Initiatives in Safe Patient Care

Enhancing patient safety through improved surveillance

Numerous studies have shown that hospital surfaces and frequently used medical equipment become contaminated by a variety of pathogenic and nonpathogenic organisms. The hands and gloves of healthcare workers readily acquire pathogens after contact with contaminated hospital surfaces and can transfer these organisms to subsequently touched patients and inanimate surfaces. The acquisition of nosocomial pathogens by a patient and the resultant development of infection depend on a multifaceted interplay between the environment, a pathogen and a susceptible host. In her article, Ms. Arias discusses several epidemiologically important pathogens that are common causes of HAIs, in particular the role of noncritical patient care items and environmental surfaces in the transmission. She also addresses strategies for reducing the risk of transmission of these pathogens, based on established guidelines.

A panel of experts discusses current strategies for reducing microbial contamination of hospital surfaces and medical equipment.

Contamination and Cross Contamination on Hospital Surfaces and Medical Equipment

Continuing Education for Nurses (CE) and Respiratory Therapists (CRCE)

Kathleen Meehan Arias, MS, CIC

The role of medical devices, such as bronchoscopes, in the transmission of healthcare-associated infections (HAIs) has long been recognized, however, the evidence that environmental and medical equipment surfaces play a role in the transmission of HAIs has been weak. Studies have demonstrated that pathogens can be transmitted from surfaces to personnel and patients, and that these pathogens are not adequately removed by routine room cleaning. This has led to an increased focus on the importance of cleaning and disinfecting hospital surfaces and medical equipment and efforts to assess and improve the effectiveness of these practices.

Microorganisms on Hospital Surfaces and Medical Equipment

Numerous studies have shown that hospital surfaces and frequently used medical equipment become contaminated by a variety of pathogenic and nonpathogenic organisms.[1,2] Common human pathogens, such as methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus* (VRE), *Clostridium difficile, Acinetobacter* species, and noroviruses can survive for prolonged periods on hospital surfaces and fomites as shown in Table 1.[2] Fomites are inanimate objects that can potentially transmit infectious organisms. However, the role of fomites and the inanimate hospital environment (e.g. surfaces and medical equipment) in the transmission of HAIs is controversial.[3,4]

Table 1. Persistence of clinically relevant organisms on dry inanimate surfaces.[2]

Organism	duration of persistence (range)
Acinetobacter spp.	3 days - 5 months
Clostridium difficile (spores)	5 months
Escherichia coli	1.5 hours - 16 months
Enterococcus spp, including VRE	5 days - 4 months
Influenza virus	1 – 2 days
Norovirus and feline calici virus	8 hours – 7 days
Staphylococcus aureus, including MRSA	7 days – 7 months

Adapted from: Kramer A, Scwebke I, Kampf G. How long do nosocomial pathogens persist on inanimate surfaces? A systematic review. BMC Infectious Diseases 2006;6:130. Used with permission.

Types of Hospital Surfaces and Medical Equipment

Medical devices, equipment and items used in hospitals can be categorized as "critical," "semi-critical," and "noncritical."[5] Critical items are objects that enter sterile tissue or the vascular system and must be sterile because they carry a high risk for infection if they are contaminated with microorganisms.[5] This category includes surgical instruments and vascular and urinary catheters. Most of the items in this category are purchased sterile or processed using a sterilizer in a centralized location in the hospital. Semi-critical items come in contact with mucous membranes or non-intact skin and include respiratory therapy and anesthesia equipment, laryngoscope blades, bronchoscopes and some endoscopes. These items can readily transmit infectious agents and should be free of all microorganisms, although small numbers of bacterial spores are permissible.[5] Semi-critical items should be cleaned meticulously and disinfected with a high-level disinfectant between use on patients.

Noncritical items are objects or surfaces that come in contact with intact skin but not mucous membranes.[5] Noncritical patient care items contact intact skin during routine use and include bedpans, blood pressure cuffs, stethoscopes, pulse oximetry sensors and ultrasound transducers. These items have been said to pose virtually no risk "when they are used as noncritical items and do not contact non-intact skin and/or mucous membranes."[5] Oximetry sensors are frequently used on

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Panel Discussion:

Infection Prevention : *Contamination and Cross Contamination on Hospital Surfaces and Medical Equipment*

Moderator: Kathleen Arias, *MS, CIC*
Panelists: Alice Neely, *PhD, FAAM, FIDSA*
John Davies, *MS, RRT, FAARC*
Janet Haas, *DNSc*
William Jarvis *MD*

What is the clinical evidence for the role of surfaces in healthcare-associated infections? While the role of medical devices has long been recognized, the evidence that environmental surfaces, including the surfaces of medical equipment, play a role in the transmission of infection has been much debated. This panel of experts was asked to discuss current strategies for reducing microbial contamination of hospital surfaces and medical equipment.

Why is there an increased focus on cleaning and disinfecting hospital surfaces and medical equipment?

Davies: A group of organisms has been implicated in an alarming increase in intensive care unit (ICU) related nosocomial infections over the past decade. Among these are *Clostridium difficile* (CD), Methicillin-resistant *Staphylococcus aureus* (MRSA), Vancomycin-resistant *Enterococcus* (VRE), *Acinetobacter spp*, and members of the norovirus family. One of the reasons for the increased disease prevalence from these organisms is the bacterial groups are more rapidly developing resistance to one or more antibiotics used in the treatment of their disease processes.

Haas: There is an increasing body of literature that shows the role of the environment in transmission of infection. For example, there is a greater risk of infection with various drug-resistant organisms and *C. difficile* for patients who are housed in rooms previously occupied by others with these organisms. In addition, surface cleaning is not done as well as protocols suggest.[1,2,3,4] The revelation that cleaning is not done consistently and that drug-resistant organisms can be recovered from hospital surfaces has brought about an awareness of the role of these areas in disease transmission.

Neely: There are 3 main ways of preventing/controlling infections: (1) cleaning and disinfection, (2) contact control and behavioral modalities, such as hand hygiene, and (3) the use of antimicrobial treatment agents. Whereas antibiotics should not be a primary means of preventing infections, they have been used to control them. In the past, healthcare workers have recognized that proper cleaning and disinfection coupled with meticulous contact controls can prevent infections. However, whenever these processes failed, they could always control the infection with an antibiotic. Today, with highly antibiotic-resistant microorganisms, this primary means of controlling infection is no longer available. Hence, now there is an increased focus on the remaining tools that are available for preventing infection, i.e. cleaning and disinfection and better compliance with behavioral practices. In addition, there is mounting pressure to decrease medical costs. The recognition that healthcare associated infections (HAIs) are expensive has led to increased investigation of causes of HAIs and of means of preventing them. There are many reports of contaminated medical equipment and surfaces leading to outbreaks, thereby providing another reason for increased focus on cleaning and disinfection.[5-11]

Jarvis: The transmission of two common HAI pathogens illustrates the importance of the environment in HAI prevention. *C. difficile*- or VRE-colonized patients contaminate their environment, leading to subsequent transmission of these pathogens to patients. Recent outbreaks of the *C. difficile* strain known as the North American Pulsefield Type 1 (or NAP 1 strain) have illustrated the critical importance of environmental cleaning in preventing *C. difficile* associated disease (CDAD). As noted by my fellow panelists, with the emergence of every more resistant pathogens, enhanced environmental cleaning is a critical for preventing infections.

What relative roles do environmental surfaces, medical items, and semi-critical items play in the transmission of infection?

Davies: Environmental surfaces act as a reservoir for bacterial and viral gathering and proliferation. These organisms can be expelled from an infected or colonized patient either through direct contact, aerosol droplets, or feces. *C. difficile* has been shown to last 5 months on hospital floors.[12] It has also been found on shoes and stethoscopes of healthcare workers.[13] MRSA can live on plastic laminate surfaces for 2 days and can spread rapidly through contact.[14] VRE can survive on gowns of health care workers as well as medical equipment, bed rails, counters, bedside tables and sheets.[15,16] One study showed that VRE could live for up to 58 days on countertops.[17] *A. baurmannii* survival can last for up to 33 days on plastic laminate surfaces.[18] As cell phone use becomes more widespread in the hospital setting, we must consider them as a possible source for cross contamination.[19] Noroviruses can also contaminate the environment, persist after drying and may even become re-aerosolized during floor sweeping. Certainly, they have been implicated in the 9 outbreaks on cruise ships in 2002. Noroviruses can survive on carpets for up to 12 days.[20] The advent of molecular epidemiology is helping with a better understanding of the role of the environment in nosocomial infection by confirming that environmental isolates are the same as patient isolates.

Haas: There is now good evidence that staying in a room following someone with *C. difficile* or MRSA increases the risk of becoming colonized or infected with these organisms. There is less specific data about stethoscopes or oximetry sensors as specific sources of infection, but they are likely vectors, especially because they are used on many patients. These items may be higher risk than semi-critical items because they are so widely used. In addition, semi-critical items are subject to specific monitored processes for high level disinfection. There can be failures of high level disinfection, but in general these processes are something that institutions (at least inpatient institutions) monitor closely. The laryngoscope blade is likely less of a problem than the handle, which is an item that requires low level disinfection. In general, high level disinfection has come under more scrutiny and has more stringent process control than cleaning and low level disinfection.

Neely: Environmental surfaces and semi-critical items have been implicated in the transmission of infections. Relatively speaking, the ICU patient will be more susceptible to infection because of possible breaks in their skin due to trauma or surgery, indwelling medical devices, or general immunosuppression due to disease state or chemotherapy. For these patients, a lower inoculum of microbes can cause an infection and microbes that are normally not pathogenic to healthy individuals can cause an infection. Hence the contaminated item in the ICU could play a more significant role in the transmission of infection to this population.

Jarvis: No studies have adequately assessed the relative role of the environment versus other modes of transmission of HAI pathogens. Furthermore, the relative importance of the environment in HAI pathogen transmission varies by the specific HAI pathogen. It is clear that for *C. difficile* (where spores rather than vegetative forms can survive for long periods in the environment and can be difficult to eradicate) and VRE, the environment plays a large and important role in transmission. For

MRSA, the environment was thought to be of relatively little importance, except in burn units where the environment[21] was contaminated by MRSA-caring skin squames. However, more recent data suggest that MRSA can contaminate the environment around infected or colonized patients. Thus the environment may play a larger role in MRSA transmission than previously thought, albeit less than healthcare worker hand hygiene. In general, the environment plays a larger role in transmission of Gram-negative than Gram-positive pathogens. Contamination of inanimate objects, particularly those taken from patient to patient increases the risk of colonization of the patient and of subsequent infection.

Why is good hand hygiene, including the use of gloves, so essential in preventing the transmission of infection via surfaces and medical equipment? What can personnel do to prevent the transmission of infection in the ICU?

Davies: Since the organisms use the environment as a reservoir, it is imperative that adherence to hand hygiene protocols be followed. The use of universal precautions, especially gloves and gowns, is an important tool in the prevention of nosocomial infection, however, gowns and gloves can become contaminated as well so healthcare workers must be prudent in their disposal. Effective disinfection of the ICU room, medical equipment and environment must take place. To add insult to injury, some strains of bacteria can be more virulent and resistant to normal cleaning methods. Cleaning products containing chlorine appear to be most effective.

Haas: Since it's known that surfaces are contaminated, it is essential to promote hand hygiene immediately before patient contact, and after contact with the environment, even when the patient is not touched. Healthcare workers remember to protect themselves after tasks that involve gross soiling, contact with feces, etc. However, we are not as cognizant of germs on surfaces as we are on patient charts, IV control panels and other frequently touched items. Many hospitals have put equipment cleaning wipes in patient care areas to make spot cleaning of equipment and surfaces easy. Frequent feedback and illustrations of the places that pathogens are found can help raise awareness, and convenient location of cleaning supplies along with the expectation that all staff members are responsible for keeping a clean environment can help improve healthcare cleanliness. As with most other aspects of good patient care, leadership is important.

Neely: Besides proper hand hygiene, good contact control is essential for preventing the transmission of organisms. Microorganisms evade us because they are invisible, and many of the currently problematic microbes (staphylococci, enterococci, Acinetobacter, Clostridium) survive longer than some other organisms on what appear to be completely clean surfaces.[21-23] Because we can't see them, it is easy to forget that they are there. Training personnel to control something that we can't see, and that the only way to do this is to think in terms of good contact control and good work habits is essential.

> Single patient use devices and equipment can help reduce potential cross contamination
>
> - Davies -

Jarvis: In every patient's room, the environment and inanimate objects are contaminated with potential HAI pathogens, regardless of the efficacy of environmental or inanimate object cleaning. Thus, hand hygiene still is critical for patient safety. To prevent HAI transmission, healthcare personnel should insure that they rigorously adhere to recommendations for hand hygiene and that the patient's environment is clean, clutter free, and they should minimize sharing of medical equipment between patients. When sharing of medical equipment between patients is essential, then they should insure that the equipment is appropriately cleaned and disinfected.

Since studies show that cleaning often fails to remove pathogens, what can be done to improve the efficacy of cleaning and disinfection practices for hospital surfaces and medical equipment?

Haas: New technologies are starting to emerge that can be adjunctive to cleaning. For example, there are now antimicrobial hospital curtains and door handles. If these work, they may play an important role, because even when cleaning is excellent, recontamination may occur shortly thereafter. In addition, there are environmental foggers and disinfectors that use hydrogen peroxide[24,25] or ultraviolet light[26] that can be helpful. These are used at discharge or overnight as patients cannot be in the room when the machines are in use. The down side to these technologies is that they add time to turnover procedures and do not replace cleaning.

Neely: First, be sure that appropriate products are being used appropriately.[27] Surfaces should be clean before they are disinfected; this entails either disinfection after cleaning or the use of a combination cleaner/disinfectant product. The entire surface must come in contact with the product and stay in contact for the recommended contact time, which can be as long as 10 minutes for some products to act against certain microbes. Secondly, recognize that some devices can not be readily disinfected. Nooks and crannies may be great for English muffins, but they are problematic for disinfecting medical equipment. It may be best to re-engineer these devices so they can be easily disinfected[28] or to review equipment/furnishings for cleaning/disinfecting practicality before purchase. Veto purchasing a cloth upholstered chair for the ICU room; it will be impossible to readily disinfect.

Jarvis: Given the critical importance of environmental cleaning in preventing HAI transmission, it is unfortunate that this component of infection prevention often gets little attention. Often, environmental personnel are the least educated, lowest paid personnel with very high turnover rates. Environmental services personnel should all receive education about HAI prevention at the time of hire and in-service. Didactic lectures are not sufficient. Visual training of how they should clean the environment and medical equipment should be provided. Videos can be helpful. They should then be asked to clean a room after glow-germ has been applied to important environmental surfaces. A black light can show them how well they've done. In addition, having personnel do a hand culture, with and without hand hygiene, can illustrate the extent to which invisible pathogens are on their hands.

How can we monitor and assess the adequacy of cleaning and disinfection practices?

Davies: An appropriate surveillance program is key to optimizing the cleaning practices of institutions. Reinforcing the importance of routine cleaning measures will most certainly lead to less surface contamination and ultimately cross contamination. Educational intervention in combination with ongoing performance feedback is required to achieve optimal disinfection results. In the present economic environment suboptimal staffing can present a formidable barrier to allow for the appropriate amount of time to effectively sanitize patient environments. An institution must be aware of this potentiality and be prepared to deal with this scenario.

Haas: Cleaning and disinfection have traditionally been monitored by supervisors using visual inspection and/or checklists. However, recent studies using trace contamination detectable by ultraviolet light have shown that visualization is not sensitive enough to detect areas that have not been cleaned.[4] There are now devices that measure adenosine triphosphate (ATP) as a surrogate for bioburden and bacteria. These technologies can help to monitor the cleaning process and to illuminate what has been missed as part of the staff education process. ATP devices may not respond accurately when bleach products are used, so care must be taken to match the monitoring process to the products used for cleaning.

Neely: We can follow infection rates, but if no action is taken until these rates rise, then the "horse is out of the barn" and we are in a very reactive mode. Proactive measures are preferable and could include checking with the Environmental Services manager to be sure appropriate cleaners and disinfectants are being used. Most hospitals buy disinfectant as a concentrate and dilute it using automatic diluting machines. Check the QA for those machines. Observe a staff person as they disinfect a room to be sure all surfaces are adequately covered with disinfectant, that cleaning cloths are changed appropriately, etc. If appropriate resources are available, then monitoring the environment for microbes using microbiologic culturing or molecular techniques can be very helpful, but care needs to be taken in properly collecting the samples and interpreting the results.

What role do single-use devices such as sensors, leads, etc. play in reducing the transmission of infection?

Davies: Single-patient use devices and equipment can help reduce potential cross contamination due to sub-optimal cleaning associated with medical equipment that is used from patient to patient. However, the cost of single-use devices tends to be higher than equipment that is reused. So, a balance must be realized. An institution must evaluate the cost associated with a superimposed, nosocomial infection versus the use of single-patient use devices. The problem with this type of comparison is that it is difficult to specifically identify outcome data due to the number of confounding variables that exist in the ICU setting in terms of cross contamination.

Haas: Single-use devices, if used for only one patient, can help to reduce the risk of transmission of infection. There may be items such as EKG leads used on patients with significant skin loss or surgical wounds that provide a critical measure of safety for patients. However, there are some significant drawbacks to using disposable items. The cost of buying and disposing of single-use devices can become substantial, and this perpetuates a wasteful, non-green healthcare setting. When reusable items are selected, consideration to how they will be cleaned, and by whom, must be addressed and budgeted. This has sometimes been overlooked in the purchasing process. Another issue is that disposable items must fit into the work flow. For example, some institutions give each patient a single patient blood pressure (BP) cuff, but if you watch staff take BPs, they don't usually use them. The work process would be to perform hand hygiene, find the patient's cuff, attach it to the machine, take/document the BP, detach the cuff and then go on to the next patient. Given the patient load and job demands, the staff member is more likely to keep the same cuff on the sphygmomanometer when going from patient to patient (and they are not likely to clean it each time). Another new item is a paper band that is meant to be placed between the patient's skin and the BP cuff; again, the process of using these items is too cumbersome to fit into the work flow.

Neely: Contaminated probes, pulse oximeters, etc have been implicated in the transmission of infections.[9-11] Leads, sensors, probes, etc can be very difficult to disinfect. First it can be time-consuming to wipe off, for example, each lead of an EKG that might touch a patient or the patient's clothes. Secondly, some of these little devices may have the notorious nooks and crannies that are difficult to get into to clean. Third, many of these devices have components that could be damaged by the disinfectant. For example, bleach-based products are often recommended for disinfecting *C. difficile* or MDROs, yet bleach can be very corrosive to metal components. Single-use devices eliminate the problem of trying to disinfect while not damaging these delicate components.

Jarvis: No studies have adequately assessed the degree to which HAI pathogens are transmitted by sensors, EKG leads, etc. Overall, their role may be relatively minor. Nevertheless, the more single-use items can be used, the less the risk of any HAI pathogen transmission. If sharing of such devices can be done with adequate disinfection between patients, the risk of HAI transmission is minimal. On the other hand, if such cleaning and disinfection cannot be assured between patient uses, then use of single-use devices is preferred.

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sites that can be dry and cracked and this increases the possibility of transmission of microorganisms. Improperly applied sensors can cause abrasions such as pressure sores, as well as skin breakdown. This is particularly important in a burn unit or NICU where patients have poor skin integrity. For this reason, oximetry sensors that contact nonintact skin should either be meticulously cleaned and disinfected with an intermediate-level disinfectant or single use.

Noncritical environmental surfaces can be divided into housekeeping surfaces (such as bed rails, bedside tables, walls and floors) and the surfaces of medical and electronic equipment (such as ventilators, IV poles, and computer equipment). Noncritical items and environmental surfaces can be cleaned and disinfected with low- or intermediate-level disinfectants.

Pathogens Linked to Transmission

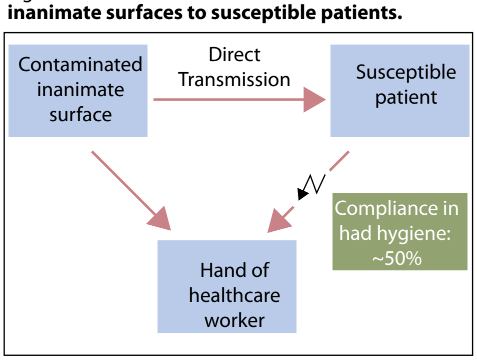
It is difficult to directly link noncritical hospital surfaces and medical equipment to infection transmission. The role of fomites and the inanimate hospital environment in the transmission of infection has been debated for many years, however, there is increasing evidence that contaminated inanimate surfaces, especially those frequently touched by hand, can contribute to the spread of healthcare-associated pathogens.[2,6] Transmission can occur either indirectly when a healthcare worker's hands or gloves become contaminated by touching contaminated surfaces after which they touch patients, or when a patient comes in direct contact with a contaminated surface, as illustrated in Figure 1.[2]

Pathogens that have been linked to transmission via contaminated environmental surfaces and medical equipment include MRSA, VRE, *Clostridium difficile, Acinetobacter spp* and norovirus. Except for norovirus, these organisms pose clinically important antimicrobial resistance problems and are among the most common causes of HAIs in intensive care units.[7,8]

Methicillin-resistant Staphylococcus aureus

HAIs caused by MRSA result in considerable morbidity and mortality. *Staphylococcus aureus* was the most common pathogen associated with HAIs reported to the National Healthcare Safety Network (NHSN) from January 2006 to October 2007. A total of 56% of the *S. aureus* isolates from device-associated HAIs (central line associated bloodstream infections, ventilator-associated pneumonia, and catheter-associated urinary tract infections) were MRSA.[7] The primary reservoirs for MRSA in the hospital are colonized or infected patients[9] who readily contaminate medical and electronic equipment and the environment in their vicinity.[10-15] MRSA can survive on dry environmental surfaces for several months.[2]

Figure 1. **Common modes of transmission from inanimate surfaces to susceptible patients.**



From: Kramer A, Scwebke I, Kampf G. How long do nosocomial pathogens persist on inanimate surfaces? A systematic review. BMC Infectious Diseases 2006;6:130. http://www.biomedcentral.com/1471-2334/6/130

Although the major mode of transmission to patients is via the transiently colonized hands of healthcare workers[16], there is some evidence that exposure to MRSA-contaminated environments can result in patient acquisition of MRSA.[13,17] In a prospective study conducted in a 9-bed intensive care unit, widespread contamination of environmental surfaces by MRSA was detected. Detailed epidemiological typing of environmental and patient isolates revealed a variety of pulsed field gel electrophoresis profiles.[13] During the study, 26 patients became colonized with MRSA while in the ICU and 14 of those acquired the organism when no other patients colonized with the same type of MRSA were present. Three of these 14 patients acquired MRSA within 10 days of the same type being isolated from the environment. The investigators concluded that there was strong evidence to suggest that 3 of 26 patients who became colonized with MRSA while in the ICU acquired MRSA from the environment.[13] Preventing colonization of patients is an important prevention measure for MRSA infection because a substantial proportion of patients who become colonized will become infected.[18]

Vancomycin-resistant Enterococcus

The enterococci are normal flora in the gastrointestinal tract and are intrinsically resistant to many antibiotics. Many have acquired resistance to penicillins, aminoglycosides, and glycopeptides. Vancomycin-resistant *Enterococcus faecalis* and *Enterococcus faecium* are major causes of HAIs. In fact, *Enterococcus* is the third most common pathogen associated with HAIs reported to the NHSN – 33% of the isolates from device-associated infections were VRE.[7] Infections caused by VRE are associated with increased morbidity, mortality, and hospital costs when compared to infections caused by vancomycin-sensitive *Enterococcus.*[19] Patients who acquire VRE are at significant risk of developing invasive disease.[17]

The primary reservoirs for VRE in the hospital are colonized or infected patients and these patients frequently contaminate medical equipment and the environment in their surrounding area.[2,17,19,20] Environmental transmission of VRE to healthcare workers' hands and gloves has been documented.[6,21,22] VRE can survive on dry inanimate surfaces from 5 days to 4 months and can persist despite routine cleaning.[2,20] Although transmission of VRE in the hospital is most commonly associated with transient colonization of healthcare workers' hands, several studies have demonstrated that medical equipment (e.g. electronic rectal thermometers and fluidized beds) and contaminated hospital surfaces can play a role in the transmission of VRE.[20,23,24]

Clostridium difficile

Clostridium difficile is the most common cause of healthcare-associated gastrointestinal infections in the United States and antibiotic exposure is the highest risk for developing *Clostridium difficile*-associated disease (CDAD).[25] The clinical spectrum of *C. difficile* ranges from asymptomatic colonization to severe diarrhea, pseudomembranous colitis, toxic megacolon, and death.[26] The incidence of CDAD has been increasing in the United States since 1996.[27] In 2003, the emergence of a hypervirulent strain of *C. difficile* caused disruptive outbreaks of severe disease in North America and Europe which resulted in significant morbidity and mortality.[28,29]

C. difficile forms spores that are resistant to alcohol and commonly used hospital disinfectants (including most quaternary ammonium compounds) and can survive for 5 months on dry inanimate surfaces.[1,2] Multiple studies have demonstrated that *C. difficile* spores contaminate a variety of items and surfaces in the vicinity of colonized or infected patients[25,30-32] and transmission of *C. difficile* from the environment to the hands of personnel has been documented.[6] Transmission of *C. difficile* in hospitals occurs most commonly via the fecal-oral route following transient contamination of the hands of healthcare workers and patients and via contamination of the patient care environment.[25,26] Transmission of *C. difficile* from the environment to patients has been linked to contaminated electronic thermometers used for obtaining rectal temperatures.[33]

Acinetobacter baumannii

Acinetobacter baumannii ranks among the top 10 most common pathogens associated with HAIs reported to the NSHN.[7] Multidrug-resistant strains have been responsible for numerous recalcitrant outbreaks.[34,35] Many outbreaks with a recognized source have been associated with contaminated ventilators and other respiratory therapy devices, bedpans, and a variety of patient care items.[36] *Acinetobacter baumannii* has been isolated from multiple surfaces and medical equipment (e.g. beds, sinks, countertops, door handles, computer keyboards, blood pressure cuffs, patient lifting equipment, and cleaned reusable laryngoscope blades) in the vicinity of infected and colonized patients,[11,34,35,37] and frequently on healthcare workers' hands.[35] *Acinetobacter spp* can persist on dry inanimate surfaces for up to 5 months.[2]

Transmission of *Acinetobacter spp* in the hospital is thought primarily to be via the contaminated hands of healthcare workers. However, because several outbreaks have been associated with extensive environmental contamination and were brought under control only after vigorous environmental disinfection, contact with contaminated surfaces is thought to play an important role in transmission.[3,35,36]

Norovirus

Noroviruses are the most common cause of non-bacterial gastroenteritis. Symptoms of norovirus-associated gastroenteritis include acute-onset vomiting, watery non-bloody diarrhea with abdominal cramps, and nausea. Noroviruses have a short incubation period of 24 to 48 hours (can be as little as 12 hours) and generally cause a self-limited illness that lasts from 24 to 60 hours.[38] In hospitals and long-term care facilities, noroviruses have caused outbreaks that spread rapidly and affected patients, personnel, and visitors. Attack rates were high and transmission was difficult to control.[39,40]

Although noroviruses are transmitted primarily through the fecal-oral route (either by consumption of contaminated food or water or by direct person-to-person spread), contamination of fomites and the environment likely plays an important role in transmission.[38,41,42] There is also evidence that transmission can occur when there is a production of a fine spray or mist containing minute particles of vomitus that results in either inhalation with subsequent ingestion of virus particles or environmental contamination.[38,43] Noroviruses are highly contagious and it is thought that ingestion of as few as 10 viral particles may be sufficient to infect an individual.[38] Noroviruses can survive on dry environmental surfaces for prolonged periods (up to 7 days)[2] and are resistant to commonly used hospital disinfectants.[1] Hands that touch virus-contaminated items readily become contaminated and can result in either self inoculation by transfer of the virus to the mouth or transfer of the virus to another person or surface.[41] For these reasons, hospital environmental surfaces contaminated by feces or vomitus of infected patients can contribute to the nosocomial spread of noroviruses.

Infection prevention measures

Hand Hygiene and Glove Use

Hand hygiene is the single most important measure that can be taken to prevent infection.[44,45] Hand hygiene is a general term that encompasses hand washing with plain or antimicrobial soap and water, applying a waterless antiseptic hand rub, and the use of surgical hand antisepsis prior to an operative procedure.[44] Appropriate use of gloves is considered an integral part of hand hygiene. The Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO) have published evidence-based guidelines for hand hygiene.[44,45] Over the past decade, efforts to increase awareness of the importance of hand hygiene in preventing infections have included guidelines and hand hygiene promotional campaigns, the standard use of alcohol-based hand rubs in healthcare settings, and the implementation multimodal strategies for promoting hand hygiene among healthcare workers.[46,47] Despite these efforts and strong evidence that adhering to recommended guidelines can prevent infections, adherence to effective hand hygiene practices remains low.[44,45]

Successful strategies for improving hand hygiene performance include ongoing education and assessment, and reporting of adherence rates to personnel, however, assessing adherence is a difficult task.[44,45] In 2009, the Joint Commission released a monograph that was developed in collaboration with 6 other organizations to promote measurement and improvement activities.[48] The monograph includes examples of rigorously tested and validated tools and training programs to improve and measure hand hygiene performance.

> Consider using dedicated single-patient use (disposable) pulse oximetry sensors and other non-critical patient care items for patients with poor skin integrity.

Standard Precautions and Contact Precautions

Hospitals should also implement and monitor adherence to protocols based on evidenced based guidelines for the use of standard precautions when caring for all patients and contact (isolation) precautions, especially glove and gown use, for patients known to be colonized or infected with multidrug resistant organisms.[44,49,50]

Cleaning and Disinfection of Hospital Surfaces and Medical Equipment

Contaminated surfaces and medical equipment can contribute to transmission by contaminating the hands of healthcare workers or directly contacting patients. Therefore meticulous attention to cleaning and disinfection is necessary to prevent cross contamination. Recommendations for cleaning and disinfection include the following:

- Implement protocols based on evidence-based guidelines for cleaning and disinfecting hospital surfaces and medical equipment.[5,49,50]
- Clean and disinfect surfaces likely to be contaminated on a routine basis, especially frequently touched surfaces (e.g. bed rails, over bed tables, bedside commodes, door knobs, bathroom fixtures in a patient's room) and equipment in the immediate vicinity of the patient.[5,49,50]
- Use a US Environmental Protection Agency (EPA)-registered disinfectant that has microbiocidal activity against the pathogens most likely to colonize or infect patients, and use in accordance with manufacturer's instructions.[49]
- Because *C. difficile* spores are resistant to alcohol and commonly used surface disinfectants, use chlorine-based agents (e.g. dilute bleach solution) for disinfecting surfaces and equipment in the room of a patient known to have CDAD.[5,31]
- Because noroviruses are resistant to destruction by many hospital disinfectants, use either a chlorine solution or an EPA-approved disinfectant with a specific claim for activity against noroviruses to disinfect environmental surfaces to control an outbreak.[51]

Protocols should be in place to prevent the transmission of pathogens via commonly used patient care items. Noncritical equipment such as blood pressure cuffs, stethoscopes, pulse oximetry sensors and ultrasound transducers become contaminated during use and can potentially transmit pathogens.[1-3,11,52,53] To minimize cross contamination, the following measures are recommended:

- Develop and implement policies and procedures to ensure that reusable patient care equipment is cleaned and reprocessed appropriately before use on another patient.[49]
- Periodically clean and disinfect noncritical medical equipment surfaces with an EPA-registered low- or intermediate-level disinfectant on a regular basis, and when visibly soiled.[5]
- For patients on contact precautions, use dedicated disposable patient care items, such as pulse oximetry probes and blood pressure cuffs. If disposable items are not available, disinfect reusable equipment appropriately before use on another patient.[1]
- Consider using dedicated single-patient use (disposable) pulse oximetry sensors, blood pressure cuffs and other non critical patient care items for patients with poor skin integrity.

Improving Adherence to Infection Prevention Practices

Hospitals should measure adherence to infection prevention measures and provide personnel with information on their performance. Ongoing training combined with monitoring environmental cleaning practices and providing feedback to staff has been shown to improve the effectiveness of room cleaning[54-56] and reduce the acquisition of VRE by patients in an ICU.[56] To ensure consistency, monitoring should be done using standardized checklists. Observation tools for hand hygiene can be found in the Joint Commission monograph;[48] examples of environmental services checklists can be found in the appendices of the Institute for Healthcare Improvement 5 Million Lives Campaign "Reduce Methicillin-Resistant *Staphylococcus aureus* (MRSA) Infection: How-to Guide."[57]

Methods for evaluating effectiveness of cleaning and disinfection include visual assessment of surfaces, application of fluorescent products to surfaces and evaluating removal after cleaning, conducting microbiologic cultures, and detection of adenosine triphosphate (ATP) on surfaces.[58,59]

Education and Training

Education is an integral component of any infection prevention and control program. Personnel should receive initial education and training at time of hire and periodically thereafter and this should be targeted to the needs, occupational activities and educational levels of specific personnel. Education should include the following:

- Modes of transmission of organisms, including how transmission can occur via hospital surfaces and equipment
- Rationale, indications and techniques for hand hygiene, standard precautions, contact (isolation) precautions, and cleaning and disinfection of hospital surfaces and equipment
- Importance of adhering to infection prevention practices
- Expectations of supervisors, managers, and hospital administrators. Competency testing should be done at commencement of employment and periodically as appropriate.

Summary

The hospital environment is contaminated by a variety of pathogenic and nonpathogenic microorganisms that can persist on surfaces for prolonged periods. Numerous studies have demonstrated that the hands and gloves of healthcare workers readily acquire pathogens after contact with contaminated hospital surfaces and can transfer these organisms to subsequently touched patients and inanimate surfaces. The acquisition of nosocomial pathogens by a patient and the resultant development of infection depend on a multifaceted interplay between the environment, a pathogen and a susceptible host. However, there is good evidence that infection transmission via hospital surfaces and medical equipment can occur. For these reasons, hospitals must implement evidence-based infection prevention measures that will reduce the risk of transmission of pathogens via contaminated hospital surfaces and medical equipment and hold personnel accountable for adhering to these measures.

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1. The role of inanimate hospital environmental surfaces in the transmission of healthcare associated infections (HAIs) is well understood.

A. True
B. False

2. Which of the following items is most likely to transmit a healthcare associated infection if it is not properly cleaned and disinfected between patients?

A. Pulse oximetry sensor
B. Bronchoscope
C. Stethoscope
D. Ultrasound transducer

3. The most common pathogen associated with HAIs reported to the National Healthcare Safety Network from January 2006 to October 2007 was:

A. *Enterococcus faecalis*
B. Norovirus
C. *Acinetobacter baumannii*
D. *Staphylococcus aureus*

4. The primary mode of transmission of norovirus is:

A. Fecal oral
B. Droplet spread
C. Airborne
D. Indirect

5. The major mode of transmission of healthcare associated pathogens to patients is via:

A. Treatment with improperly disinfected semi-critical medical devices
B. Direct contact with colonized or infected patients
C. Transiently colonized hands of healthcare workers
D. Contact with inadequately cleaned hospital environmental surfaces

6. This organism forms spores that are resistant to alcohol and many disinfectants:

A. *Staphylococcus aureus*
B. Norovirus
C. *Clostridium difficile*
D. *Enterococcus faecalis*

7. Transmission of this organism to patients has been linked to contaminated electronic thermometers used for obtaining rectal temperatures.

A. Norovirus
B. Vancomycin resistant *Enterococcus*
C. *Acinetobacter baumannii*
D. *Staphylococcus aureus*

8. This organism has caused gastroenteritis outbreaks that had high attack rates, spread rapidly, and affected patients, personnel, and visitors in hospitals and long term care facilities.

A. Norovirus
B. *Escherichia coli*
C. Methicillin resistant *Staphylococcus aureus*
D. Vancomycin resistant *Enterococcus*

9. The most important measure that can be taken to prevent the transmission of pathogens in the ICU is:

A. High-level disinfection of semi-critical devices
B. Contact precautions for patients infected with multidrug resistant organisms
C. Hand hygiene
D. Appropriate antimicrobial therapy for infected patients

10. *Clostridium difficile* has been found to survive on hospital environmental surfaces for as long as

A. 5 months
B. 1-2 days
C. 18 months
D. 8 hours to 7 days

11. ICU patients are likely to have increased susceptibility to infection because of breaks in their skin due to trauma or surgery, the presence of indwelling medical devices, and general immunosuppression due to disease or chemotherapy.

A. True
B. False

12. In 2003, the emergence of a hypervirulent strain of this organism caused disruptive outbreaks of severe disease in North America and Europe.

A. Methicillin resistant *Staphylococcus aureus*
B. Norovirus
C. Vancomycin resistant *Enteroccus*
D. *Clostridium difficile*

Participant's Evaluation

This program has been approved for 2.0 contact hours of continuing education (CRCE) by the American Association for Respiratory Care (AARC). AARC is accredited as an approver of continuing education in respiratory care.

Saxe Communications is approved as a provider by the Vermont State Nurses' Association Inc. which is accredited as an approver of continuing education in nursing by the American Nurses' Credentialing Center's Commission on Accreditation.*

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6. Your results will be sent within 4-6 weeks after forms are received by fax or mail.
7. To earn 2.0 CRCEs, or CEs you must achieve a score of 75% or more. If you do not pass the test you may take it over one more time.
8. The fee has been waived through an unrestricted educational grant from Covidien Patient Monitoring Division.
9. Answer forms must be postmarked by Dec. 31, 2012 (Respiratory Therapists) and Mar., 15, 2014 (Nurses).
10. Faculty disclosures: No faculty disclosed any conflicts

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The goal of this program is to educate healthcare professionals on the management of healthcare-associated infections.

What is the highest degree you have earned? Circle one. 1. Diploma 2. Associate 3. Bachelor 4. Masters 5. Doctorate

Indicate to what degree the program met the objectives:

1. List the pathogens linked to transmission from medical equipment and hospital surfaces.
   Strongly Agree **Strongly Disagree**
   1 2 3 4 5 6
2. Identify the medical equipment and hospital surfaces that can be contaminated with pathogens.
   Strongly Agree **Strongly Disagree**
   1 2 3 4 5 6
3. Discuss the prevention strategies for reducing risk of transmission.
   Strongly Agree **Strongly Disagree**
   1 2 3 4 5 6
4. Please indicate your agreement with the following statement. "The content of this course was presented without bias of any product or drug."
   Strongly Agree **Strongly Disagree**
   1 2 3 4 5 6

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Answers

1	A ☐	B ☐	C ☐	D ☐	9	A ☐	B ☐	C ☐	D ☐
2	A ☐	B ☐	C ☐	D ☐	10	A ☐	B ☐	C ☐	D ☐
3	A ☐	B ☐	C ☐	D ☐	11	A ☐	B ☐	C ☐	D ☐
4	A ☐	B ☐	C ☐	D ☐	12	A ☐	B ☐	C ☐	D ☐
5	A ☐	B ☐	C ☐	D ☐	13	A ☐	B ☐	C ☐	D ☐
6	A ☐	B ☐	C ☐	D ☐	14	A ☐	B ☐	C ☐	D ☐
7	A ☐	B ☐	C ☐	D ☐	15	A ☐	B ☐	C ☐	D ☐
8	A ☐	B ☐	C ☐	D ☐	16	A ☐	B ☐	C ☐	D ☐

Name & Credentials ____________________
Position/Title ____________________
Address ____________________
City________________ State __ Zip ______
Phone # ____________________
Fax # or email ____________________
AARC Membership #____________________
(AARC Members: Results will be sent directly to AARC)

Credit given only if all information is provided. Please PRINT clearly.

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