants with an increase of length of stay up to 24 days and an increased cost of up to 20% per patient (Gaynes et al., 1996; Sohn et al., 2001; Stoll et al., 2002).

With the passage of the Patient Protection and Affordable Care Act, the Federal Government has devised a system for rewarding hospitals that cut HAIs by increasing Medicare payments. However, the caveat of the Medicare position of not reimbursing for “Never Events” creates a carrot and stick approach. Either way, accountability for the impacts of HAIs is in the foreground, along with other safety and quality of care concerns. “Never Events” are serious reportable events that are clearly identifiable, preventable, and serious in their consequences for patients. It is a clear indication that a real problem of safety and credibility exists for the healthcare facility. On October 1, 2008, Medicare and Medicaid stopped reimbursing for never events. Other insurers quickly followed suit with their own policies. Hospitals are prohibited from passing charges on to the patient. This increases costs and liability for the hospital. However, at this time, HAIs are not formally a part of this list.

In a literature review of the role of the hospital environment on the occupants, over 120 studies linking the hospital environment to infection were identified (Ulrich & Zimring, 2004). The focus of these studies was on airborne infections: 1) natural and forced ventilation; 2) use of HEPA filters; 3) vehicles of transmission; and 4) hand washing policies and practices. While the use of HEPA filters have been integrated into best practice and code requirements, the practical application of processes to target vehicles of transmission are less understood. Hand washing policies are more likely to be effective when
supplemented with education/compliance programs and design features to support proper hand washing. Hand washing sinks with offset drains located within the patient room and throughout the patient unit along with secondary options; such as the alcohol based waterless hand cleaner provide opportunities to comply with existing policies.

**COMMON PATHOGENS IN THE HEALTHCARE ENVIRONMENT**

The pathogens most often linked in the literature to contaminated surfaces in hospitals are *Clostridium difficile* (C. diff.), *Vancomycin-resistant enterococci* (VRE), and *Methicillin-resistant Staphylococcus aureus* (MRSA). C. diff. incidence has been increasing for years, but the recent emergence and spread of strains that produce much higher levels of a potent toxin have made control even more urgent (Siegel, Rhinehart, Jackson, & Chiarello, 2006). This pathogen causes intestinal illness, ulcers and colitis. Studies have shown that this pathogen can survive up to 5 months on hospital surfaces (Kramer, Schwebke, & Kampf, 2006). Some common surfaces that have shown contamination include floors, bed rails, bedside table, the telephone and the call button. Transmission occurs via the healthcare worker through hand contamination. This pathogen is one of the most widespread infections in hospitals; where prevalence of hand contamination is proportional to environmental contamination suggesting the importance of the role of the physical environment in the transmission of this pathogen (Samore, Venkataraman, DeGirolami, Arbeit, & Karchmer, 1996).

A recent study at the Mayo Clinic in Rochester, Minnesota targeted two patient units with high rates of C. *diff.* for an intervention focused on housekeeping (Orenstein et al., 2010). The environmental services personnel were trained to use Clorox Ultra Germicidal Bleach Wipes containing .55% sodium hypochlorite for daily and terminal cleaning of patient rooms. A random sample of rooms was assessed using Clean Trace Technology before and during the intervention. Surveys of patients and environmental services staff were conducted before and during the intervention period. Finally, the rate of incidence was tracked for analysis. The results found that the rate of incidence was reduced by 30%; the intervals between incidence of C. *diff.* was increased to greater than 20 days; and the Clorox wipes were well tolerated by patients and environmental services staff.

VRE is a blood borne pathogen that causes infection in the urinary tract, heart, brain, and wounds. Transmission of VRE from environmental surfaces to the hands or gloves
of healthcare workers are well documented. In one study, 46% of healthcare workers who touched contaminated surfaces in rooms of colonized patients were found to have contaminated gloves (Boyce, Potter-Bynoe, Chenevert, & King, 1997); other research has shown that patients can become infected from direct contact with contaminated surfaces within the patient environment (Grabsch et al., 2006). VRE can survive for up to 2 months on countertops, 7 days on fabric chairs and up to 3 months or more on cloth, plastic and dry polyvinyl chloride surfaces (Boyce, 2007).

In a controlled study assessing 14 materials commonly specified in healthcare interiors, the research team investigated the impact of the materials harboring VRE and Pseudomonas aeruginosa (PSAE) and evaluated the potential healthcare provider transmission of VRE (Lankford et al., 2006). The materials included upholstery, wall surfaces and flooring finishes typically used in healthcare environments. The samples were inoculated with PSAE and VRE, and then cleaned according to the manufacturer’s recommendations. Each sample was assessed for recovery of organisms at 24 hours, 72 hours, and 7 days. Volunteer healthcare workers touched VRE-inoculated surfaces and imprinted palms onto contact-impression plates. The results showed that after 24 hours, VRE was recovered from all the surfaces while PSAE was recovered from about 93% of the surfaces. After cleaning, 50% of the surfaces showed recovery of VRE, whereas about 36% of surfaces tested positive for PSAE. Regarding the palm transfer, VRE was recovered from 100% of the surfaces touched. This study shows the importance that maintenance plays in infection prevention for the transmission of pathogens like VRE.

MRSA is probably the best known pathogen due to the coverage in the news when this HAI also became classified as a community acquired illness. This disease causes skin infections, fever, chest pain, fatigue and muscle aches. MRSA accounts for more than 50% of all hospital acquired Staphylococcus aureus (Siegel et al., 2006) and can remain viable for up to 14 days on surfaces; and for up to nine weeks on cotton blanket material (Beard-Pegler, Stubbs, & Vickery, 1988; Duckworth & Jordens, 1990). Common materials where this pathogen can be found include carpet and plastic laminate. Transmission occurs direct from environment to patient or through healthcare workers (Boyce et al., 1997). Boyce et al. (1997) discusses studies that demonstrate the transmission via healthcare workers showing that 42% of nurses contaminated their gloves by touching objects in the room of patients with MRSA without ever having touched the patient.

A research study that shows transmission of MRSA among patients is a study investigating the effectiveness of contact isolation during a hospital outbreak of MRSA (Jernigan, Titus, Gröschel, Getchell-White, & Farr, 1996). The site for this study was a neonatal intensive care unit (NICU) at a 700-bed hospital with nine intensive care units. The NICU has 33 beds and admits approximately 700 neonates each year. The unit consists of four pods of six to ten beds each, along with an isolation room containing an anteroom and two beds. Over a seven month period, surveillance was conducted with cultures performed on all patients. Sixteen of 331 admissions became colonized with MRSA. The research suggests that the patients were the reservoir and the caregivers were the vehicles of transmission. Those patients who were in isolation had a significantly lower rate of infection, supporting the recommendation of private patient rooms to minimize the spread of infection.
Disinfection of patient environments is dependent on collaboration between the Designer, Facility Manager, Infection Prevention and Environmental Services. The right materials must be specified and maintained so that cleaning and disinfecting is productive. Surveillance and education are crucial to the management of behavioral aspects of the prevention of infection outbreaks.

The CDC recommends a strategy for the routine prevention and control of infection in healthcare settings (Siegel et al., 2006). Some of the recommendations are:

1. Provide administrative support – fiscal and human resources – to prevent and control HAI transmission;
2. Through the use of experts, conduct an assessment to identify the problem and provide guidance in implementing interventions;
3. Healthcare worker education and training on risks and prevention of HAI transmission;
4. Judicious antimicrobial use;
5. Surveillance to detect and communicate evidence of HAIs;
6. Follow established protocols for infection control precautions to prevent transmission;
7. Follow recommended cleaning, disinfection and sterilization guidelines for maintaining patient care areas and equipment; and
8. Focus on cleaning and disinfecting frequently touched surfaces and equipment in immediate vicinity of the patient.

A study identifying 14 high touch objects investigated the patient room disinfection of 36 acute care hospitals (Carling et al., 2008). A fluorescent targeting method was used to objectively evaluate the thoroughness of terminal room disinfection cleaning before and after educational and procedural interventions. Of 20,646 standardized environmental surfaces, only 9,910 (48%) were cleaned at baseline. After the education and protocol interventions, 77% of 9,464 objects were cleaned at baseline. The study found that thoroughness of cleaning at baseline correlated only with hospital expenditures for environmental services personnel. This study concluded that significant improvements in disinfection cleaning can be achieved in most hospitals, by the use of a structured approach that incorporates a simple, highly objective surface targeting method, repeated performance feedback to environmental services personnel, and ongoing administrative support.

Another study focused on the hospital’s interest in the use of carpet tiles on patient unit corridor floors (Harris, Pacheco, & Lindner, 2010). Carpet tiles are a viable solution for healthcare environments since, “in the event of contamination with blood or other organic
substances, the tiles can be removed, discarded and replaced (Sehulster & Chinn, 2003).” 
This study tested the viability of carpet tile in a medical patient unit corridor by measuring 
the level of microbial penetration at the seams. In addition, the study developed a 
methodology for detecting potential pathogens populated on hospital surfaces. Because 
of the limited number of samples and test sites, this study should be considered a pilot 
study, where caution must be taken in generalizing the findings.

Harris et al. (2010) found that the physical environment complied with industry standards 
for temperature, relative humidity, surface and substrate temperatures and moisture 
levels; though spores were observed on all surfaces tested, fungal colonization was not 
observed. Since fungal conditions were not promoted under the conditions measured, 
testing the viability of the seam to prevent moisture and contamination from traveling from 
the surface to the back of the tile was not completely proven. Comparing the moisture 
level of the subfloor between visits 4 and 5 when a scheduled hot water extraction 
method cleaning occurred, the study found that the moisture levels of the subfloor did 
not change, suggesting that the carpet tile seams do provide a barrier for moisture from 
surface to backing.

The DNA sequencing successfully identified bacteria harbored in the carpet tile, 
non-tile carpet, resilient flooring and other surfaces present in the hospital corridor that 
was subject to this study. While the profile of the carpet tile contained the highest number 
of identified different species and total species, the backing contained the lowest number 
of species and exhibited a decrease in diversity over time. Finally, no sequence retrieved 
from the tiled carpet was closely related to bacterial pathogens, though samples from the 
resilient flooring, a nurse’s shoe sole, and a wheel of a patient’s bed revealed sequences 
from known or potential pathogens.

RECENT ADVANCES IN ANTIMICROBIAL TREATMENTS

After years of increases of incidence and morbidity rates related to HAIs, the focus has 
turned to the healthcare environment and the potential to increase safety through design, 
specification and maintenance of products that mitigate the transmission of pathogens. 
Infection control specialists, facility managers, risk managers, microbiologists and design 
professionals are involved in 
the deliberation on the 
effectiveness, safety and value 
of antimicrobial agents. The 
Environmental Protection 
Agency (EPA) classifies 
antimicrobial agents as 
pesticides, which are defined 
as substances used to 
destroy or suppress the growth 
of harmful microorganisms 
whether bacteria, viruses, or 
fungi on inanimate objects and
surfaces (EPA, 2011). Those related to public health products include sterilizers (paracides), disinfectants, sanitizers, antiseptics, and germicides. Antiseptics and germicides are used to prevent infection and decay; and are used in or on living humans or animals, so they are considered drugs and are approved and regulated by the U. S. Food and Drug Administration (FDA). Most importantly, the EPA has taken vendors to task for making unsubstantiated public health claims. Basically, a manufacturer can state that a product treated with or containing a pesticide to protect the product itself (i.e. paint treated with a pesticide to protect the paint coating), but cannot state that the pesticide protects the persons coming into contact with that product. The antimicrobials protect the product, not the people. The EPA’s position is that public health claims such as “fights germs, provides antibacterial protection, or controls fungus” is limited to articles and products that are registered pesticides, not treated with such a pesticide (EPA, 2003).

Metals are being touted as the next great thing for use in interior finish products as antimicrobial agents. Silver, for instance, is currently added to various kinds of interior finish materials, though real concerns about the efficacy and potential unintended consequences of using these products in healthcare facilities are presented in the research literature (Meyer, Curran, & Gonzalez, 2010; Thanh & Phong, 2009). Several products have been developed using silver (Ag). This product is used in sportswear, the food industry, air purifiers, and cheese coating (wax). In the interior design industry, silver, in the form of colloidal silver, silver ions and silver attached to nanotubes are used in fabrics, paint and other commercial finish materials. The silver based disinfectant is reported to kill bacteria and fungi and remain active on surfaces for 24 hours after disinfection. It is colorless, noncorrosive and nonflammable. It has been shown to be effective against MRSA, VRE, HIV, influenza, athletes foot fungus, etc. The effectiveness of silver to minimize contamination is reliant on the form of silver (threads, salt compounds, etc.) and the amount in the product or disinfectant (one study indicated that 80 ppm was required to be effective, in this case the antibacterial fabric with 758 mg/kg of silver nanoparticles on surface cotton) (Thanh & Phong, 2009). Through cleaning and abrasion, products with added silver may become less effective over time.

Copper is another metal being marketed for use in healthcare facilities. In controlled laboratory studies, uncoated copper and copper alloys (brass and bronze) eradicate pathogens like E. coli, Streptococcus, and Staphylococcus (Noyce, Michels, & Keevil, 2006, 2007; Wheeldon et al., 2008). It has been shown to be effective against MRSA and was recently approved by the EPA as a registered antimicrobial material, allowing the claim that copper, when used in accordance with the label, “kills 99.9% of bacteria within two hours.” Currently, new products are in development for healthcare furniture and materials – door hardware, over bed tables, bed rails, armchairs, call buttons and medical equipment like IV stands. However, The label states that this health claim is viable when the product is “cleaned regularly” (CDA, 2011) which needs further explanation; and findings from applied research studies remain elusive.

A nanoparticle acts as a vehicle for the distribution and adherence of materials (like silver or titanium dioxide) to another material, such as an upholstery fabric. Nanotechnology is clearly a part of the future of technological advances in many areas of the indoor environment; however research is still needed to evaluate potential risks. Recent studies
indicate possible unintended consequences. In a study evaluating socks that have silver nanoparticles to reduce foot odor showed that silver was being released in the wash and eventually into our environment (Benn & Westerhoff, 2008). Silver nanoparticles may destroy beneficial bacterial needed to break down organic matter in waste treatment plants and farms (Quadros & Marr, 2010). Nanoparticles can enter the human body through the lungs, the intestinal tract, and to a lesser extent the skin, and are likely to be a health issue, although the extent of effects on health are inconclusive (Albrecht, Evans, & Raston, 2006).

**DESIGN FOR INFECTION PREVENTION**

Research and experience contribute to best practices when designing and specifying healthcare interiors. Design to minimize patient transfers to reduce risk of medical errors. Compliance of hand washing protocols is uneven at best. Design to support hand washing by standardizing on hand washing sinks in patient rooms, corridors, and healthcare worker areas. Hospital administrators and design professionals have varying opinions and positions on the use of antimicrobial agents. In this fast changing arena, stay up to date on the research to inform design of healthcare facilities. For instance, how will the specified finish materials withstand the disinfectants and sterilizers used in the healthcare facility by the environmental services staff?

Pathogens may be transmitted by direct contact with the environment or through a healthcare worker. Design and specify furniture and finishes that are easy to clean without complicated procedures or special cleaners. Seamless casework and furniture will minimize places where sources of food can reside. Fabric on seating should provide a barrier to the cushion and be easy to clean. Seating should have a “wipe out space between the seat and the back to reduce the source of food for bacterial growth. Carpet tiles may be used in patient areas as recommended by the CDC, providing easy access for removal of contaminated tiles (Sehulster & Chinn, 2003).
REFERENCES


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