Principles of Environmental Cleaning and Monitoring the Adequacy of Practices

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Environmental Contamination

- **Patients with pathogens such as methicillin-resistant *S. aureus* (MRSA), *Clostridium difficile*, vancomycin-resistant enterococci (VRE), and *Acinetobacter* frequently contaminate environmental surfaces in their immediate vicinity**
- **These organisms can remain viable in the environment for weeks or months**

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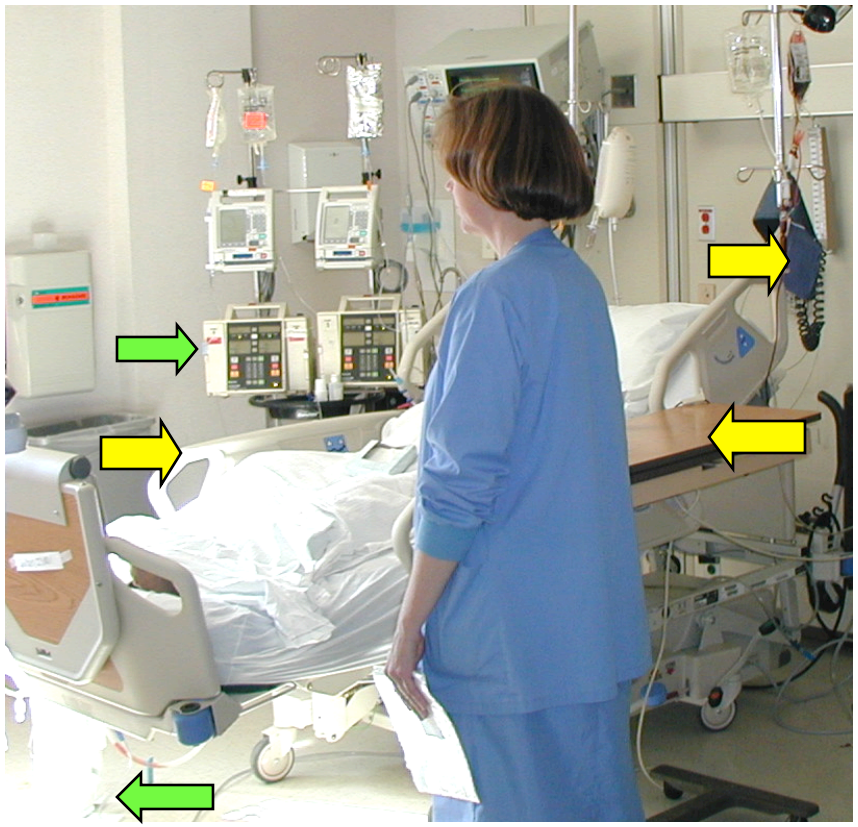
Examples of Contaminated Environmental Surfaces

- **Items frequently contaminated near patients include:**
  - **Bed rails**
  - **Bed linen**
  - **Overbed tables**
  - **Blood pressure cuffs**
  - **Intravenous pumps**
  - **Nurse call buttons**
  - **Urinary collection bags**



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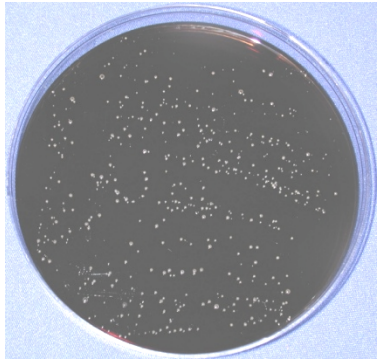
Cleaning Practices Are Often Suboptimal

- Daily cleaning of surfaces near patients is often performed poorly
- Terminal cleaning of rooms after patient discharge is often inadequate
  - Carling et al. found that only 47% of surfaces targeted for terminal cleaning had been cleaned

Overbed Table Before Cleaning

Overbed Table After Cleaning



VRE on call button after cleaning

Carling PC et al. Clin Infect Dis 2006;42:385
Eckstein BC et al. BMC Infect Dis 2007;7:61

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Contaminated Surfaces Can Contribute to Transmission

- Contaminated environmental surfaces can contribute to transmission of pathogens
  - By serving as a source from which healthcare workers contaminate their hands or gloves
- Contaminated medical equipment that comes into direct contact with the patient can serve as a source of transmission

Samore MH et al. Amer J Med 1996;100:32
Boyce JM et al. Infect Control Hosp Epidemiol 1997;
Bhalla A et al. Infect Control Hosp Epidemiol 2004;25:164
Duckro AN et al. Arch Intern Med 2005;165:302

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Contaminated Surfaces Can Contribute to Transmission

- **Patients admitted to a room formerly occupied by a patient with VRE or MRSA are at increased risk of acquiring the organism, suggesting that**
  - **terminal cleaning of rooms was inadequate**
  - **patients acquire the organism**
    - **directly from contaminated surfaces**
    - **from HCWs who contaminate their hands in the room**

Martinez JA et al. Arch Intern Med 2003;163:1905
Huang SS et al. Arch Intern Med 2006;166:1945
Drees M et al. Clin Infect Dis 2008;46:678

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Does Increased Cleaning/Disinfection Help Reduce Transmission of Pathogens?

- **A number of studies have shown that improved cleaning and disinfection of environmental surfaces can reduce transmission of pathogens such as *C. difficile,* vancomycin-resistant enterococci (VRE), and methicillin-resistant *S. aureus* (MRSA)**

Kaatz GW et al. Am J Epidemiol 1988;127:1289
Mayfield JL et al. Clin Infect Dis 2000;31:995
Hayden MK et al. Clin Infect Dis 2006;42:1552
Boyce JM et al. Infect Control Hosp Epidemiol 2008;29:723
Dancer SJ et al. BMC Med 2009;7:28

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Reducing Environmental Contamination Reduces VRE Transmission

- **Prospective, 9-month study in an MICU included**
  - Admission and daily screening of patients
  - Environmental and HCW hand cultures twice weekly
- **Study design included**
  - Baseline period (1)
  - Education/monitoring/feedback for housekeepers (2)
  - Wash-out period with no specific intervention (3)
  - Multimodal hand hygiene intervention (4)

Hayden MK et al. Clin Infect Dis 2006;42:1552

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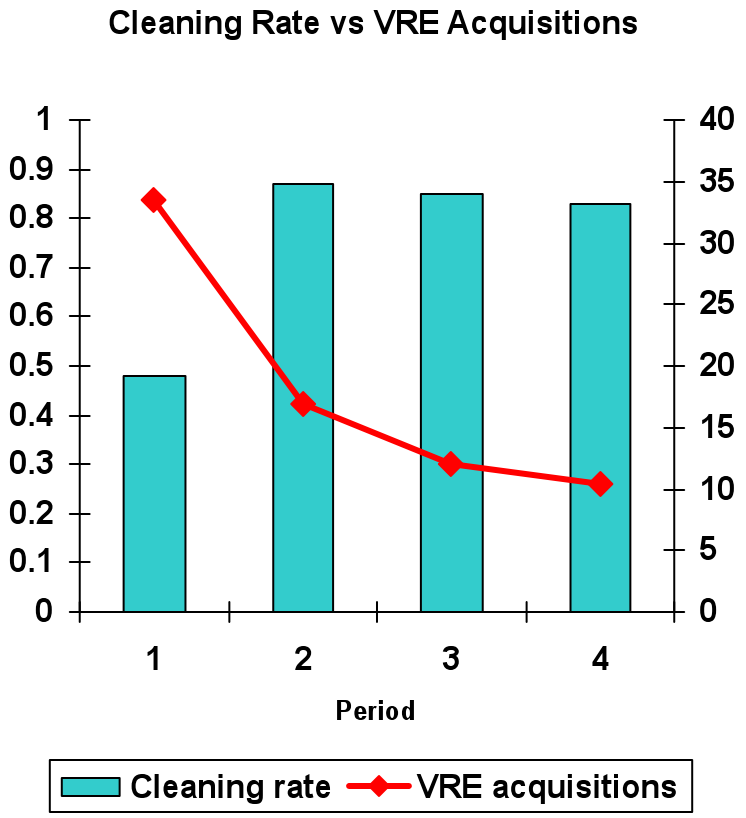
Reducing Environmental Contamination Reduces VRE Transmission

- Environmental cleaning rate increased significantly
- VRE environmental contamination decreased significantly
- VRE acquisitions by patients decreased significantly
- Other factors analyzed could not explain decreased VRE acquisition rate



Hayden MK et al. Clin Infect Dis 2006;42:1552

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Level of Disinfection/Cleaning Required for Patient Care Equipment

Spaulding Classification of Objects	Application	Level of Germicidal Action Required
Critical	Entry or penetration into sterile tissue, cavity or bloodstream	Sterilization
Semi-critical	Contact with mucous membranes, or non-intact skin	High-level Disinfection
Non-critical	Contact with intact skin	Low-level Disinfection

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Non-Critical Items

- **Non-critical patient care items**
  - Bedpans
  - Blood pressure cuffs
  - Crutches
  - Computers
- **Non-critical environmental surfaces**
  - Bed rails
  - Bedside or overbed tables
  - Nurse call buttons
  - Furniture in patient rooms
  - Floors

Rutala WA et al. CDC Guideline for Disinfection & Sterilization In Healthcare Facilities, 2008

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Common Agents Used for Disinfection of Environmental Surfaces

- Chlorine and Chlorine compounds
  - Sodium hypochlorite (5.25 – 6.15% solutions) – “bleach”
  - Sodium dichloroisocyanurate tablets
  - Demand-release chlorine dioxide, chloramine-T
- Ethyl or isopropyl alcohol (70-90%)
- Quaternary ammonium germicidal solutions
- Phenolic germicidal detergent solutions
- Iodophor germicidal solutions
- Accelerated hydrogen peroxide solutions

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Sodium hypochlorite (5.25 – 6.15% solutions) "household bleach"

Preparation	Parts per million (ppm) available chlorine	Comments
household bleach (undiluted)	52,500 - 61,500	
1:10 dilution of household bleach	5,250 - 6,150	Active against *C. difficile* spores
1:50 dilution of household bleach	1,050 - 1,230	Active against Mtb, Norovirus
1:500 dilution of household bleach	105 - 123	Active against vegetative bacteria

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Advantages and Disadvantages of Common Disinfectants

Disinfectant	Advantages	Disadvantages
Sodium hypochlorite (household bleach)	Inexpensive Fast-acting Widely available Active against bacteria,spores, Mtb, viruses	Odor can be irritating Corrosive to metals Inactivated by organic material May discolor fabrics
Ethyl or isopropyl alcohol (70-90%)	Inexpensive Widely available Rapidly effective Active against bacteria, Mtb, viruses	Not effective against bacterial spores Not for large surfaces

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Advantages and Disadvantages of Common Disinfectants

Disinfectant	Advantages	Disadvantages
Quaternary ammonium compounds	Not too expensive Widely available Good cleaning agents	Not effective against bacterial spores, Mtb, non-enveloped viruses May become contaminated
Phenolics	Widely available	Use on bassinets may be toxic to infants Poor activity against bacterial spores and non-enveloped viruses

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New Room Decontamination Methods: Hydrogen Peroxide Vapor

- **2 main hydrogen peroxide vapor technologies are commercially available for room decontamination**
  - **Micro-condensation process (BIOQUELL)**
  - **"Dry gas" process (Steris)**

- **Despite differences in method of application, both technologies have been validated as effective**
  - **Most experience in healthcare settings is with the micro-condensation process**

McAnoy AM: Vaporous Decontamination Methods, Australian Government DSTO 2006
French GL et al. J Hosp Infect 2004;57:31
Jeanes A et al. J Hosp Infect 2005;61:85
Bates CJ et al. J Hosp Infect 2005;61:364

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Hydrogen Peroxide Vapor (HPV)

- Ventilation ducts/doors must be taped shut
- HPV injected into empty room until defined dose delivered
- Catalytic converter converts HPV into oxygen & water vapor
- No toxic residuals
- Turn-around time for standard hospital room = ~ 2 hr 20 min
- Highly effective against Mtb, bacterial spores, fungi, viruses
- Has been shown to reduce acquisition of *C. difficile* and vancomycin-resistant enterococci

French GL et al. J Hosp Infect 2004;57:31
Boyce JM et al. Infect Control Hosp Epidemiol 200829:723
Otter JA et al. Infect Control Hosp Epidemiol 2009;30:574
Passaretti CL et al. 48th ICAAC, 2008, Abstr K-4214b

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New Room Decontamination Methods: Ultraviolet Light Systems

- Automated mobile UV light units that emit UV-C (254 nm range) can be placed in patient rooms after patient discharge and terminal cleaning had been performed
- Units can be set to kill vegetative bacteria or to kill spores
- Significantly reduce bacterial counts in patient rooms
- Easy to use and require relatively short cycle times

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Non-Critical Patient Care Equipment

- **Disinfect non-critical medical devices with accepted disinfectant using concentration and contact time recommended by manufacturer**
  - **Contact time of > 1 min. often effective**
- **Disinfect non-critical patient care devices when visibly soiled and on a regular basis**
  - **After use on each patient, or once daily or once weekly**
- **If dedicated equipment is not available, disinfect items after using on a patient who is being isolated due to resistant microorganisms**

Rutala WA et al. CDC Guideline for Disinfection & Sterilization In Healthcare Facilities, 2008

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Non-Critical Environmental Surfaces

- Disinfect (or clean) environmental surfaces on a regular basis and when visibly soiled
- Follow manufacturers' recommendations for use of disinfectant (or detergent) products
- Clean walls, window blinds and window curtains in patient-care areas when they are visibly soiled
- Use an approved disinfectant in patient-care areas
  - If contamination by blood/body fluids is possible
  - If contamination by multidrug-resistant organisms is possible

Rutala WA et al. CDC Guideline for Disinfection & Sterilization In Healthcare Facilities, 2008

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Non-Critical Environmental Surfaces

- Prepare disinfectant (or detergent) solutions as needed, and replace them with fresh solution frequently
  - Replace floor mopping solution every 3 patient rooms
  - Change no less often than at 60-min. intervals
- Decontaminate mop heads and cleaning cloths regularly to prevent contamination
- Detergent and water are adequate for cleaning surfaces in nonpatient-care areas
  - Example: administrative offices

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Non-Critical Environmental Surfaces

- **Promptly clean and disinfect spills of blood and other potentially infectious materials**
  - **Use protective gloves and other personal protective equip.**
  - **Use disinfectant active against HIV or HBV**
    - **E.g., 1:100 dilution of household bleach for small spill**
    - **E.g., 1:10 dilution of household bleach for large spill**
- **In patient-care areas with high rates of *C. difficile* infection or in an outbreak setting**
  - **Use 1:10 dilution of household bleach**

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Non-Critical Environmental Surfaces

- Clean and disinfect “high-touch” surfaces on a more frequent schedule than housekeeping surfaces seldom touched by patients and healthcare workers
- Examples of “high-touch” surfaces: bed rails, overbed tables, surfaces in and around patient toilets, nurse call buttons

Sehulster L et al. HICPAC Environmental Guideline
MMWR Recomm Rep 2003;52(RR-10):1

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Factors Contributing to Suboptimal Cleaning/Disinfection Practices

- Housekeepers and nursing staff often do not agree on who should clean what
- Housekeepers do not always understand
  - Which detergent/disinfectant to use
  - What concentration should be used
  - How often to change cleaning cloths/mop heads
- Other contributing factors
  - Demands for fast room “turnaround times”
  - Staff shortages and frequent turnover of personnel

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Improving Cleaning/Disinfection Practices

- Educate housekeepers regarding recommended cleaning practices and the importance of following hospital cleaning policies
- Ensure compliance by housekeeping staff with cleaning and disinfection procedures
- Develop policies regarding which patient-care equipment and environmental surfaces are to be cleaned by housekeepers and by nursing staff

Sehulster L et al. HICPAC Environmental Guideline MMWR Recomm Rep 2003;52(RR-10):1
Rutala WA et al. HICPAC Guideline for Disinfection and Sterilization in Healthcare Facilities, 2008
Dumigan DG et al. Am J Infect Control 2010 (in press)

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Methods for Assessing Cleaning Practices

- Visual inspection
  - Check list to assure surfaces have been wiped
- Marking surfaces with fluorescent dye, and checking to see if marker was removed during cleaning
- Culturing surfaces (aerobic colony counts)
  - Contact agar plates or moistened swab cultures
- ATP bioluminescence assays to measure cleanliness

Griffith CJ et al. J Hosp Infect 2000;45:19
Cooper RA et al. Am J Infect Control 2007;35:338
Lewis T et al. J Hosp Infect 2008;69:156
Dancer SJ J Hosp Infect 2009;73:378

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Checklist For Daily Cleaning of High-Touch Surface

Bedrails, bed frame	☐
Overbed table	☐
TV remote control	☐
Nurse call button	☐
Telephone	☐
Bathroom: grab bars	☐
toilet seat	☐
faucet handles	☐
Light switches	☐
Door handles	☐

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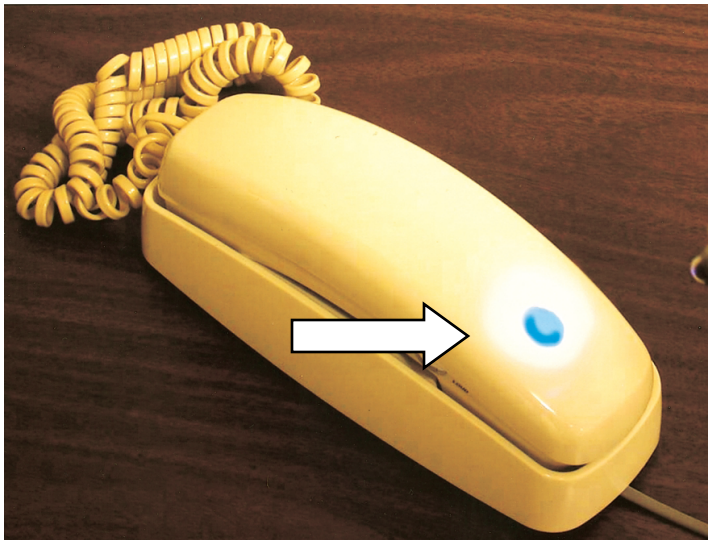
Fluorescent Dye Marker System for Monitoring Cleaning Practices

- Prospective study conducted in 3 hospitals
- 12 high-touch objects in patient rooms were marked with invisible fluorescent solution after terminal cleaning
  - Marks moistened by disinfectant spray could be removed by wiping surface for 5 seconds with light pressure



Carling PC et al Clin Infect Dis 2006;42:385.

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Monitoring Cleaning Practices

- After at least 2 patients had occupied the rooms and rooms had been terminally cleaned, target surfaces were evaluated using a portable UV light to see if the marker had been wiped off
- Education and feedback given to cleaning staff

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Monitoring Cleaning Practices

- 1404 objects were evaluated before the intervention
- 744 objects were evaluated after the intervention
- Proportion of objects cleaned
  - Before intervention: 47%
  - After interventions: 76 - 92%
- Technique improved in all hospitals ($p < 0.001$)
- Technique has been adopted in numerous hospitals and has led to improved cleaning practices

Carling PC et al. Clin Infect Dis 2006;42:385
Carling PC et al. Infect Control Hosp Epidemiol 2008;29:1

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Aerobic Colony Counts

- Methods of culturing environmental surfaces
  - Moistened swab inoculated onto agar +/- broth enrichment
    - Most useful for irregularly shaped surfaces
  - Agar contact plates (Rodac)
    - Recommended for flat surfaces
    - Yields number of colonies per square inch or centimeter
- Currently, no standard methods for how to obtain & to process specimens for aerobic colony counts
  - Provide data on contamination by important pathogens
- No accepted criteria for defining a surface as “clean” by using aerobic colony counts

Sehulster L et al. MMWR Recomm Rep 2003;52(RR-10):1
Dancer SJ J Hosp Infect 2004;56:10

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Monitoring Cleaning Practices

- ATP bioluminescence methods have been used for years to monitor adequacy of cleaning procedures
  - in beverage and food processing industries
- Methods detect ATP from bacteria, human secretions, food

Luciferase + D-Luciferin + O_2 + ATP

Luciferase + oxy-luciferin + CO_2 + AMP + PP_i + Light

- Amount of light is proportional to concentration of ATP present

Griffith CL et al. J Hosp Infect 2000;45:19
Malik RE et al. Am J Infect Control 2003;31:181
Lewis T et al. J Hosp Infect 2008;69:156

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ATP Bioluminescence Assay Systems

Step 1

Use special swab to sample surface

Step 2

Place swab in reaction tube

Step 3

Place tube in luminometer
Results: Relative Light Units

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ATP Bioluminescence Assay Systems

- Provide quantitative measure of cleanliness
- Results are available in seconds
- Can be used to educate housekeepers and give them feedback regarding their performance
- Can identify variations in housekeeping practices

Griffith CL et al. J Hosp Infect 2000;45:19
Boyce JM et al. Infect Control Hosp Epidemiol 2009;30:678
Boyce JM et al. Infect Control Hosp Epidemiol 2010;31:99

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Advantages and Disadvantages of Methods for Assessing Cleaning Practices

Method	Advantages	Disadvantages
Visual inspection	Simple	Does not provide reliable assessment of cleanliness
Fluorescent marker system	Inexpensive Minimal equipment needed	Must mark surfaces before cleaning, and check them after cleaning
Aerobic colony counts	Relatively simple Detects presence of pathogens	More expensive Results not available for 48 hrs later
ATP bioluminescence assay systems	Provides quantitative measure of cleanliness Quick results	More expensive Requires special equipment

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Internet Resources

- **HICPAC guidelines**
  - www.cdc.gov/ncidod/dhqp/gl_environinfection.html
  - www.cdc.gov/ncidod/dhqp/pdf/guidelines/Disinfection_Nov_2008.pdf
- www.disinfectionandsterilization.org
- www.cleanhospitals.net
  - **Click on Clean Environment**

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