

Environmental Cleaning and Disinfection: Principles of Infection Transmission and the Role of the Environment



Presenter

David P. Calfee, MD, MS

Associate Professor of Medicine
Weill Cornell Medicine

Contributions by

Dan Bennett, CHESP, M-CHEST, T-CHEST

St. Joseph's Hospital-North

Ruth Carrico, PhD, FNPC, FSHEA, CIC

University of Louisville School of Medicine

Association for the Health Care Environment



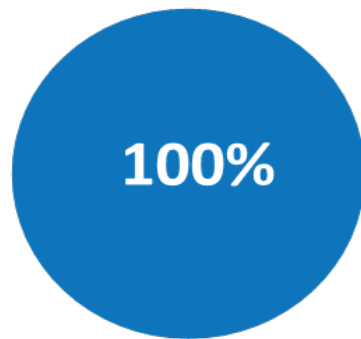
Learning Objectives

- Describe the significance of microbial contamination of the healthcare environment
- Identify the role that environmental cleaning and disinfection play in patient safety
- List factors that should be considered when implementing an environmental cleaning and disinfection program



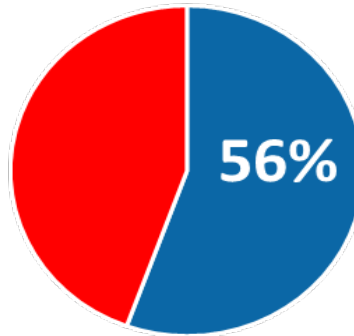
Contamination of the Healthcare Environment is Common

CDI Patient Rooms



■ Contaminated

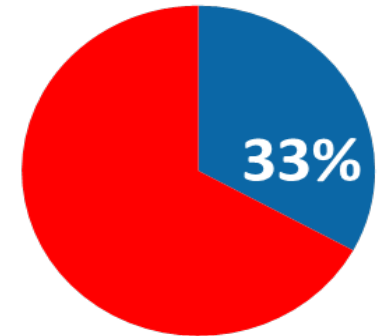
Items & Surfaces in CDI Patient Rooms



■ Contaminated

■ Not contaminated

Non-CDI Patient Rooms



■ Contaminated

■ Not contaminated

CDI: *Clostridioides difficile* infection

(Dubberke E, Am J Infect Control, 2007; Eckstein BC, BMC Infect Dis, 2007)



Many Important Pathogens Contaminate the Hospital Environment

Organism	Setting	Sample Positivity Rate
Methicillin-resistant <i>S. aureus</i> (MRSA)	Hospital	27%-73%
Vancomycin-resistant <i>Enterococcus</i> (VRE)	Hospital	25.2%
Multidrug-resistant <i>A. baumannii</i>	Hospital, Long-term acute care hospital	1.8%-42%
Carbapenem-resistant <i>K. pneumoniae</i>	Intensive Care Unit	8%-67%
ESBL <i>K. oxytoca</i>	Intensive Care Unit	94%
Multidrug-resistant gram-negative bacilli	Hospital	4.9%

(Sexton T, J Hosp Infect, 2006; Friedman ND, Am J Infect Control, 2013; Palmore T, Infect Control Hosp Epidemiol, 2011; Ray A, Infect Control Hosp Epidemiol, 2010; Thom KA, J Clin Microbiol, 2012; Bratu S, Arch Intern Med, 2005; Munoz-Price L, Infect Control Hosp Epidemiol, 2010; Lowe C, Emerg Infect Dis, 2012; Lemmen SW, J Hosp Infect, 2004; French GL., J Hosp Infect 2004)



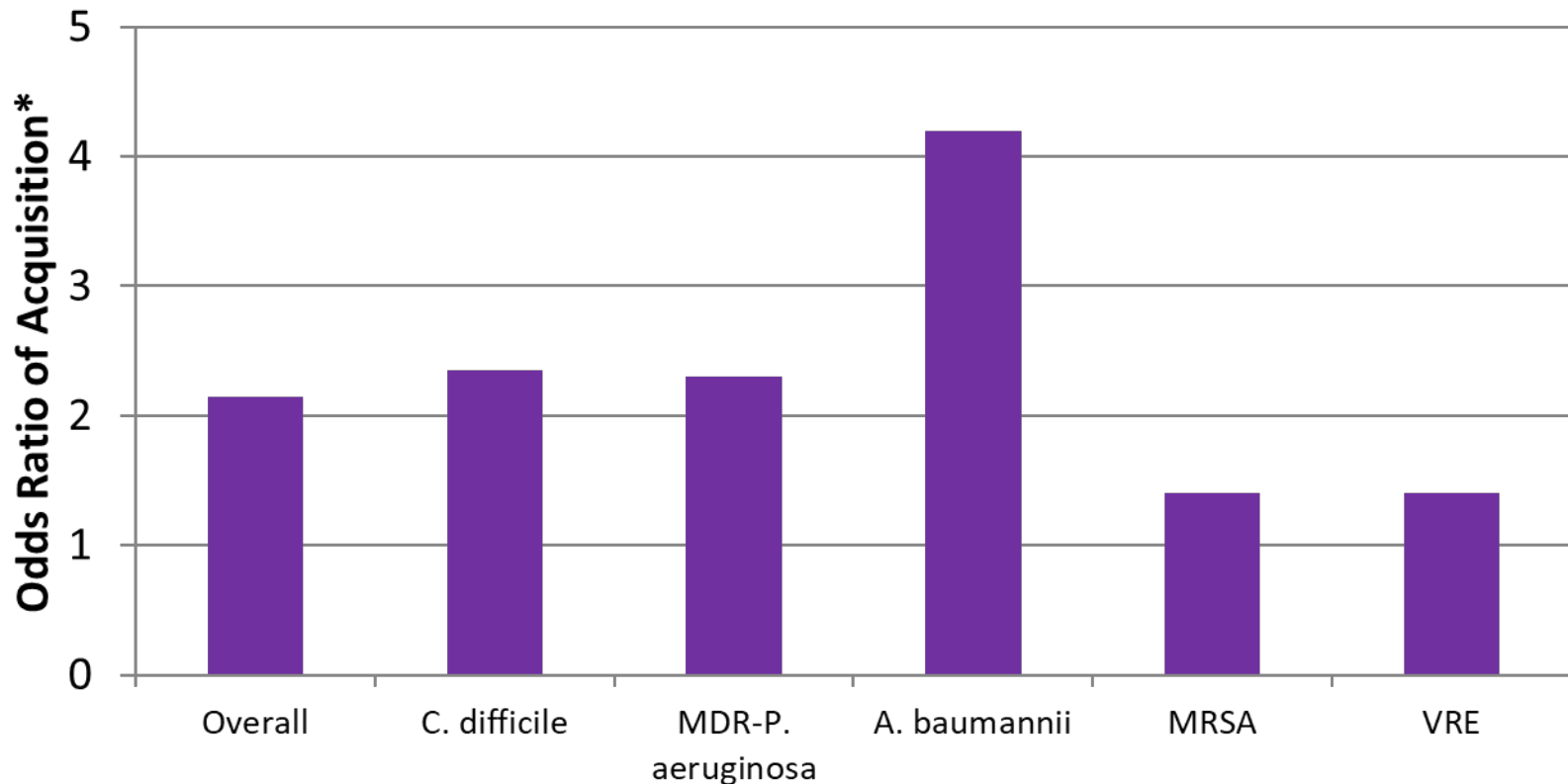
Pathogens Can Survive in the Environment for Long Periods of Time

Organism	Duration of Survival
<i>Acinetobacter</i> sp.	3 days-5 months
<i>Clostridioides difficile</i>	5 months
<i>E. coli</i>	1.5 hours-16 months
<i>Enterococcus</i> (VRE, VSE)	5 days-4 months
<i>Klebsiella</i> sp.	2 hours->30 months
<i>Proteus vulgaris</i>	1-2 days
<i>Pseudomonas aeruginosa</i>	6 hours-16 months
<i>Serratia marcescens</i>	3 days-2 months
<i>S. aureus</i> (including MRSA)	7 days-7 months

(Kramer A, *BMC Infect Dis*, 2006)



A Prior Room Occupant's Pathogens Can Put the Next Patient at Risk



*Odds ratio compared to admission to a room in which the prior occupant was not colonized or infected.

(Shaughnessy MK, *Infect Control Hosp Epidemiol*, 2011; Nseir S, *Clin Microbiol Infect*, 2011; Huang SS, *Arch Intern Med*, 2006; Mitchell BG, *J Hosp Infect*, 2015)



Environmental Contamination Leads to Healthcare Personnel Contamination

After **5 seconds** of contact with the bedrail and bedside table, healthcare personnel hand cultures were positive* in:

53% of occupied rooms

24% of vacant, “clean” rooms

*Including: *S. aureus*, vancomycin-resistant enterococci (VRE), *C. difficile*, gram-negative bacilli



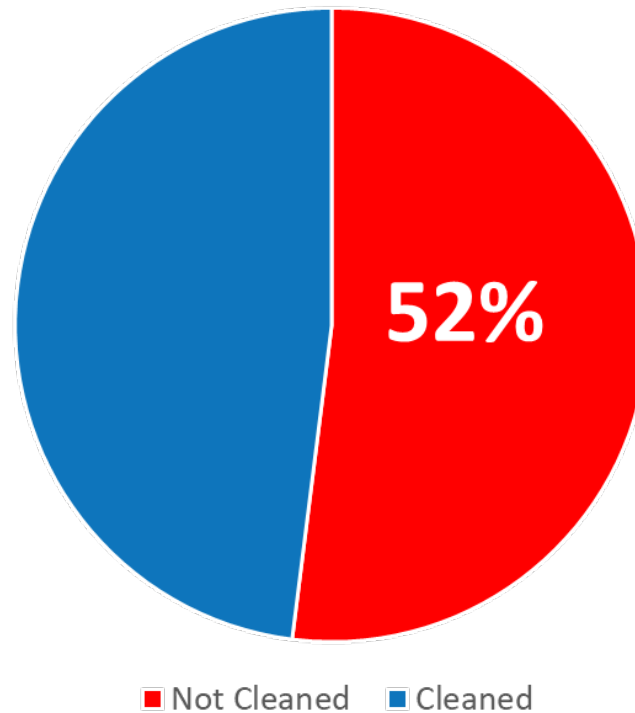
(Image source: Donskey CJ, *N Eng J Med*, 2009)

(Bhalla A, *Infect Control Hosp Epidemiol*, 2004)



More than Half of “High Touch” Surfaces Are Not Effectively Cleaned at Discharge

High-Touch Surfaces



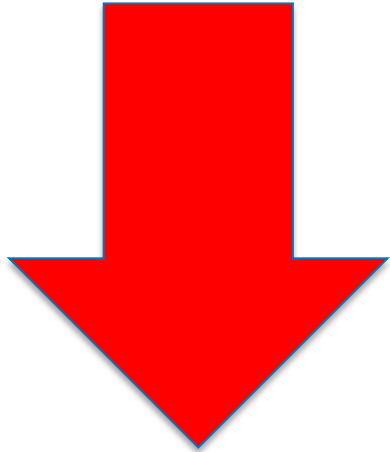
Year: **2006**

Location: **36** hospitals

14 high-touch surfaces



Improving Cleaning and Disinfection Prevents Pathogen Transmission



- **25%** lower risk of acquiring MRSA
- **Elimination** of the risk associated with an MRSA-positive prior room occupant



Basic Concepts Related to Cleaning and Disinfection

- **Cleaning**: removal of visible soil and other organic matter from objects and surfaces
- **Disinfection**: a process that results in the elimination of many or all pathogenic microorganisms on inanimate objects with the exception of bacterial spores
- **Sterilization**: a process that kills all forms of microbial life, including spores



There are Different Levels of Disinfectants and Disinfection Processes

- **Low level disinfection:** kills most vegetative bacteria, some viruses, and some fungi, but cannot be relied on to kill mycobacteria or bacterial spores
- **Intermediate level disinfection:** kills vegetative bacteria, most viruses and most fungi, but does not reliably kill bacterial spores
- **High level disinfection (HLD):** completely eliminates all microorganisms except for small numbers of bacterial spores



The Spaulding Classification Informs Our Approach to Disinfection and Sterilization

Category (Spaulding Class)	Definition	Examples	Minimum reprocessing requirements*
Noncritical equipment	Objects that touch only intact skin	Blood pressure cuffs, stethoscopes, high-touch environmental surfaces	Low level disinfection
Semi-critical equipment	Objects that touch mucous membranes or non-intact skin	Endoscopes, laryngoscopes, respiratory therapy equipment, vaginal specula	High level disinfection (HLD)
Critical equipment	Objects which enter normally sterile tissue or vascular system	Implants, surgical instruments	Sterilization

*Cleaning is **always** required before disinfection and/or sterilization.

(Rutala WA, HICPAC, 2008)



Differences Exist Among Agents Used for Low Level Disinfection

	Quaternary Ammonium	Phenolics	H ₂ O ₂	Hypochlorite (bleach)	Accelerated H ₂ O ₂ and Peracetic Acid
Bactericidal	Yes	Yes	Yes	Yes	Yes
Virucidal (enveloped viruses)	Yes	Yes	Yes	Yes	Yes
Fungicidal	Yes	Yes	Yes	Yes	Yes
Mycobactericidal	No	Yes	Yes	Yes	Yes
Sporicidal	No	No	+/-	Yes	Yes
Active in presence of organic matter	Yes	Yes		No	Yes
Other characteristics	Some persistent activity	Tissue irritation, skin depigmentation		Corrosive, eye and skin irritation, instability after dilution	Environmentally safe, more expensive

H₂O₂, hydrogen peroxide.
Peracetic acid is also known as peroxyacetic acid.



Many Factors Must Be Considered When Selecting a Disinfectant

- Spectrum of activity (“kill claim”)
 - EPA-registered
- Ease of use
 - Contact time*
 - Mixing requirements
 - Stability
 - Need for a separate cleaning step
 - Method of delivery
- Safety
 - Toxicity
 - Flammability
- Surface compatibility
- Persistent activity
- Odor
- Cost

***Contact time:** the length of time a surface needs to remain wet with a disinfectant in order to achieve the claimed disinfection activity



Other Factors Must Also Be Considered

- Selection of other products (mops, cloths, etc.)
- Initial education and training
- Periodic retraining
- Assessment of competency, effectiveness
- Feedback to/from personnel
- Identification and elimination of barriers
 - Equipment and product availability
 - Staffing
 - Workflow
 - Hospital “culture”



The Environment is More Than Horizontal Surfaces and Furniture



Our efforts need to include the personnel (e.g., nurses, doctors, technicians) who are responsible for cleaning and disinfection of medical equipment.



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Speaker Notes



Speaker Notes: Slide 1

Hello and welcome to the first module of the Environmental Cleaning course. This module, entitled “Environmental Cleaning and Disinfection: Principles of Infection Transmission and the Role of the Environment” will provide background information that illustrates the important role that the hospital environment can play in pathogen transmission and will introduce concepts that are useful in establishing and optimizing a hospital cleaning and disinfection program. This module will serve to set the stage for subsequent modules in this course.



Speaker Notes: Slide 2

This module was developed by national infection prevention experts devoted to improving patient safety and infection prevention efforts.



Speaker Notes: Slide 3

After completing this module you will be able to:

- Describe the significance of microbial contamination of the healthcare environment;
- Identify the role that environmental cleaning and disinfection play in patient safety; and
- List factors that should be considered when implementing an environmental cleaning and disinfection program.



Speaker Notes: Slide 4

One of the things that we hope to accomplish with this module is to demonstrate why cleaning and disinfection of the hospital environment is such an important aspect of a healthcare-associated infection (HAI) prevention and safety program. To do this, we'll first look at some data that highlight how commonly the hospital environment is contaminated with pathogens.

We probably all recognize that the healthcare environment can be contaminated with pathogens. However, we may not recognize how commonly and extensively it occurs. To illustrate this point, this slide displays data from studies that have assessed the frequency of contamination of the hospital environment with *Clostridioides difficile* (*C. diff*).



Speaker Notes: Slide 4 Continued

The first figure shows data from a study by Dubberke and colleagues that was conducted in six healthcare facilities in which investigators sampled the environment in rooms housing patients with *C. diff* infection (CDI). In this study, *C. diff* was isolated from at least one sampled site in 100 percent of the rooms that were evaluated. The second figure represents the findings from a study by Eckstein and colleagues, in which *C. diff* was isolated from 56 percent of sampled items and surfaces in CDI rooms, including bedrails, bedside tables, phones, call buttons, toilets and door handles. And finally, the third figure, again for Dubberke et al., shows that *C. diff* can be isolated from about one third of rooms, even if they are not currently housing patients with CDI.



Speaker Notes: Slide 5

Of course, *C. difficile* is not the only pathogen that contaminates the hospital environment. This table summarizes the findings of several studies in which environmental culturing was performed to determine the frequency of environmental contamination with other pathogens.

As you can see, similar to the studies of *C. difficile*, the percentages of environmental samples that were positive were quite high for multiple drug-resistant organisms. For example, culture positivity rates of 27-73 percent were seen for methicillin-resistant *Staphylococcus aureus* (MRSA), and approximately 25 percent for vancomycin-resistant *Enterococcus* (VRE).



Speaker Notes: Slide 5 Continued

Rates for the gram-negative pathogens, such as *Acinetobacter* and *Klebsiella pneumoniae*, ranged from about two percent to 94 percent.

To note, most of these studies were conducted in the setting of outbreaks or on units with a high endemic rate of the pathogen for which testing was performed and may not reflect the current status in the average hospital, but the findings are nonetheless eye opening and important for all of us to be aware of as we consider the important role that the hospital environment can play in the transmission of infection.



Speaker Notes: Slide 6

Another fact to be aware of is that once these pathogens have contaminated environmental surfaces, fixtures, furniture and equipment, they can survive for very long periods of time in the absence of effective cleaning and disinfection processes. Most of us have probably heard that *C. diff* spores can survive in the environment for months, but I think it is less commonly known how long many other pathogens can survive in the environment. As shown in this table, many of these pathogens, including MRSA and gram-negative organisms such as *Acinetobacter* and *Pseudomonas*, are capable of surviving for hours to days to weeks, and even for several months. This ability to persist in the environment can play a critical role in the transmission of pathogens from patient-to-patient.



Speaker Notes: Slide 7

The role that a contaminated environment can play in transmission is further supported by a number of studies showing that patients admitted to a room in which the prior occupant was colonized or infected with a particular pathogen are significantly more likely to acquire that same pathogen during their hospital stay than patients who are admitted to a room in which the prior occupant was not colonized or infected. Overall, as shown by the bar on the far left of the graph, the odds of acquiring the organism were more than two times higher among patients admitted to the rooms in which the prior occupant was colonized or infected.



Speaker Notes: Slide 7 Continued

These findings are consistent across a large variety of pathogens, as shown by the other bars, including *C. difficile*, *Pseudomonas*, *Acinetobacter*, MRSA and VRE. This frequent and persistent environmental contamination poses a serious risk to subsequent patients who occupy these contaminated spaces. These spaces are supposed to be safe.



Speaker Notes: Slide 8

You may recall from the STRIVE hand hygiene modules that there are several moments or opportunities for healthcare personnel to clean their hands. One of these moments is after contact with the patient care environment. That is because, in addition to potential direct environment-to-patient transmission, the contaminated environment can lead to contamination of healthcare personnel hands that can subsequently result in transmission to other surfaces, objects and patients. For example, in one study, 64 healthcare personnel performed hand hygiene, went into hospital rooms where they placed their hand on the bed rail for 5 seconds and also on the bedside table for 5 seconds.



Speaker Notes: Slide 8 Continued

They, then, had a hand imprint culture performed prior to performing hand hygiene. When this experiment was conducted in occupied patient rooms, hand cultures were positive for pathogenic organisms, such as *Staphylococcus aureus*, VRE, gram-negative bacilli and *C. difficile*, in 53 percent of the experiments. Perhaps even more surprising and concerning, hand cultures were positive for one or more of these pathogens in 24 percent of experiments conducted in vacant rooms that had been terminally cleaned and were waiting for a new patient admission.



Speaker Notes: Slide 9

So you might and probably should be thinking “Why is the healthcare environment so frequently contaminated, even in rooms that have undergone discharge cleaning?” A major problem, and perhaps one of the most important answers to that question, is that we don’t reliably clean the hospital environment. In one study that used fluorescent markings to assess the effectiveness of discharge cleaning, the investigators found that about half of high-touch surfaces in hospital rooms was not cleaned. These high touch surfaces are those surfaces and items in a hospital room that are frequently touched by patients and/or healthcare providers, such as bedrails and over-bed tables.



Speaker Notes: Slide 9 continued

I should point out that this was not a small study conducted in a single hospital. These data were collected for 14 types of high-touch surfaces in 36 acute care hospitals in the US, suggesting that these findings may be fairly reflective of what is happening in hospitals across the country.



Speaker Notes: Slide 10

Those results can be pretty disheartening, but I want to point out that when we do it right, cleaning and disinfection can substantially reduce environmental contamination and the associated risk of transmission to and infection of our patients. For example, in a Boston hospital, enhancing the cleaning and disinfection process was associated with a 25 percent reduction in patient MRSA acquisitions and an elimination of the previously described increased risk of MRSA acquisition among patients admitted to hospital rooms in which the previous patient was MRSA-positive. This is a great example of why optimizing our hospitals' environmental cleaning and disinfection programs is so important in our efforts to enhance patient safety.



Speaker Notes: Slide 11

Now, with that background and hopefully with a keen appreciation for the importance of cleaning and disinfection of the healthcare environment, let's move on to a discussion of some common terminology related to cleaning and disinfection. Even if you are not directly involved in the process, having a working knowledge of this terminology is important to ensure that we all communicate effectively with regard to this topic. While we sometimes hear the terms “cleaning” and “disinfection” used interchangeably, they are, in fact, two different concepts.



Speaker Notes: Slide 11 Continued

Cleaning refers to the physical removal of visible soil and other organic matter from objects and surfaces. It does not imply killing of any microorganisms. Disinfection, on the other hand, is a process that results in the elimination of many or all pathogenic microorganisms on inanimate objects with the exception of bacterial spores. Finally, sterilization is a process that kills all forms of microbial life, including spores.



Speaker Notes: Slide 12

It is important to understand that even within the category of disinfection, there are three subcategories, or levels of disinfection, with which one should be familiar. Low level disinfection kills most vegetative bacteria, some viruses, and some fungi, but cannot be relied upon to kill mycobacteria or bacterial spores. Intermediate level disinfection kills vegetative bacteria, most viruses and most fungi, but does not reliably kill bacterial spores.

High level disinfection, often referred to as HLD, completely eliminates all microorganisms except for small numbers of bacterial spores.



Speaker Notes: Slide 13

Given the variety of options available to us, such as low-level disinfection, high-level disinfection and sterilization, it is important to understand which process is required for the various environmental surfaces and medical equipment that we use during the care of patients. The Spaulding classification defines the minimum level of disinfection or sterilization required based on how the item is used or the part of the body with which it makes contact. In the Spaulding classification system, non-critical equipment is that which touches only intact skin. Examples of non-critical equipment include blood pressure cuffs, stethoscopes and environmental surfaces in the patient care environment.



Speaker Notes: Slide 13 Continued

Non-critical equipment is reprocessed by cleaning and, at a minimum, low level disinfection. Semi-critical equipment includes any equipment or item that comes into contact with mucous membranes or non-intact skin. Semi-critical equipment includes endoscopes, laryngoscopes, respiratory therapy equipment, and vaginal specula. These items must be reprocessed by cleaning and high level disinfection. Lastly, critical equipment is equipment that enters normally sterile tissue or the vascular system and includes implanted devices and materials and surgical instruments.



Speaker Notes: Slide 13 Continued

Critical equipment must be cleaned and sterilized prior to use. Because this module is focused on cleaning and disinfection of the healthcare environment and other non-critical equipment, our discussion will focus on low level disinfection.

Note: All of these categories of reprocessing require that they be cleaned before disinfection and sterilization.



Speaker Notes: Slide 14

An important part of cleaning and disinfecting non-critical equipment is using the correct disinfectant, so we will spend a little time talking about some of the different types of disinfectants that are approved by the Environmental Protection Agency (EPA) for this use, including quaternary ammonium compounds (knowns as “quats”), phenolics, hydrogen peroxide, hypochlorite solutions (or bleach), accelerated hydrogen peroxide and peracetic acid (often formulated in a combined product). Not all disinfectants are created equal, and the differences between products should be compared when selecting one or more agents for use.



Speaker Notes: Slide 14 Continued

One of the first things to consider is a disinfectant's spectrum of activity or, in other words, the germs against which it has been proven to be effective. If you recall from earlier in the presentation, low-level disinfectants, by definition, are not required to have sporicidal activity and, in fact, most do not. Thus, if you are looking for an agent with activity against *C. diff* spores, for instance, that is something that you would want to consider when selecting a product. Differences also exist with regard to activity in the presence of organic matter, toxicity, corrosiveness, odor and cost, among other factors.

[Note: the sporicidal activity of H_2O_2 is dependent on the concentration and exposure time. Many hydrogen peroxide-based products sold for use in low-level disinfection do not have *C. difficile* spore kill claims.]



Speaker Notes: Slide 15

When selecting products for cleaning and disinfection, there are many factors, in addition to the spectrum of activity that we discussed on the previous slide that must be considered during the decision-making process. Another thing to consider is the ease with which the product can effectively be used. One aspect of this is contact time, which is the length of time a surface needs to remain wet in order for the disinfectant to achieve the claimed disinfection activity. Contact time (also known as “Dwell” time) varies considerably among different disinfectants and thus may be an important factor to consider.



Speaker Notes: Slide 15 Continued

For example, the likelihood that a two-minute contact time will be reliably achieved may be notably higher than the likelihood that a 10-minute contact time will be reliably achieved. Other factors that may influence the ease and reliability of use include requirements for mixing chemicals before they can be used (which may introduce opportunities for error or worker injury or exposure), the stability of the product over time, whether the product serves as both a cleaner and disinfectant or if a separate cleaning step is needed prior to disinfection, and the method of delivery (whether by spray, cloth or pre-saturated wipe).



Speaker Notes: Slide 15 Continued

Safety issues such as toxicity and flammability should also be considered as should factors such as compatibility with environmental surfaces and equipment, the presence or absence of persistent activity after the disinfectant has dried, the odor of the product (which may influence worker and/or patient acceptance of the product), and cost.



Speaker Notes: Slide 16

Of course, selecting appropriate cleaning and disinfecting agents is only one aspect of an effective environmental disinfection program. Even if we had a perfect disinfectant, it wouldn't produce perfect results if the rest of our program was ineffective. Thus, we also need to pay attention to selection and proper use of other products, such as the mops and cloths we use with our cleaners and disinfectants. We also need to provide appropriate and thorough education and initial training to personnel who are responsible for cleaning. In addition, we need to provide periodic retraining, assessment of competency and feedback of performance.



Speaker Notes: Slide 16 Continued

We need to continue to look for and eliminate barriers to consistent and reliable implementation of our cleaning and disinfection policies and protocols. Such barriers may include lack of availability of or easy access to, the necessary equipment and products, inadequate staffing, workflow challenges and hospital “culture” that may impede optimal program implementation. For example, facilities leadership should empower and support environmental services staff to have authority to accomplish their work and be sufficiently resourced and staffed for consistent and effective work. Another example, would be to ensure environmental services teams are included in facility quality and infection control committees.



Speaker Notes: Slide 17

One last, but very important thing to highlight is that the hospital environment that can contribute to patient-to-patient transmission of pathogens is more than the horizontal surfaces, fixtures and furniture that are typically cleaned by environmental services technicians. It also includes a large number of items and equipment for which environmental services technicians typically do not have cleaning responsibility. This includes shared, mobile equipment, such as electronic blood pressure machines, glucometers and portable ultrasounds that moves from patient to patient and room to room on a frequent basis.



Speaker Notes: Slide 17 Continued

Like the built environment such as furniture and fixtures, these items are frequently contaminated with organic material and microorganisms. Thus, in our efforts to minimize the infectious disease risk of our hospital environment, we must be inclusive of these items and the people who carry the responsibility for their cleanliness and ensure that all healthcare personnel understand their role in keeping the patient environment clean and safe.



Speaker Notes: Slide 17 Continued

Like the built environment such as furniture and fixtures, these items are frequently contaminated with organic material and microorganisms. Thus, in our efforts to minimize the infectious disease risk of our hospital environment, we must be inclusive of these items and the people who carry the responsibility for their cleanliness and ensure that all healthcare personnel understand their role in keeping the patient environment clean and safe.



Speaker Notes: Slide 18

No notes.



Speaker Notes: Slide 19

No notes.

