ICT INFECTION CONTROL TODAY®

December 2013 • $12.00 US

SPECIAL DIGITAL PULSE ISSUE: Environmental Hygiene

PRIMER ON HOSPITAL PATHOGENS:

A Review of Key Bugs and the Need for Environmental Hygiene

Primer on Hospital Pathogens: A Review of Key Bugs and the Need for Environmental Hygiene

By Kelly M. Pyrek

In recent years there have been a number of studies indicating the importance of the role of the environment in infection acquisition and transmission. As Weber and Rutala (2013) explain, “Over the past decade, substantial scientific evidence has accumulated indicating that contamination of environmental surfaces in hospital rooms plays an important role in the transmission of several key healthcare-associated pathogens, including methicillin-resistant Staphylococcus aureus (MRSA), vancomycin-resistant Enterococcus (VRE), Clostridium difficile, Acinetobacter and norovirus. All of these pathogens have been demonstrated to persist in the environment for hours to days (and, in some cases, months), to frequently contaminate the surface environment and medical equipment in the rooms of colonized or infected patients, to transiently colonize the hands of healthcare personnel (HCP), to be associated with person-to-person transmission via the hands of HCP, and to cause outbreaks in which environmental transmission was deemed to play a role. Furthermore, hospitalization in a room in which the previous patient had been colonized or infected with MRSA, VRE, C. difficile, multidrug-resistant Acinetobacter, or multidrug-resistant Pseudomonas has been shown to be a risk factor for colonization or infection with the same pathogen for the next patient admitted to the room.”

Still under debate is the degree to which pathogen transfer occurs from contaminated environmental surfaces to the hands of healthcare workers and patients. As Weber and Rutala (2013) note, “Although pathogen transfer from a colonized or infected patient to a susceptible patient most commonly occurs via the hands of HCP, contaminated hospital surfaces and medical equipment (and, less commonly, water and air) can be directly or indirectly involved in the transmission pathways. HCP have frequent contact with environmental surfaces in patients’ rooms, providing ample opportunity for contamination of gloves and/or hands. Importantly, hand contamination with MRSA has been demonstrated to occur with equal frequency when HCP have direct contact with a colonized or infected patient or through touching only contaminated surfaces. The most important risk factor for HCP hand and glove contamination with multidrug-resistant pathogens has been demonstrated to be positive environmental cultures."

Common sense dictates the need for proper and rigorous environmental hygiene as one of several key ways to control and eliminate infections; however studies have indicated that routine and terminal cleaning of room surfaces by environmental services personnel and medical equipment by nursing staff is frequently inadequate. Carling, et al. (2008) and Goodman, et al. (2008) are among the researchers who have shown that less than half of hospital room surfaces are adequately cleaned and disinfected.

When one considers the persistence of the vast majority of pathogens in the environment for days, weeks and even months, it becomes clear that cleaning and disinfection is of utmost importance. There are some pathogens that are more prevalent in the hospital environment and are of significant concern, and this report takes a look at a few of them.

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Acinetobacter

Acinetobacter is a group of bacteria commonly found in soil and water. While there are many species of Acinetobacter and all can cause human disease, Acinetobacter baumannii accounts for about 80 percent of reported infections. Outbreaks of Acinetobacter infections typically occur in intensive care units and healthcare settings housing very ill patients. Acinetobacter causes a variety of diseases, ranging from pneumonia to serious blood or wound infections, and the symptoms vary depending on the disease. Acinetobacter may also colonize a patient without causing infection or symptoms, especially in tracheostomy sites or open wounds. Acinetobacter poses very little risk to healthy individuals; however, people who have weakened immune systems, chronic lung disease, or diabetes may be more susceptible to infections with Acinetobacter. Hospitalized patients, especially very ill patients on a ventilator, those with a prolonged hospital stay, those who have open wounds, or any person with invasive devices like urinary catheters are also at greater risk for Acinetobacter infection. Acinetobacter can be spread to susceptible persons by person-to-person contact or contact with contaminated surfaces. Acinetobacter can live on the skin and may survive in the environment for several days. Careful attention to infection control procedures, such as hand hygiene and environmental cleaning, can reduce the risk of transmission.

As Manchanda, et al. (2010) emphasize, "Emergence and spread of Acinetobacter species, resistant to most of the available antimicrobial agents, is an area of great concern. It is now being frequently associated with healthcare-associated infections."

According to Manchanda et al. (2010), among the patients who are hospitalized in non-intensive care units, the skin carriage rate of Acinetobacter spp. has been found to be as high as 75 percent. In particular, high colonization rates have been observed in ICU patients, especially of the respiratory tract. Residency in an ICU, particularly in the presence of other patients who are colonized with Acinetobacter, predisposes patients to colonization. It is particularly seen in patients who are intubated and in those who have multiple intravenous lines, monitoring devices, surgical drains, or indwelling urinary catheters. It is often cultured from hospitalized patient's sputum or respiratory secretions, wounds, and urine, and commonly colonizes in irrigating solutions and intravenous fluids. Acinetobacter infections usually involve organ systems with a high fluid content (such as respiratory tract, blood, CSF, peritoneal fluid, urinary tract). Invasive devices used to facilitate fluid monitoring, administer medications, and provide lifesaving support may also be sources of colonization. The incidence of severe infection caused by MDR and PDR A. baumannii has been increasing worldwide. Crude mortality rates of 30 percent to 75 percent have been reported for nosocomial pneumonia caused by A. baumannii. However, it has also been seen that mortality resulting from A. baumannii infection relates to the underlying cardiopulmonary and immune status of the host rather than the inherent virulence of the organism. Patients who are very ill with multisystem disease have higher mortality and morbidity rates, which may be due to their underlying illness rather than the superimposed infection with Acinetobacter.

> Acinetobacter baumannii accounts for about 80% of reported infections.

Acinetobacter spp. has the ability to survive in hospital environments, with this organism persisting for long periods on both dry and moist surfaces. In fact, several studies have shown the capacity of this organism to survive on dry surfaces, for durations longer than that found for Staphylococcus aureus. Although the reservoirs of this pathogen are poorly understood, its survival is most likely assisted by the ability of Acinetobacter spp. to grow at a range of different temperatures and pH values. Acinetobacter spp. has commonly been isolated from the hospital environment and hospitalized patients. According to APIC's Guide to the Elimination of Multidrug-resistant Acinetobacter baumannii Transmission in Healthcare Settings, "Studies have shown that A. baumannii strains could be isolated from a hospital bed rail for nine days after the discharge of an infected patient. In another study, Wendt et al. showed that A. baumannii strains isolated from dry sources had better survival rates than strains isolated from wet sources. Acinetobacter spp. have been identified on some inanimate hospital objects for up to five months. Ventilators, suctioning equipment, mattresses, sinks and portable radiology equipment are some of the more common sources that remain colonized for extended periods."

Many case control studies have revealed that prior exposure to antimicrobial therapy has been the most common risk factor identified in multivariate analysis. Carbapenems and third-generation cephalosporins are the most commonly implicated antibiotics, followed by fluoroquinolones, aminoglycosides, and metronidazole. The second most common risk factor identified in case-control studies is mechanical ventilation. Other risk factors include a stay in an ICU, length of ICU and hospital stay, severity of the illness, recent surgery, and invasive procedures. Furthermore, studies on A. baumannii outbreaks have revealed environmental contamination as an important risk factor in the causation of outbreaks. Munoz-Price, et al. report a high frequency of environmental contamination in the rooms of patients colonized or infected with Acinetobacter baumannii, compared with A. baumannii–negative patients (39 percent of rooms positive versus 10 percent).

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As Manchanda, et al. (2010) note, "During the outbreaks, extensive contamination of the environment, including respirators and air samplers in the vicinity of the infected or colonized patients have been documented. Bed linen of colonized patients is consistently culture positive for Acinetobacter species, whereas, the bed linen of non-colonized patients is found to harbor Acinetobacter spp. on several occasions. It has also been recovered from mattresses, pillows, bed curtains, and blankets in the immediate vicinity of infected patients. It has also been isolated from food (including hospital food), ventilator equipment, suctioning equipment, infusion pumps, stainless steel trolleys, pillows, mattresses, tap water, bed rails, humidifiers, soap dispensers, and other sources. Also, other fomites like door handles, telephone handles, tabletops, and so on have tested positive for Acinetobacter species during outbreaks, probably contaminated by the hands of the staff. One or more epidemic Acinetobacter species clones often coexist with the endemic strains, making it difficult to detect and control transmission. Compounding to the problem of the ease to survive in a hospital environment and increasing antibiotic resistance, is the ability of this organism to form biofilms. It has been shown that Acinetobacter species can form biofilms on the surface of various implants and also in the environment. In such situations, the antibiotics for which it is showing in vitro susceptibility will also be ineffective in treating the infection."

As Manchanda, et al. (2010) summarize, "Acinetobacter spp. are rapidly spreading with emergence of extended resistance to even newer antimicrobials. They have the ability to acquire resistance at a much faster pace than other gram-negative organisms. Due to their ease of survival in the hospital environment, they have immense potential to cause nosocomial outbreaks. In addition to antibiotic resistance, their biofilm forming ability plays a crucial role in their in-vitro and in-vivo survival. Thus, to decrease the spread of Acinetobacter infections and reduce the pace of emergence of resistance in MDR Acinetobacter, it is important to promote the rational use of antimicrobials, with implementation and monitoring of the antibiotic stewardship program in hospitals. Hand hygiene and barrier nursing are important to keep the spread of infection in check."

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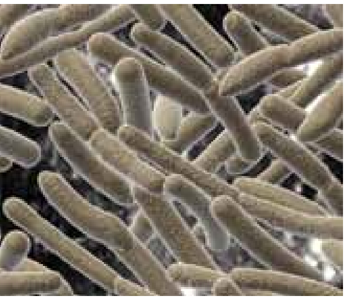
APIC's elimination guide explains that cleaning and disinfection protocols are effective tools for providing and maintaining consistent management of environmental contamination with antimicrobial resistant pathogens: "All personnel directly or indirectly involved in patient care, including environmental services, must be aware of multidrug resistant organisms, including MDRAb and its role in contamination of the environment. An environmental cleaning and disinfection plan includes policies or protocols that specify appropriate use of cleaning and disinfecting products. The plan must specify that environmental surfaces be cleaned with the proper dilution and amount of the standard facility-approved disinfecting agents, with compliance to contact times. Protocols should be in place for rooms of patients who are placed in isolation on precautions, with daily cleaning, terminal cleaning and enhanced cleaning during outbreak situations. Proper cleaning and/or disinfecting of electronic equipment is necessary. Personal care electronic equipment and multi-use electronic items, including any equipment used during delivery of patient care and mobile devices that are moved in and out of residents' rooms, may have special manufacturer instructions for meeting cleaning and disinfection requirements. Training staff to carefully follow manufacturer instructions is an important safety component of an effective cleaning and disinfection process and protection of equipment. An environmental cleaning and disinfection plan should include policies or protocols that specify a defined schedule of environmental cleaning. Daily cleaning of patient rooms by trained environmental staff is an essential policy component. Healthcare facilities can assign dedicated environmental staff to targeted patient-care areas to provide consistency of appropriate cleaning and disinfection procedures. Monitoring of staff, education and reinforcement of training is required to maintain appropriate cleaning and disinfection of the environment."

APIC's elimination guide continues, "A facility or specific units in a facility that are experiencing high or increasing infection rates should consider increasing the frequency of cleaning and disinfection. It is important to stress that high-touch areas undergo effective cleaning and disinfection. High-touch areas include, but are not limited to, bed rails, light switches, over-bed tables, bedside commodes, bathroom fixtures in the resident's room, doorknobs, any equipment in the immediate area of the resident, and any equipment that is multi-use between residents. In addition, it is important to make sure the floor is cleaned completely, including the moving of equipment to allow for access to all surfaces. Equipment cleaning that is not performed by environmental services staff must be clearly delegated to the appropriate healthcare staff per facility protocols. For instance, respiratory therapists may be responsible for cleaning respiratory equipment. Facility cleaning and disinfection policy or protocol will address the specific patient care staff responsibility for disinfection of equipment that may be taken from one resident to another."



Clostridium difficile

Clostridium difficile is quickly surpassing methicillin-resistant Staphylococcus aureus (MRSA) as the most problematic pathogen in healthcare institutions. Clostridium difficile is a spore-forming, Gram-positive anaerobic bacillus that produces two exotoxins: toxin A and toxin B. It is a common cause of antibiotic-associated diarrhea (AAD). It accounts for 15 percent to 25 percent of all episodes of AAD. Acquisition risk increases for patients with: antibiotic exposure, proton pump inhibitors, gastrointestinal surgery/manipulation, long length of stay in healthcare settings, Immunocompromising conditions, and advanced age.

Activities to stop the spread of the intestinal superbug Clostridium difficile are on the rise, but they are not yielding large improvements, according to a recent nationwide survey of infection preventionists by the Association for Professionals in Infection Control and Epidemiology (APIC). According to the survey, 70 percent of infection preventionists have adopted additional interventions in their healthcare facilities to address C. difficile infection (CDI) since March of 2010, but only 42 percent have seen a decline in their healthcare facility-associated CDI rates during that time period; 43 percent have not seen a decline. While CDI rates have climbed to all-time highs in recent years, few facilities (21 percent of respondents) have added more infection prevention staff to address the problem.

APIC conducted the 2013 CDI Pace of Progress survey in January 2013 to assess activities that have been implemented in U.S. healthcare facilities in the last three years to prevent and control CDI, a healthcare-associated infection that kills 14,000 Americans each year. A total of 1,087 APIC members completed the survey which was intended to provide a general overview of trends and indicate areas where more in-depth research might be beneficial.

> Because antimicrobial use is one of the most important risk factors for CDI, stewardship programs that promote judicious use of antimicrobials should be encouraged.

The Pace of Progress survey also noted an inconsistency between cleaning efforts and monitoring. More than nine in 10 respondents (92 percent) have increased the emphasis on environmental cleaning and equipment decontamination practices since March 2010, but 64 percent said they rely on observation, versus more accurate and reliable monitoring technologies to assess cleaning effectiveness. Fourteen percent said that nothing was being done to monitor room cleaning.

According to the survey, antimicrobial stewardship programs are slowly increasing. Sixty percent of respondents have antimicrobial stewardship programs at their facilities, compared with 52 percent in 2010. Because antimicrobial use is one of the most important risk factors for CDI, stewardship programs that promote judicious use of antimicrobials should be encouraged.

According to the survey, 53 percent of respondents reported adopting additional measures to control the spread of CDI. Less than a quarter, however, have been able to add more infection prevention staff. APIC conducted the 2010 CDI Pace of Progress poll to determine if hospitals have increased interventions to prevent CDI in the 18 months since the 2008 APIC CDI prevalence study revealed CDI rates to be six to 20 times greater than previous estimates. According to the 2010 survey, institutions that have not added interventions believe their rates of CDI are under control: 45 percent said CDI was not identified as a high-priority problem for their facility, 34 percent have an infection control plan to increase interventions in the event of an outbreak, and 30 percent said that CDI rates were declining with current practices.

APIC's 2010 CDI Pace of Progress poll indicated that institutions are using multiple strategies, as recommended, to address CDI:

- 83 percent of respondents currently have hospital-wide hand hygiene initiatives
- 90 percent perform surveillance or conduct activities to promptly identify CDI cases
- 94 percent always place patients with CDI on Contact Precautions, meaning they isolate patients suspected of having CDI, and healthcare professionals use gowns and gloves when caring for them
- 86 percent have increased their emphasis on environmental cleaning

According to the Centers for Disease Control and Prevention (CDC), deaths related to CDI increased 400 percent between 2000 and 2007, due in part to a stronger germ strain. CDI is estimated to add at least $1 billion annually to U.S. healthcare costs. A 2012 Vital Signs report from the CDC says that C. difficile infections are at an all-time high, and are linked to 14,000 deaths in the U.S. annually. Deaths related to C. difficile increased 400 percent between 2000 and 2007, due in part to a stronger pathogen strain. Almost half of infections occur in people younger than 65, but more than 90 percent of deaths occur in people 65 and older. Most C. difficile infections are connected with receiving medical care — about 25 percent of C. difficile infections first show symptoms in hospital patients; 75 percent first show in nursing home patients or in people recently cared for in doctors' offices and clinics.

Clostridium difficile is the most frequent etiologic agent for healthcare-associated diarrhea. In one hospital, 30 percent of adults who developed healthcare-associated diarrhea were positive for C. difficile. One recent study employing PCR-ribotyping techniques demonstrated that cases of C.difiicile-acquired diarrhea occurring in the hospital included patients whose infections were attributed to endogenous C. difficile strains and patients whose illnesses were considered to be healthcare-associated infections. Most patients remain asymptomatic after infection, but the organism continues to be shed in their stools.

In about 20 percent of patients, Clostridium difficile infection will resolve within two to three days of discontinuing the antibiotic to which the patient was previously exposed. The infection can usually be treated with an appropriate course (about 10 days) of antibiotics, including metronidazole, vancomycin (administered orally), or recently approved fidaxomicin. After treatment, repeat Clostridium difficile testing is not recommended if the patients' symptoms have resolved, as patients may remain colonized.

Healthcare facilities should monitor the number of C. difficile infections and, especially if rates at the facility increase, the severity of disease and patient outcomes.

If an increase in rates or severity is observed, healthcare facilities should reassess compliance with core recommended practices as outlined in the CDC Toolkit for Evaluation of Environmental Cleaning for known cases of C. diff infection.

Cohen, et al. (2010) explain that the primary mode of C. difficile transmission resulting in disease is person-to-person spread through the fecal-oral route, principally within inpatient healthcare facilities: “Studies have found that the prevalence of asymptomatic colonization with C. difficile is 7 percent to 26 percent among adult inpatients in acute care facilities and is 5 percent to 7 percent among elderly patients in long-term care facilities. Other studies, however, indicate that the prevalence of asymptomatic colonization may be more on the order of 20 percent to 50 percent in facilities where CDI is endemic. The risk of colonization increases at a steady rate during hospitalization, suggesting a cumulative daily risk of exposure to C. difficile spores in the healthcare setting. Other data suggest that the prevalence of C. difficile in the stool among asymptomatic adults without recent healthcare facility exposure is less than 2 percent.”

According to Cohen, et al. (2010), the usual incubation period from exposure to onset of CDI symptoms is not known with certainty; however, “in contrast to the situation with other multidrug-resistant pathogens that cause healthcare-associated infections, persons who remain asymptomatically colonized with C. difficile over longer periods of time appear to be at decreased, rather than increased, risk for development of CDI.” The researchers note further that the period between exposure to C. difficile and the occurrence of CDI has been estimated in several studies to be a median of two to three days: “This is to be distinguished from the increased risk of CDI that can persist for many weeks after cessation of antimicrobial therapy and which results from prolonged perturbation of the normal intestinal flora. However, recent evidence suggests that CDI resulting from exposure to C. difficile in a healthcare facility can have onset after discharge. The hands of healthcare workers, transiently contaminated with C. difficile spores, are probably the main means by which the organism is spread during non-outbreak periods.”

So as we have seen, transfer of the pathogen to the patient via the hands of healthcare workers is thought to be the most likely mechanism of exposure. Standard isolation techniques intended to minimize enteric contamination of patients, healthcare workers’ hands, patient-care items, and environmental surfaces have been published. Handwashing remains the most effective means of reducing hand contamination. Proper use of gloves is an ancillary measure that helps to further minimize transfer of these pathogens from one surface to another.

Clostridium difficile is shed in feces. Any surface, device, or material (e.g., commodes, bathing tubs, and electronic rectal thermometers) that becomes contaminated with feces may serve as a reservoir for the Clostridium difficile spores. Clostridium difficile spores are transferred to patients mainly via the hands of healthcare personnel who have touched a contaminated surface or item.

C. difficile moves with patients from one healthcare facility to another, infecting other patients. Remember, the 2012 Vital Signs report found that half of all hospital patients with C. difficile infections have the infection when admitted and may spread it within the facility. The most dangerous source of spread to others is patients with diarrhea.

The 2012 Vital Signs report says that despite the numerous challenges, C. difficile infections can be prevented. Early results from hospital prevention projects show 20 percent fewer C. difficile infections in less than two years with infection prevention and control measures.

Clostridium difficile infection be prevented in healthcare settings through the following strategies:

- Use antibiotics judiciously
- Use contact precautions: for patients with known or suspected Clostridium difficile infection:
- Place these patients in private rooms. If private rooms are not available, these patients can be placed in rooms (cohorted) with other patients with Clostridium difficile infection.
- Use gloves when entering patients' rooms and during patient care.
- Perform hand hygiene after removing gloves. Because alcohol does not kill Clostridium difficile spores, use of soap and water is more efficacious than alcohol-based handrubs. However, early experimental data suggest that, even using soap and water, the removal of C. difficile spores is more challenging than the removal or inactivation of other common pathogens. Preventing contamination of the hands via glove use remains the cornerstone for preventing Clostridium difficile transmission via the hands of healthcare workers; any theoretical benefit from instituting soap and water must be balanced against the potential for decreased compliance resulting from a more complex hand hygiene message. If your institution experiences an outbreak, consider using only soap and water for hand hygiene when caring for patients with Clostridium difficile infection.
- Use gowns when entering patients' rooms and during patient care.
- Dedicate or perform cleaning of any shared medical equipment.

- Continue these precautions until diarrhea ceases. Because Clostridium difficile-infected patients continue to shed organism for a number of days following cessation of diarrhea, some institutions routinely continue isolation for either several days beyond symptom resolution or until discharge, depending upon the type of setting and average length of stay.
- Implement an environmental cleaning and disinfection strategy:
  - Ensure adequate cleaning and disinfection of environmental surfaces and reusable devices, especially items likely to be contaminated with feces and surfaces that are touched frequently.
  - Consider using an Environmental Protection Agency (EPA)-registered disinfectant with a sporicidal claim for environmental surface disinfection after cleaning in accordance with label instructions; generic sources of hypochlorite (e.g., household chlorine bleach) also may be appropriately diluted and used. (Note: Standard EPA-registered hospital disinfectants are not effective against Clostridium difficile spores.) Hypochlorite-based disinfectants may be most effective in preventing Clostridium difficile transmission in units with high endemic rates of Clostridium difficile infection.
- Follow the manufacturer's instructions for disinfection of endoscopes and other devices.

In the Clinical Practice Guidelines for Clostridium difficile Infection in Adults, Cohen, et al. (2010) address environmental cleaning and disinfection: "Identification and removal of environmental sources of C. difficile, including replacement of electronic rectal thermometers with disposables, can reduce the incidence of CDI. Use chlorine-containing cleaning agents or other sporicidal agents to address environmental contamination in areas associated with increased rates of CDI. Routine environmental screening for C. difficile is not recommended."

To help control Clostridium difficile, environmental surfaces should be kept clean, and body substance spills should be managed promptly as outlined in CDC's Guidelines for Environmental Infection Control in Health-Care Facilities. Routine cleaning should be performed prior to disinfection. EPA-registered disinfectants with a sporicidal claim have been used with success for environmental surface disinfection in those patient-care areas where surveillance and epidemiology indicate ongoing transmission of Clostridium difficile.

In a section for special pathogens, the Guidelines for Environmental Infection Control in Health-Care Facilities, 2003 emphasizes the challenge of dealing with

C. diff spores: “Normally fastidious in its vegetative state, it is capable of sporulating when environmental conditions no longer support its continued growth. The capacity to form spores enables the organism to persist in the environment (e.g., in soil and on dry surfaces) for extended periods of time. Environmental contamination by this microorganism is well known, especially in places where fecal contamination may occur. The environment (especially housekeeping surfaces) rarely serves as a direct source of infection for patients. However, direct exposure to contaminated patient-care items (e.g., rectal thermometers) and high-touch surfaces in patients’ bathrooms (e.g., light switches) have been implicated as sources of infection.”

The guideline adds, “The degree to which the environment becomes contaminated with C. difficile spores is proportional to the number of patients with C. difficile-associated diarrhea, although asymptomatic, colonized patients may also serve as a source of contamination. Few studies have examined the use of specific chemical germicides for the inactivation of C. difficile spores, and no well-controlled trials have been conducted to determine efficacy of surface disinfection and its impact on healthcare-associated diarrhea. Some investigators have evaluated the use of chlorine-containing chemicals (e.g., 1,000 ppm hypochlorite at recommended use-dilution, 5,000 ppm sodium hypochlorite [1:10 v/v dilution], 1:100 v/v dilutions of unbuffered hypochlorite, and phosphate-buffered hypochlorite [1,600 ppm]). One of the studies demonstrated that the number of contaminated environmental sites was reduced by half, whereas another two studies demonstrated declines in healthcare-associated C. difficile infections in a HSCT unit and in two geriatric medical units during a period of hypochlorite use. The presence of confounding factors, however, was acknowledged in one of these studies. The recommended approach to environmental infection control with respect to C. difficile is meticulous cleaning followed by disinfection using hypochlorite-based germicides as appropriate. However, because no EPA-registered surface disinfectants with label claims for inactivation of C. difficile spores are available, the recommendation is based on the best available evidence from the scientific literature.” Since the writing of this guideline, a number of products with C. diff claims have emerged; infection preventionists are encouraged to investigate manufacturers’ product information and read product labels carefully.

The recommended approach to environmental infection control with respect to C. difficile is meticulous cleaning followed by disinfection using hypochlorite-based germicides as appropriate.

Methicillin-resistant Staphylococcus aureus (MRSA)

Methicillin-resistant Staphylococcus aureus (MRSA) is a type of staph bacteria that is resistant to many antibiotics. In a healthcare setting, MRSA can cause severe problems such as bloodstream infections, pneumonia and surgical site infections. MRSA is usually spread by direct contact with an infected wound or from contaminated hands, usually those of healthcare providers. Also, individuals who carry MRSA but do not have signs of infection can spread the bacteria to others and potentially cause an infection.

MRSA bacteria have many virulence factors that enable them to cause disease. For example, MRSA is a cause of healthcare-associated bloodstream and catheter-related infections. MRSA is also a common cause of community-associated infections, especially skin and soft tissue infections, and can also cause necrotizing pneumonia. MRSA is resistant to first-line antibiotics, leaving clinicians and patients with limited treatment options. IDSA has recent guidelines for treatment of MRSA.

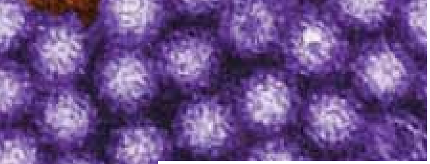
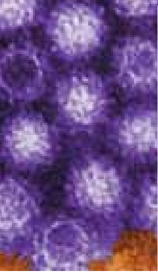
MRSA is primarily spread through direct and indirect contact with infected or colonized patients. Poor adherence to standard infection control precautions such as hand hygiene can lead to transmission between patients and to clusters of infections. Adherence to infection control measures is critical to preventing MRSA outbreaks.

As APIC's Guide to the Elimination of Methicillin-Resistant Staphylococcus aureus (MRSA) Transmission in Hospital Settings (2nd Edition), notes, "Staphylococci, including MRSA, can survive in the hospital environment. In studies by Neely and Huang, staphylococci were recovered for a least one day and up to 56 days after contamination on common hospital materials, and two strains of MRSA survived for nine to 11 days on a plastic patient chart, a laminated tabletop, and a cloth curtain in a hospital. As noted by Dancer, both coagulase negative and positive staphylococci have the ability to survive in the environment regardless of temperature, humidity and sunlight; and when mixed with hospital dust, MRSA can still be revived more than one year after inoculation. People colonized continually shed staphylococci into their environment. Since neither the environment nor equipment are self-cleaning, all reusable medical equipment that contacts patients and or their environment have the potential to become a vehicle for transmission of MRSA."

Regarding transmission of MRSA, APIC's elimination guide explains further, "It been proven that MRSA can survive on common hospital surfaces, and some studies have implicated contaminated hospital surfaces in MRSA acquisition. Hardy et al. found strong evidence to suggest that three of 26 patients who acquired MRSA while in the intensive care unit acquired the organism from the environment. In addition, MRSA was isolated in every environmental room screening done per study protocol. In a study of MRSA environmental contamination in rooms of MRSA patients, Boyce et al5 recovered MRSA from the rooms of 73 percent of infected patients and 69 percent of colonized patients. The authors of both studies concluded that inanimate surfaces in close proximity to infected or colonized patients commonly become contaminated and may become a source of transmission of MRSA. Healthcare workers, patients and visitors contract MRSA by touching contaminated room surfaces. This has major implications for any effort to eliminate the transmission of MRSA in hospital settings. There is an increasing body of evidence demonstrating that healthcare workers contaminate hands or gloves by touching inanimate objects in the immediate vicinity of patients who are colonized or infected with organisms that can survive for prolonged time periods in the environment. It is a recognized principle of standard precautions that healthcare-associated pathogens are frequently spread from one patient to another via the transiently contaminated hands of healthcare workers."

There is an increasing body of evidence demonstrating that healthcare workers contaminate hands or gloves by touching inanimate objects in the immediate vicinity of patients who are colonized or infected with organisms that can survive for prolonged time periods in the environment.

Although MRSA is still a major patient threat, a CDC study published in the *Journal of the American Medical Association Internal Medicine* showed that invasive MRSA infections in healthcare settings are declining. Invasive MRSA infections that began in hospitals declined 54 percent between 2005 and 2011, with 30,800 fewer severe MRS infections. In addition, the study showed 9,000 fewer deaths in hospital patients in 2005 versus 2011. This study complements data from the National Healthcare Safety Network (NHSN) that found rates of MRSA bloodstream infections occurring in hospitalized patients fell nearly 50 percent from 1997 to 2007. Taken together and with other reports such as the March 2011 CDC Vital Signs article and a 2013 study showing a decrease in overall central line-associated bloodstream infections, the CDC says that these studies provide evidence that rates of hospital-onset, severe MRSA infections in the United States are falling. While MRSA remains an important public health problem and more remains to be done to further decrease risks of developing these infections, this decrease in healthcare-associated MRSA infections is encouraging.

Norovirus

Norovirus is the most common cause of acute gastroenteritis as well as gastroenteritis outbreaks, and it can affect nearly everyone in the population particularly because there is no long term immunity to the virus. Because of high levels of contact and vulnerable patient populations, healthcare settings can be particularly susceptible to norovirus outbreaks. Noroviruses (genus Norovirus, family Caliciviridae) are a group of related, single-stranded RNA, non-enveloped viruses that cause acute gastroenteritis in humans. Norovirus is the official genus name for the group of viruses provisionally described as “Norwalk-like viruses.” Currently, human noroviruses belong to one of three norovirus genogroups (GI, GII, or GIV), which are further divided into more than 25 genetic clusters. Additionally, more than 75 percent of confirmed human norovirus infections are associated with genotype GII. The average incubation period for norovirus-associated gastroenteritis is 12 to 48 hours, with a median period of approximately 33 hours. Illness is characterized by nausea, acute-onset vomiting, and watery, non-bloody diarrhea with abdominal cramps. In addition, myalgia, malaise, and headache are commonly reported. Low-grade fever is present in about half of cases. Dehydration is the most common complication and may require intravenous replacement fluids. Symptoms usually last 24 to 60 hours. Up to 30 percent of infections may be asymptomatic.

Noroviruses are highly contagious, with as few as 18 virus particles thought to be sufficient to cause infection. This pathogen is estimated to be the causative agent in more than 21 million gastroenteritis cases every year in the United States, representing approximately 60 percent of all acute gastroenteritis cases from known pathogens. Noroviruses are transmitted primarily through the fecal-oral route, either by direct person-to-person spread or fecally contaminated food or water. Noroviruses can also spread via a droplet route from vomitus. These viruses are relatively stable in the environment and can survive freezing and heating to 60 degrees C (140 degrees F). In healthcare facilities, transmission can also occur through hand transfer of the virus to the oral mucosa via contact with materials, fomites and environmental surfaces that have been contaminated with either feces or vomitus.

Norovirus infections are seen in all age groups, although severe outcomes and longer durations of illness are most likely to be reported among the elderly. Among hospitalized persons who are immuno-compromised or have significant medical co-morbidities, norovirus infection can directly result in prolonged hospital stays, additional medical complications, and, rarely, death. There is currently no vaccine available for norovirus and, generally, no specific medical treatment is offered for norovirus infection apart from oral or intravenous repletion of volume. The ease of its transmission, a very low infectious dose, a short incubation period, environmental persistence, and lack of durable immunity following infection enables norovirus to spread rapidly through confined populations. Healthcare facilities and other institutional settings (e.g., daycare centers, schools, etc.) are particularly at-risk for outbreaks because of increased person-to-person contact. Healthcare facilities managing outbreaks of norovirus gastroenteritis may experience significant costs relating to isolation precautions and personal protective equipment, ward closures, supplemental environmental cleaning, staff cohorting or replacement, and sick time.

> Healthcare facilities managing outbreaks of norovirus gastroenteritis may experience significant costs relating to isolation precautions and personal protective equipment, ward closures, supplemental environmental cleaning, staff cohorting or replacement, and sick time.

It's common sense, but it bears repeating — Avoid exposure to vomitus or diarrhea, as these are reservoirs for norovirus. Place patients on contact precautions (CP) in a single occupancy room if they present with symptoms consistent with norovirus gastroenteritis; they should be on CP for a minimum of 48 hours after the resolution of symptoms. If norovirus infection is suspected, adherence to personal protective equipment (PPE) use according to Contact and Standard Precautions is recommended for individuals entering the patient care area (i.e., gowns and gloves upon entry). Use a surgical or procedure mask and eye protection or a full face shield if there is an anticipated risk of splashes to the face during the care of patients, particularly among those who are vomiting. According to the CDC's Guideline for the Prevention and Control of Norovirus Gastroenteritis Outbreaks in Healthcare Settings, more research is needed to evaluate the utility of implementing universal gloving (e.g., routine use of gloves for all patient care) during norovirus outbreaks. No recommendation is made and it remains an unresolved issue.

When symptomatic patients cannot be accommodated in single occupancy rooms, efforts should be made to separate them from asymptomatic patients. These efforts may include placing patients in multi-occupancy rooms, or designating patient care areas or contiguous sections within a facility for patient cohorts.

Additionally, to underscore the aforementioned practices, healthcare workers who have recovered from recent suspected norovirus infection associated with an outbreak may be best suited to care for symptomatic patients until the outbreak resolves. Also consider the following precautions to help curb the potential spread of norovirus to the larger healthcare environment:

- Minimize patient movements within a ward or unit during norovirus outbreaks
- Restrict symptomatic and recovering patients from leaving the patient-care area unless it is for essential care or treatment
- Suspend group activities, such as events where food will be served, for the duration of a norovirus outbreak.
- Consider the closure of wards to new admissions or transfers as a measure to attenuate the magnitude of a norovirus outbreak.
- Consider limiting transfers to those for which the receiving facility is able to maintain contact precautions; otherwise, it may be prudent to postpone transfers until patients no longer require contact precautions. During outbreaks, medically suitable individuals recovering from norovirus gastroenteritis can be discharged to their place of residence.

According to the CDC's Guideline for the Prevention and Control of Norovirus Gastroenteritis Outbreaks in Healthcare Settings, further research is needed to understand the correlation between prolonged shedding of norovirus and the risk of infection to susceptible patients. In their literature review conducted for the crafting of the CDC norovirus guideline, HICPAC members found high-quality evidence to demonstrate the presence of viral shedding in asymptomatic subjects, and low-quality evidence demonstrating that shedding can persist for up to 22 days following infection and five days after the resolution of symptoms. They did not identify studies that correlated other clinical factors to duration of viral shedding. For now, there is no recommendation and it remains an unresolved issue.

It is important to actively promote adherence to hand hygiene among healthcare workers, patients, and visitors in patient-care areas affected by outbreaks of norovirus gastroenteritis. During outbreaks, use soap and water for hand hygiene after providing care or having contact with patients suspected or confirmed with norovirus gastroenteritis. For all other hand hygiene indications refer to the 2002 HICPAC Guideline for Hand Hygiene in Health-Care Settings.

Consider ethanol-based hand sanitizers (60 percent to 95 percent) as the preferred active agent compared to other alcohol or non-alcohol based hand sanitizer products during outbreaks of norovirus gastroenteritis. Further research is required to directly evaluate the efficacy of alcohol-based hand sanitizers against human strains of norovirus, or against a surrogate virus with properties convergent with human strains of norovirus. According to the CDC's Guideline for the Prevention and Control of

Norovirus Gastroenteritis Outbreaks in Healthcare Settings, more research is required to evaluate the virucidal capabilities of alcohol-based as well as non-alcohol based hand sanitizers against norovirus.

Consider limiting transfers to those for which the receiving facility is able to maintain contact precautions; otherwise, it may be prudent to postpone transfers until patients no longer require contact precautions. Consider the closure of wards to new admissions as a measure to attenuate the magnitude of an outbreak of norovirus gastroenteritis. The threshold for ward closure varies and depends on risk assessments by infection prevention personnel and facility leadership. Implement systems to designate patients with symptomatic norovirus and to notify receiving healthcare facilities or personnel prior to transfer of such patients within or between facilities. During outbreaks, medically suitable individuals recovering from norovirus gastroenteritis can be discharged to their place of residence.

It cannot be overstated that rigorous and proper environmental cleaning is a key way to control and prevent norovirus from proliferating and spreading throughout a healthcare facility. Clean surfaces and patient equipment prior to the application of a disinfectant. Clean and disinfect shared equipment between patients using EPA-registered products with label claims for use in healthcare. Follow the manufacturer's recommendations for application and contact times. The EPA lists products with activity against norovirus on their website.

Perform routine cleaning and disinfection of frequently touched environmental surfaces and equipment in isolation and cohorted areas, as well as high-traffic clinical areas. Frequently touched surfaces include, but are not limited to, commodes, toilets, faucets, hand/bedrailing, telephones, door handles, computer equipment, and kitchen preparation surfaces.

Increase the frequency of cleaning and disinfection of patient-care areas and frequently touched surfaces during outbreaks of norovirus gastroenteritis (e.g., increase ward/unit level cleaning twice daily to maintain cleanliness, with frequently touched surfaces cleaned and disinfected three times daily using EPA-approved products for healthcare settings).

Clean and disinfect surfaces starting from the areas with a lower likelihood of norovirus contamination (e.g., tray tables, counter tops) to areas with highly contaminated surfaces (e.g., toilets, bathroom fixtures). Change mop heads when new solutions are prepared, or after cleaning large spills of emesis or fecal material.

Consider discarding all disposable patient-care items and laundering unused linens from patient rooms after patients on isolation for norovirus gastroenteritis are discharged or transferred. Facilities can minimize waste by limiting the number of disposable items brought into rooms/areas on contact precautions. No additional provisions for using disposable patient service items such as utensils or dishware are suggested for patients with symptoms of norovirus infection. Silverware and dishware may undergo normal processing and cleaning using standard procedures.

Handle soiled linens carefully, without agitating them, to avoid dispersal of virus. Use Standard Precautions, including the use of appropriate PPE (e.g., gloves and gowns), to minimize the likelihood of cross-contamination. Double-bagging, incineration, or modifications for laundering are not indicated for handling or processing soiled linen.

Consider changing privacy curtains routinely and/or when they are visibly soiled, and upon patient discharge or transfer.

Consider avoiding the use of upholstered furniture and rugs or carpets in patient care areas, as these objects are difficult to clean and disinfect completely. If this option is not possible, immediately clean soilage, such as emesis or fecal material, from upholstery, using a manufacturer-approved cleaning agent or detergent. Opt for seating in patient-care areas that can withstand routine cleaning and disinfection.

> It cannot be overstated that rigorous and proper environmental cleaning is a key way to control and prevent norovirus from proliferating and spreading throughout a healthcare facility.

Consider steam cleaning of upholstered furniture in patient rooms upon discharge. Consult with manufacturer's recommendations for cleaning and disinfection of these items. Consider discarding items that cannot be appropriately cleaned/disinfected.

According to the CDC's Guideline for the Prevention and Control of Norovirus Gastroenteritis Outbreaks in Healthcare Settings, more research is required to clarify the effectiveness of cleaning and disinfecting agents against norovirus, either through the use of surrogate viruses or the development of human norovirus culture system. In addition, further research is required to clarify the effectiveness and reliability of fogging, UV irradiation and ozone mists to reduce norovirus environmental contamination.

There are areas that need further study. The authors of the CDC's Guideline for the Prevention and Control of Norovirus Gastroenteritis Outbreaks in Healthcare Settings emphasize that the literature review conducted for this guideline revealed that many of the studies addressing strategies to prevent norovirus gastroenteritis outbreaks in healthcare facilities were not of sufficient quality to allow firm conclusions regarding the benefit of certain interventions. Future studies of norovirus gastroenteritis prevention in healthcare settings should include:

1. Analyses of the impact of specific or bundled infection control interventions
2. Use of controls or comparison groups in both clinical and laboratory trials
3. Comparisons of surrogate and human norovirus strains, focusing on the differences in their survival and persistence after cleaning and disinfection, and compare the natural history of disease in animal models to that in human norovirus infections
4. Assessment of healthcare-focused risk factors (e.g., the impact of isolation versus cohorting practices, duration of isolation, hand hygiene policies during outbreaks of norovirus, etc.)
5. Statistically powerful studies able to detect small but significant effects of norovirus infection control strategies or interventions
6. Quantitative assessments of novel, and practical methods for effective cleaning and disinfection during norovirus outbreaks

Pseudomonas aeruginosa

Pseudomonas infection is caused by strains of bacteria found widely in the environment; the most common type causing infections in humans is called Pseudomonas aeruginosa. Serious Pseudomonas infections usually occur in people in the hospital and/or with weakened immune systems. Infections of the blood, pneumonia, and infections following surgery can lead to severe illness and death in these people. However, healthy people can also develop mild illnesses with Pseudomonas aeruginosa, especially after exposure to water. Patients in hospitals, especially those on breathing machines, those with devices such as catheters, and patients with wounds from surgery or from burns are potentially at risk for serious, life-threatening infections. Pseudomonas aeruginosa accounts for 10 percent of all hospital-acquired infections. Specifically, this bacterium is the second most frequently recovered pathogen from ICU patients.

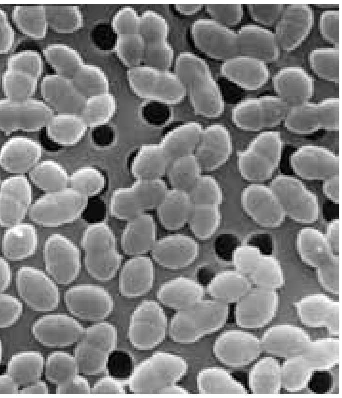
In hospitals, where the most serious infections occur, Pseudomonas can be spread on the hands of healthcare workers or by equipment that gets contaminated and is not properly cleaned. In the hospital, careful attention to routine infection control practices, especially hand hygiene and environmental cleaning, can substantially lower the risk of infection. Outside the hospital, avoid hot tubs or pools that may be poorly maintained, and keep contact lenses, equipment, and solutions from becoming contaminated.

Notably, Pseudomonas aeruginosa can survive from six hours to 16 months on dry, inanimate surfaces in hospitals.

Pseudomonas infections are generally treated with antibiotics. Unfortunately, in hospitalized patients, Pseudomonas infections, like those caused by many other hospital bacteria, are becoming more difficult to treat because of increasing antibiotic resistance. Selecting the right antibiotic usually requires that a specimen from a patient be sent to a laboratory to test to see which antibiotics might still be effective for treating the infection.

Prevention of Pseudomonas aeruginosa infection includes:

- Prevent exposure through water testing and disinfection.
- Maintain good hygiene and handwashing practice
- Minimize unnecessary antibiotic use
- Use sterile medicated solutions
- Minimize the use of medical devices



Vancomycin-Resistant Enterococci (VRE)

Enteroccocci are bacteria that are normally present in the human intestines and in the female genital tract and are often found in the environment. These bacteria can sometimes cause infections. Vancomycin is an antibiotic that is used to treat some drug-resistant infections caused by enterococci. In some instances, enterococci have become resistant to this drug and thus are called vancomycin-resistant enterococci (VRE). Most VRE infections occur in hospitals. VRE can live in the human intestines and female genital tract without causing disease, referred to as colonization. However, sometimes it can cause infections of the urinary tract, the bloodstream, or of wounds associated with catheters or surgical procedures.

Persons at increased risk for VRE include: those who have been previously treated with the antibiotic vancomycin or other antibiotics for long periods of time; people who are hospitalized, particularly when they receive antibiotic treatment for long periods of time; people with weakened immune systems such as patients in intensive care units, or in cancer or transplant wards; people who have undergone surgical procedures such as abdominal or chest surgery people with indwelling medical devices that stay in for some time such as urinary catheters or central intravenous (IV) catheters; and individuals who are already colonized with VRE.

VRE is often passed from person to person by the contaminated hands of caregivers. VRE can get onto a caregiver's hands after they have contact with other people with VRE or after contact with contaminated surfaces. VRE can also be spread directly to people after they touch surfaces that are contaminated with VRE. VRE is not spread through the air by coughing or sneezing.

The spread of VRE can be kept in check with the following strategies:

- Keep hands clean. Always wash hands thoroughly after using the bathroom and before preparing food. Clean hands after contact with persons who have VRE. Wash with soap and water (particularly when visibly soiled) or use alcohol-based handrubs.
- Frequently clean areas, such as bathrooms, that may become contaminated with VRE.
- Wear gloves if hands may come in contact with body fluids that may contain VRE, such as stool or bandages from infected wounds. Always wash hands after removing gloves.
- Healthcare facilities must use special precautions to help prevent the spread of VRE to others.

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