Reduce *C. difficile* Infection: Environmental Perspective

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Disclosure: Clorox

LECTURE OBJECTIVES

- Understand the epidemiology and impact of *C. difficile*
- Discuss how to prevent transmission of *C. difficile* via contaminated surfaces
- Identify effective preventive strategies

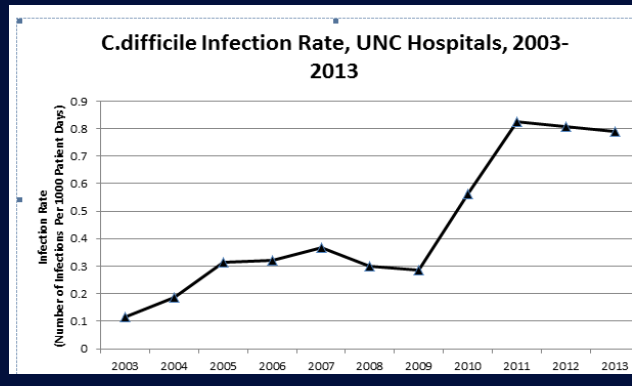
CLOSTRIDIUM DIFFICILE MICROBIOLOGY

- Anaerobic bacterium
- Forms spores that persist
- Colonizes human GI tract
- Fecal-oral spread
- Toxins produce colitis
  - Diarrhea
  - More severe disease; death
- 2-steps to infection
  - New acquisition via transmission
  - Antibiotics result in vulnerability
- CDI due to BI/NAP1/027 carries high mortality and management remains problematic

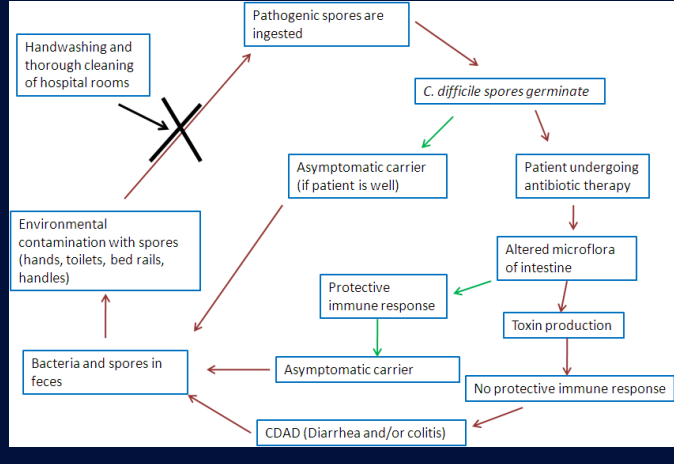
C. difficile: MICROBIOLOGY AND EPIDEMIOLOGY

- Gram-positive bacillus: Strict anaerobe, spore-former
- Colonizes human GI tract
- Increasing prevalence and incidence
- New epidemic strain that hyperproduces toxins A and B
- Introduction of CDI from the community into hospitals
- High morbidity and mortality in elderly
- Asymptomatic *C. difficile* carriers may be reservoir in healthcare
- Inability to effectively treat fulminant CDI
- Absence of a treatment that will prevent recurrence of CDI
- Inability to prevent CDI

C. difficile Infection Rate, 2003-2013



C. difficile PATHOGENESIS



CDC

FACTORS LEADING TO ENVIRONMENTAL TRANSMISSION OF *CLOSTRIDIUM DIFFICILE*

- Frequent contamination of the environment
- Stable in the environment
- Relatively resistant to disinfectants
- Low inoculating dose
- Common source of infectious gastroenteritis
- Susceptible population (limited immunity)

ENVIRONMENTAL CONTAMINATON

- **25%** (117/466) of cultures positive (<10 CFU) for *C. difficile*. **>90% of sites positive with incontinent patients.** (Samore et al. AJM 1996;100:32)
- **31.4%** of environmental cultures positive for *C. difficile*. (Kaatz et al. AJE 1988;127:1289)
- **9.3%** (85/910) of environmental cultures positive (floors, toilets, toilet seats) for *C. difficile*. (Kim et al. JID 1981;143:42)
- **29%** (62/216) environmental samples were positive for *C. difficile*. 29% (11/38) positive cultures in rooms occupied by asymptomatic patients and 49% (44/90) in rooms with patients who had CDAD. (NEJM 1989;320:204)
- **10%** (110/1086) environmental samples were positive for *C. difficile* in case-associated areas and **2.5%** (14/489) in areas with no known cases. (Fekety et al. AJM 1981;70:907)

C. difficile Environmental Contamination

Rutala, Weber. SHEA. 3rd Edition. 2010

- Frequency of sites found contaminated~10->50% from 13 studies-stethoscopes, bed frames/rails, call buttons, sinks, hospital charts, toys, floors, windowsills, commodes, toilets, bedsheets, scales, blood pressure cuffs, phones, door handles, electronic thermometers, flow-control devices for IV catheter, feeding tube equipment, bedpan hoppers
- *C. difficile* spore load is low-7 studies assessed the spore load and most found <10 colonies on surfaces found to be contaminated. Two studies reported >100; one reported a range of "1->200" and one study sampled several sites with a sponge and found 1,300 colonies *C. difficile*.

SURVIVAL

C. difficile

- Vegetative cells
  - Can survive for at least 24 h on inanimate surfaces
- Spores
  - Spores survive for up to 5 months. 10^6 CFU of *C. difficile* inoculated onto a floor; marked decline within 2 days. Kim et al. J Inf Dis 1981;143:42.

FREQUENCY OF ACQUISITION OF *C. difficile* ON GLOVED HANDS AFTER CONTACT WITH SKIN AND ENVIRONMENTAL SITES

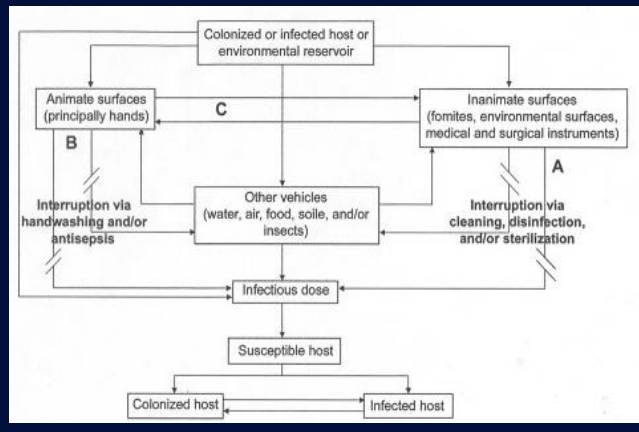
Risk of hand contamination after contact with skin and commonly touched surfaces was identical (50% vs 50%)

FREQUENCY OF ENVIRONMENTAL CONTAMINATION AND RELATION TO HAND CONTAMINATION

- Study design: Prospective study, 1992
- Setting: Tertiary care hospital
- Methods: All patients with CDI assessed with environmental cultures
- Results
  - Environmental contamination frequently found (25% of sites) but higher if patients incontinent (>90%)
  - Level of contamination low (<10 colonies per plate)
  - Presence on hands correlated with prevalence of environmental sites

Samore MH, et al. Am J Med 1996;100:32-40

TRANSMISSION MECHANISMS INVOLVING THE SURFACE ENVIRONMENT



Rutala WA, Weber DJ. In:"SHEA Practical Healthcare Epidemiology" (Lautenbach E, Woeltje KF, Malani PN, eds), 3rd ed, 2010.

ACQUISITION OF MRSA ON HANDS AFTER CONTACT WITH ENVIRONMENTAL SITES

ACQUISITION OF MRSA ON HANDS/GLOVES AFTER CONTACT WITH CONTAMINATED EQUIPMENT

TRANSFER OF MRSA FROM PATIENT OR ENVIRONMENT TO IV DEVICE AND TRANSMISSON OF PATHOGEN

ACQUISITION OF *C. difficile* ON PATIENT HANDS AFTER CONTACT WITH ENVIRONMENTAL SITES AND THEN INOCULATION OF MOUTH

Effective Surface Decontamination

Product and Practice = Perfection

Effective Surface Decontamination

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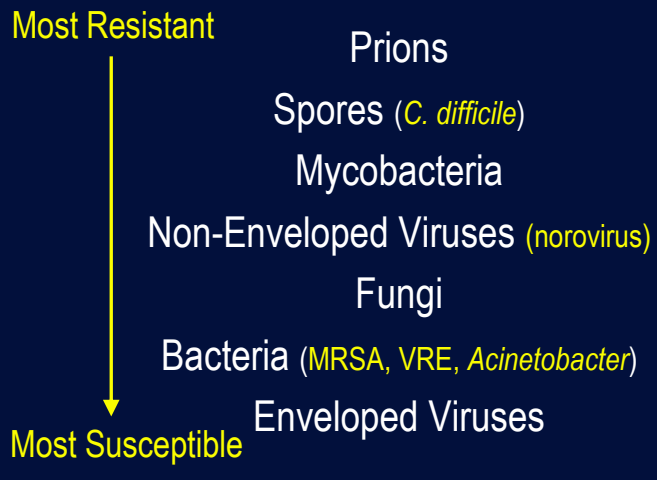
DECREASING ORDER OF RESISTANCE OF MICROORGANISMS TO DISINFECTANTS/STERILANTS



DISINFECTANTS AND ANTISEPSIS

C. difficile spores at 20 min, Rutala et al, 2006

- No measurable activity (1 *C. difficile* strain, J9)
  - CHG
  - Vesphene (phenolic)
  - 70% isopropyl alcohol
  - 95% ethanol
  - 3% hydrogen peroxide
  - Clorox disinfecting spray (65% ethanol, 0.6% QUAT)
  - Lysol II disinfecting spray (79% ethanol, 0.1% QUAT)
  - TBQ (0.06% QUAT); QUAT may increase sporulation capacity-Lancet 2000;356:1324
  - Novaplus (10% povidone iodine)
  - Accel (0.5% hydrogen peroxide)

DISINFECTANTS AND ANTISEPSIS

C. difficile spores at 10 and 20 min, Rutala et al, 2006

- ~4 $\log_{10}$ reduction (3 *C. difficile* strains including BI-9)
  - Clorox, 1:10, ~6,000 ppm chlorine (but not 1:50)
  - Clorox Clean-up, ~19,100 ppm chlorine
  - Tilex, ~25,000 ppm chlorine
  - Steris 20 sterilant, 0.35% peracetic acid
  - Cidex, 2.4% glutaraldehyde
  - Cidex-OPA, 0.55% OPA
  - Wavicide, 2.65% glutaraldehyde
  - Aldahol, 3.4% glutaraldehyde and 26% alcohol

C. difficile Spores
EPA-Registered Products

- List K: EPA's Registered Antimicrobials Products Effective Against *C. difficile* spores, April 2014
- http://www.epa.gov/oppad001/list_k_clostridium.pdf
- 34 registered products; most chlorine-based, some HP/PA-based, PA with silver

SURFACE DISINFECTION
Effectiveness of Different Methods

Technique (with cotton)	*C. difficile* Log_{10} Reduction (1:10 Bleach)
Saturated cloth	3.90
Spray (10s) and wipe	4.48
Spray, wipe, spray (1m), wipe	4.48
Spray	3.44
Spray, wipe, spray (until dry)	4.48
5500 ppm chlorine pop-up wipe	3.98
Non-sporicidal wipe	≥2.9

Rutala, Gergen, Weber. **ICHE 2012;33:1255-58**

Disinfectant Product Substitutions

Donskey CJ. AJIC. May 2013

- Six of the 7 interventions were quasi-experimental studies in which rates were compared before and after interventions with no concurrent control group
- Confounding factors not reported (e.g., hand hygiene or Contact Precaution compliance)
- Decrease in the incidence in 6 of 7 studies

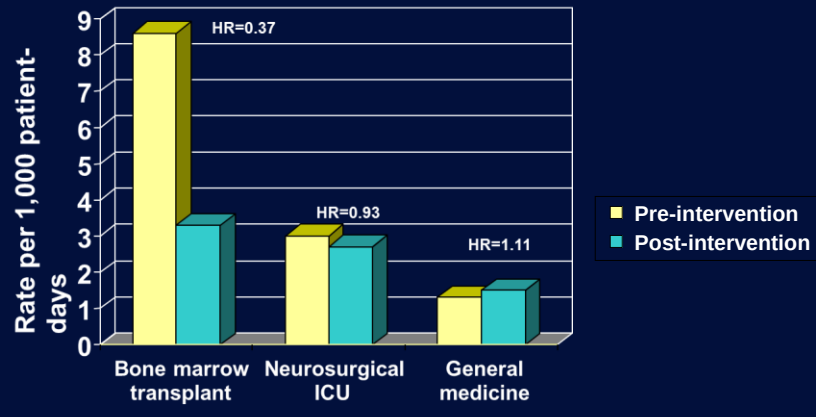
Substitution of Hypochlorite for Non-Sporicidal Cleaning Agents to Control *C. difficile*

Ref	Setting	Effect on CDI rates
1	Medical Ward	Outbreak ended
2	Bone marrow transplant (BMT) unit, Medical Ward, ICU	Significant decrease on BMT unit, but not on the other 2 wards
3	2 medical wards (crossover study)	Decreased on 1 of 2 wards
4	Medical and surgical ICUs	Decreased on both units
5	3 hospitals	48% decrease in prevalence density of CDI
6	2 medical wards	85% decrease in hospital acquired CDI

1). Katz G. Am J Epidemiol 1988;127:1289-94; 2). Mayfield JL. Clin Infect Dis 2000;31:995-1000;
3). Wilcox MH. J Hosp Infect 2003;54:109-114; 4). McMullen KM. Infect Control Hosp Epidemiol 2007;28:205-7; 5). Hacek DM. Am J Infect Control 2010;38:350-3; 6). Orenstein R. Infect Control Hosp Epidemiol 2011;32:1137-9

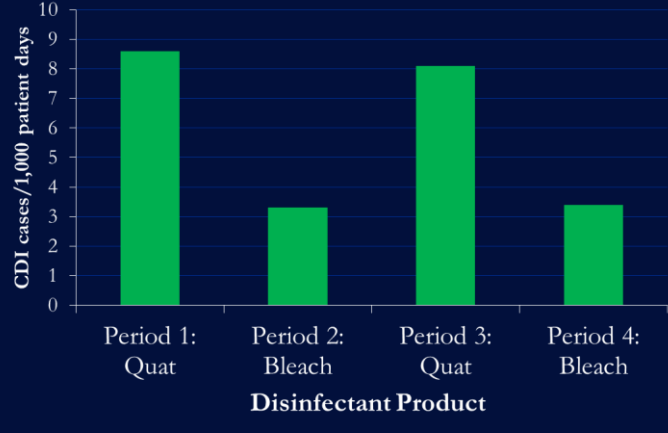
Effect of Environmental Disinfection with 10% Bleach on CDI Rates

(results suggest greater impact when baseline incidence is high)



Mayfield JL, et al. Clin Infect Dis. 2000;31:995-1000

Increased CDI Incidence on BMT Unit after Switch Back to Quaternary Ammonium Product



Mayfield JL, et al. Clin Infect Dis. 2000;31:995-1000

ALL "TOUCHABLE" (HAND CONTACT) SURFACES SHOULD BE WIPED WITH DISINFECTANT

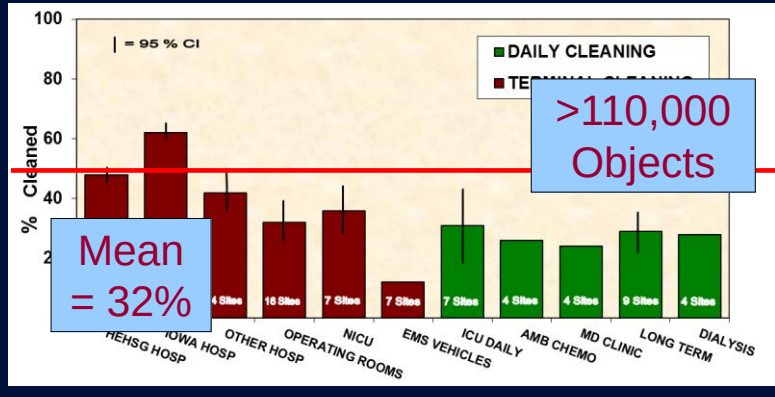
"High touch" objects only recently defined (no significant differences in microbial contamination of different surfaces) and "high risk" objects not epidemiologically defined.

Effective Surface Decontamination

Product and Practice = Perfection

Thoroughness of Environmental Cleaning

Carling P. AJIC 2013;41:S20-S25



Mean proportion of surfaces disinfected at terminal cleaning is 32%

Terminal cleaning methods ineffective (products effective practices deficient [surfaces not wiped]) in eliminating epidemiologically important pathogens

EVALUATION OF HOSPITAL ROOM ASSIGNMENT AND ACQUISITION OF CDI

- Study design: Retrospective cohort analysis, 2005-2006
- Setting: Medical ICU at a tertiary care hospital
- Methods: All patients evaluated for diagnosis of CDI 48 hours after ICU admission and within 30 days after ICU discharge
- Results (acquisition of CDI)
  - Admission to room previously occupied by CDI = 11.0%
  - Admission to room not previously occupied by CDI = 4.6% (p=0.002)

Shaughnessy MK, et al. ICHE 2011;32:201-206

MONITORING THE EFFECTIVENESS OF CLEANING

Cooper et al. AJIC 2007;35:338; Carling P AJIC 2013;41:S20-S25

- Visual assessment-not a reliable indicator of surface cleanliness
- ATP bioluminescence-measures organic debris (each unit has own reading scale, <250-500 RLU)
- Microbiological methods-<2.5CFUs/cm^2-pass; can be costly and pathogen specific
- Fluorescent marker-transparent, easily cleaned, environmentally stable marking solution that fluoresces when exposed to an ultraviolet light (applied by IP unbeknown to EVS, after EVS cleaning, markings are reassessed)

TERMINAL ROOM CLEANING: DEMONSTRATION OF IMPROVED CLEANING

- Evaluated cleaning before and after an intervention to improve cleaning
- 36 US acute care hospitals
- Assessed cleaning using a fluorescent dye
- Interventions
  - Increased education of environmental service workers
  - Feedback to environmental service workers

†Regularly change "dotted" items to prevent targeting objects

Carling PC, et al. ICHE 2008;29:1035-41

SURFACE EVALUATION USING ATP BIOLUMINESCENCE

Swab surface → luciferace tagging of ATP → Hand held luminometer

Used in the commercial food preparation industry to evaluate surface cleaning before reuse and as an educational tool for more than 30 years.

Wipes

Cotton, Disposable, Microfiber, Cellulose-Based, Nonwoven Spunlace

Wipe should have sufficient wetness to achieve the disinfectant contact time (e.g. >1 minute)

Daily Disinfection of High-Touch Surfaces

Kundrapu et al. ICHE 2012;33:1039

Daily disinfection of high-touch surfaces (vs cleaned when soiled) with sporicidal disinfectant in rooms of patients with CDI and MRSA reduced acquisition of pathogens on hands after contact with surfaces and of hands caring for the patient

REDUCTION IN CDI INCIDENCE WITH ENHANCED ROOM DISINFECTION

- Before-after study of CDI incidence rates in two hyperendemic wards at a 1,249 bed hospital
- Intervention: Change from cleaning rooms with QUAT to bleach wipes (0.55% Cl) for both daily and terminal disinfection
- Results: CDI incidence dropped 85% from 24.2 to 3.6 cases per 10,000 pt-days ($p<0.001$); prolonged median time between HA CDI from 8 to 80 days

Orenstein R, et al
ICHE 2011;32:1137

Effective Surface Decontamination

Practice and Product

CONTROL MEASURES

C. difficile Disinfection

- In units with high endemic *C. difficile* infection rates or in an outbreak setting, use dilute solutions of 5.25-6.15% sodium hypochlorite (e.g., 1:10 dilution of bleach) or an approved-sporicidal product for environmental decontamination of rooms of patients with CDI. (Dubberke et al. SHEA 2014).
- We now use chlorine solution in all CDI rooms for routine daily and terminal cleaning. One application of an effective product covering all hand contact surfaces (chlorine not used on floors) to allow a sufficient wetness for > 1 minute contact time. Chlorine solution normally takes 1-3 minutes to dry.
- For semicritical equipment, glutaraldehyde (20m), OPA (12m) and peracetic acid (12m) kills *C. difficile* spores using normal exposure times

NEW "NO TOUCH" APPROACHES TO ROOMDECONTAMINATION

Supplement Surface Disinfection

Rutala, Weber. Infect Control Hosp Epidemiol. 2011;32:743

EFFECTIVENESS OF UV ROOM DECONTAMINATION

Rutala WA, et al. Infect Control Hosp Epidemiol. 2010;31:1025-1029.

EFFECTIVENESS OF UV-C FOR ROOM DECONTAMINATION (Inoculated Surfaces)

Pathogens	Dose*	Mean log_{10} Reduction Line of Sight	Mean log_{10} Reduction Shadow	Time	Reference
MRSA, VRE, MDR-A	12,000	3.90-4.31	3.25-3.85	~15 min	Rutala W, et al.[1]
C. difficile	36,000	4.04	2.43	~50 min	Rutala W, et al.[1]
MRSA, VRE	12,000	>2-3	NA	~20 min	Nerandzic M, et al.[2]
C. difficile	22,000	>2-3	NA	~45 min	Nerandzic M, et al.[2]
C. difficile	22,000	2.3 overall		67.8 min	Boyce J, et al.[3]
MRSA, VRE, MDR-A, *Asp*	12,000	3.-5->4.0	1.7->4.0	30-40 min	Mahida N, et al.[4]
MRSA, VRE, MDR-A, *Asp*	22,000	≥4.0*	1.0-3.5	60-90 min	Mahida N, et al.[4]
C. difficile, G. stear spore	22,000		2.2 overall	73 min	Havill N et al[5]
VRE, MRSA, MDR-A	12,000	1.61	1.18	25 min	Anderson et al[6]

[1]ICHE 2010;31:1025; [2]BMC 2010;10:197; [3]ICHE 2011;32:737; [4]JHI 2013;84:323I [5]ICHE 2012;33:507-12 [6]ICHE 2013;34:466 * $\mu Ws/cm^2$; min = minutes; NA = not available

HP for Decontamination of the Hospital Environment
Falagas et al. J Hosp Infect. 2011;78:171

Author, Year	HP Syst	Pathogen	Before HPV	After HPV	% Reduct
French, 2004	VHP	MRSA	61/85-72%	1/85-1%	98
Bates, 2005	VHP	*Serratia*	2/42-5%	0/24-0%	100
Jeanes, 2005	VHP	MRSA	10/28-36%	0/50-0%	100
Hardy, 2007	VHP	MRSA	7/29-24%	0/29-0%	100
Dryden, 2007	VHP	MRSA	8/29-28%	1/29-3%	88
Otter, 2007	VHP	MRSA	18/30-60%	1/30-3%	95
Boyce, 2008	VHP	*C. difficile*	11/43-26%	0/37-0%	100
Bartels, 2008	HP dry mist	MRSA	4/14-29%	0/14-0%	100
Shapey, 2008	HP dry mist	*C. difficile*	48/203-24%; 7	7/203-3%; 0.4	88
Barbut, 2009	HP dry mist	*C. difficile*	34/180-19%	4/180-2%	88
Otter, 2010	VHP	GNR	10/21-48%	0/63-0%	100

USE OF HPV TO REDUCE RISK OF ACQUISITION OF MDROs

- Design: 30 mo prospective cohort study with hydrogen peroxide vapor (HPV) intervention to assess risks of colonization or infection with MDROs
- Methods:12 mo pre-intervention phase followed by HPV use on 3 units for terminal disinfection
- Results
  - Prior room occupant colonized or infected with MDRO in 22% of cases
  - Patients admitted to HPV decontaminated rooms 64% less likely to acquire any MDRO (95% CI, 0.19-0.70) and 80% less likely to acquire VRE (95% CI, 0.08-0.52)
  - Risk of *C. difficile*, MRSA and MDR-GNRs individually reduced but not significantly
  - Proportion of rooms environmentally contaminated with MDROs significantly reduced (RR, 0.65, P=0.03)
- Conclusion-HPV reduced the risk of acquiring MDROs compared to standard cleaning

Passaretti CL, et al. Clin Infect Dis 2013;56:27-35

Retrospective Study on the Impact of UV on HA MDROs Plus *C. difficile*

Haas et al. Am J Infect Control. 2014;42:S86-90

During the UV period (pulsed Xenon), **significant decrease in HA MDRO plus C. difficile**. UV used for 76% of Contact Precaution discharges. 20% decrease in HA MDRO plus C. difficile during the 22-m UV period compared to 30-m pre-UV period.

This technology should be considered (capital equipment budget) for terminal room disinfection (e.g., after discharge of patients under CP, during outbreaks) if studies continue to demonstrate a benefit.

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- Understand the epidemiology and impact of *C. difficile*
- Discuss how to prevent transmission of *C. difficile* via contaminated surfaces
- Identify effective preventive strategies

Reduce *C. difficile* Infections: Environmental Perspective

- Contaminated environment likely important for *C. difficile*
- Sodium hypochlorite (diluted 1:10 with water) or EPA-registered sporicidal products are effective but surfaces must be thoroughly wiped to eliminate environmental contamination
- Monitor the effectiveness of room cleaning (e.g., fluorescent dye)
- Inadequate terminal cleaning of rooms occupied by patients with *C. difficile* pathogens places the next patients in these rooms at increased risk of acquiring these organisms
- Eliminating the environment as a source for transmission of nosocomial pathogens requires: adherence to proper room cleaning and disinfection protocols (thoroughness), effective product (EPA-registered sporicide), and “no touch” technology if studies continue to demonstrate a benefit.

THANK YOU!
www.disinfectionandsterilization.org