C. difficile and the Environment: Disinfection Practices and Mitigating Risk to Patients

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DISCLOSURES

- Consultation
 - Advanced Sterilization Products, Clorox
- Honoraria (speaking)
 - Advanced Sterilization Products, 3M
- Grants
 - CDC

LECTURE OBJECTIVES

- Understand the impact of *C. difficile*
- Review the role of the environment in disease transmission
- Discuss how to prevent transmission of *C. difficile* via contaminated surfaces
- Identify effective preventive strategies

HAZARDS IN THE HOSPITAL



Weinstein RA. Am J Med 1991;91(suppl 3B):179S

THE ROLE OF THE ENVIRONMENT IN DISEASE TRANSMISSION

- Over the past decade there has been a growing appreciation that environmental contamination makes a contribution to HAI with MRSA, VRE, *Acinetobacter*, norovirus and *C. difficile*
- Surface disinfection practices are currently not effective in eliminating environmental contamination
- Inadequate terminal cleaning of rooms occupied by patients with MDR pathogens places the next patients in these rooms at increased risk of acquiring these organisms

KEY PATHOGENS WHERE ENVIRONMENTIAL SURFACES PLAY A ROLE IN TRANSMISSION

- MRSA
- VRE
- Acinetobacter spp.
- Clostridium difficile
- Norovirus
- Rotavirus
- SARS

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
- Inability to effectively treat fulminant CDI
- Absence of a treatment that will prevent recurrence of CDI
- Inability to prevent CDI

C. difficile

- Linked to more than 30,000 deaths/year among the 347,000 hospitalizations in US
- 75% show symptoms in nursing homes/MD offices/clinics
- At least \$1B in extra health care per year

C. difficile: A GROWING THREAT

CDI NOW THE MOST COMMON HEALTHCARE-ASSOCIATED PATHOGEN

Analysis of 10 community hospitals, 2005-2009, in the Duke DICON system



Miller BA, et al. ICHE 2011;32:387-390

C. difficile PATHOGENESIS



CDC



FACTORS LEADING TO ENVIRONMENTAL TRANSMISSION OF *CLOSTRIDIUM DIFFICILE*

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

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.

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. 10⁶ 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%)



Guerrero et al. AJIC 2012; 40:556-8

FREQUENCY OF ENVIRONMENTAL CONTAMINATION AND RELATION TO HAND CONTAMINATION

- Study design: Prospective study, 1992 ٠
- Setting: Tertiary care hospital ٠
- Methods: All patients with CDI • assessed with environmental cultures
- Results ٠
 - **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

	All Rooms	Double Rooms	
Site	No. Positive/ No. Tested (%)	Index Side (%)	Roommate Side (%)
Floor	15/31 (48)	NA	NA
Commode	7/17 (41)	NA	NA
Windowsill	6/16 (38)	NA	NA
Toilet	15/45 (33)	NA	NA
Buzzer	11/57 (19)	6/19 (32)	1/17 (6)
Bedsheets	12/56 (21)	4/20 (20)	2/14 (14)
Bedrails	15/81 (18)	7/26 (27)	2/25 (8)
Totals	81/303 (27)	17/65 (26)*	5/56 (9)

Frequency of Cultures Positive for Clostridium difficile From Different Environmental Sites Within the Hospital Room

*P = 0.02 by Fisher's exact test, index side versus roommate side. NA = not applicable.

Correlation Between Proportion of Positive Environmental Sites and Isolation of **Clostridium difficile From Hands of Hospital Personnel**

Environmental Sites Positive (%)	No. of Index Cases With Environmental Sites and Personnel Cultured	No. of Positive Personnel/ No. of Personnel Cultured (%)
0	12	0/25
1–25	. 5	0/11
26–50	5	1/12 (8)
>50	6	9/25 (36)

Chi-square test for linear trend in proportions: P < 0.01.

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PERCENT OF STOOL, SKIN, AND ENVIRONMENT CULTURES POSITIVE FOR *C. difficile*



Skin (chest and abdomen) and environment (bed rail, bedside table, call button, toilet seat) Sethi AK, et al. ICHE 2010;31:21-27

Risk of Acquiring MRSA and VRE from Prior Room Occupants

- Admission to a room previously occupied by an MRSApositive patient or VRE-positive patient significantly increased the odds of acquisition for MRSA and VRE (although this route is a minor contributor to overall transmission). Arch Intern Med 2006;166:1945.
- Prior environmental contamination, whether measured via environmental cultures or prior room occupancy by VRE-colonized patients, increases the risk of acquisition of VRE. Clin Infect Dis 2008;46:678.
- Prior room occupant with CDAD is a significant risk for CDI acquisition. Shaughnessy et al. ICHE 2011;32:201

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)

ABLE 3.	Multivariate	Analysis	of Risk	Factors	for	Ac-
uisition of	f Clostridium	difficile In	nfection	(CDI)		

Risk factor	HR (95% CI)	Р	
Prior room occupant with CDI	2.35 (1.21-4.54)	.01	
Greater age	1.00 (0.99-1.01)	.71	
Higher APACHE III score	1.00 (1.00-1.01)	.06	
Proton pump inhibitor use	1.11 (0.44-2.78)	.83	
Antibiotic exposure			
Norfloxacin	0.38 (0.05-2.72)	.33	
Levofloxacin	1.08 (0.67-1.73)	.75	
Ciprofloxacin	0.49 (0.15-1.67)	.23	
Fluoroquinolones	1.17 (0.72-1.91)	.53	
Clindamycin	0.45 (0.14-1.42)	.17	
Third- or fourth-generation			
cephalosporins	1.17 (0.76-1.79)	.48	
Carbapenems	1.05 (0.63-1.75)	.84	
Piperacillin-tazobactam	1.31 (0.82-2.10)	.27	
Other penicillin	0.47 (0.23-0.98)	.04	
Metronidazole	1.31 (0.83-2.07)	.24	
Vancomycin			
Oral	1.38 (0.32-5.89)	.67	
Intravenous	1.55 (0.88-2.73)	.13	
Aminoglycosides	1.27 (0.78-2.06)	.35	
Multiple (≥3 antibiotic			
classes)	1.28 (0.75-2.21)	.37	

NOTE. APACHE, Acute Physiology and Chronic Health Evaluation; CI, confidence interval; HR, hazard ratio.

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

FACTORS LEADING TO ENVIRONMENTAL TRANSMISSION OF *CLOSTRIDIUM DIFFICILE*

- Stable in the environment
- Low inoculating dose
- Common source of infectious gastroenteritis
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C. difficile spores



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
 - Phenolic
 - 70% isopropyl alcohol
 - 95% ethanol
 - 3% hydrogen peroxide
 - Disinfecting spray (65% ethanol, 0.6% QUAT)
 - Disinfecting spray (79% ethanol, 0.1% QUAT)
 - 0.06% QUAT; QUAT may increase sporulation capacity- Lancet 2000;356:1324
 - 10% povidone iodine
 - 0.5% hydrogen peroxide

DISINFECTANTS AND ANTISEPSIS

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

- ~4 log₁₀ reduction (3 *C. difficile* strains including BI-9)
 Bleach, 1:10, ~6,000 ppm chlorine (but not 1:50)
 - Chlorine, ~19,100 ppm chlorine
 - Chlorine, ~25,000 ppm chlorine
 - 0.35% peracetic acid
 - 2.4% glutaraldehyde
 - OPA, 0.55% OPA
 - 2.65% glutaraldehyde
 - 3.4% glutaraldehyde and 26% alcohol



Effective Surface Decontamination

Practice and Product

Environmental Surface Disinfection

Product-5000-6000ppm chlorine effective, other sporicidal products

SURFACE DISINFECTION

Effectiveness of Different Methods

Technique (with cotton)	<i>C. difficile</i> 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	<u>></u> 2.9

Rutala, Gergen, Weber. ICHE. In press

Thoroughness of Environmental Cleaning

Carling et al. ECCMID, Milan, Italy, May 2011



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

"High touch" objects only recently defined and "high risk" objects not scientifically defined.

CLINICAL PRACTICE GUIDELINES FOR *C. difficile*, SHEA & IDSA, 2010

- HCWs and visitors must use gloves (AI) and gowns (BIII) on entry to room
- Emphasize compliance with the practice of hand hygiene (AII)
- In a setting in which there is an outbreak or an increased CDI rate, instruct visitors and HCP to wash hands with soap (or antimicrobial soap) and water after caring for or contacting patients with CDI (BIII)
- Accommodate patients with CDI in a private room with contact precautions (BIII)
- Maintain contact precautions for the duration of diarrhea (CIII)
- Identification and removal of environmental sources of *C. difficile*, including replacement of electronic rectal thermometers with disposables, can reduce the incidence of CDI (BII)
- Use chlorine containing cleaning agents or other sporicidal agents in areas with increased rates of CDI (BII)
- Routine environmental screening for *C. difficile* is NOT recommended (CIII)

Cohen SH, et al. ICHE 2010;31:431-435

PROVING THAT ENVIRONMENTAL CONTAMINATION IMPORTANT IN *C. difficile* TRANSMISSION

- Environmental persistence (Kim et al. JID 1981;14342)
- Frequent environmental contamination (McFarland et al. NEJM 1989;320:204)
- Demonstration of HCW hand contamination (Samore et al. AJM 1996;100:32)
- Environmental \Rightarrow hand contamination (Samore et al. AJM 1996;100:32)
- Person-to-person transmission (Raxach et al. ICHE 2005;26:691))
- Transmission associated with environmental contamination (Samore et al. AJM 1996;100:32)
- CDI room a risk factor (Shaughnessy et al. IDSA/ICAAC. Abstract K-4194)
- Improved disinfection $\Rightarrow \Downarrow$ epidemic CDI (Kaatz et al. AJE 1988;127:1289)
- Improved disinfection $\Rightarrow \Downarrow$ endemic CDI (Boyce et al. ICHE 2008;29:723)

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



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



FIGURE 1. Effect of daily disinfection of high-touch environmental surfaces on acquisition of *Clostridium difficile* and methicillin-resistant Staphylococcus aureus (MRSA) on gloved hands of investigators after contact with the surfaces. A, Percentage of positive C, difficile cultures; B, mean number of C, difficile colony-forming units acquired; C, percentage of positive MRSA cultures; D, mean number of MRSA colonyforming units acquired.

Effect of Hypochlorite on Environmental Contamination and Incidence of *C. difficile*

- Use of chlorine (500-1600 ppm) decreased surface contamination and the outbreak ended. Mean CFU/positive culture in outbreak 5.1, reduced to 2.0 with chlorine. (Kaatz et al. Am J Epid 1988;127:1289)
- In an intervention study, the incidence of CDAD for bone marrow transplant patients decreased significantly, from 8.6 to 3.3 cases per 1000 patient days after the environmental disinfection was switched from QUAT to 1:10 hypochlorite solution in the rooms of patients with CDAD. No reduction in CDAD rates was seen among NS-ICU and medicine patients for whom baseline rates were 3.0 and 1.3 cases per 1000-patient days. (Mayfield et al. Clin Inf Dis 2000;31:995)

Effect of Hypochlorite on Environmental Contamination and Incidence of *C. difficile*

- 35% of 1128 environmental cultures were positive for *C*. *difficile*. To determine how best to decontaminate, a crossover study conducted. There was a significant decrease of *C*. *difficile* on one of two medicine wards (8.9 to 5.3 per 100 admissions) using hypochlorite (1,000 ppm) vs. detergent. (Wilcox et al. J Hosp Infect 2003;54:109)
- Acidified bleach (5,000 ppm) and the highest concentration of regular bleach tested (5,000 ppm) could inactivate all the spores in <10 minutes. (Perez et al. AJIC 2005;33:320)

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) for routine disinfection. (Category II).
- We now use chlorine solution in all CDI rooms for routine daily and terminal cleaning (formerly used QUAT in patient rooms with sporadic CDI). One application of an effective product covering all surfaces 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) reliably kills *C. difficile* spores using normal exposure times

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

"High touch" objects only recently defined and "high risk" objects not scientifically defined.

	Percentage cleaned		
Object	Mean ± SD	Range	CI
Sink	82 ± 12	57-97	77-88
Toilet seat	76 ± 18	40-98	68-84
Tray table	77 ± 15	53-100	71-84
Bedside table	64 ± 22	23-100	54-73
Toilet handle	60 ± 22	23-89	50-69
Side rail	60 ± 21	25-96	51-69
Call box	50 ± 19	9-90	42-58
Telephone	49 ± 16	18-86	42-56
Chair	48 ± 28	11-100	35-61
Toilet door knobs	28 ± 22	0-82	18-37
Toilet hand hold	28 ± 23	0-90	18-38
Bedpan cleaner	25 ± 18	0-79	17-33
Room door knobs	23 ± 19	2-73	15-31
Bathroom light switch	20 ± 21	0-81	11-30

Rates of Cleaning for 14 Types of High-Risk Objects TABLE.

NOTE. CI, confidence interval.

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DEFINING HIGH TOUCH SURFACES



Huslage K, Rutala WA, Sickbert-Bennett E, Weber DJ. ICHE 2010;31:850-853

ICU

Microbiologic Assessment of High, Medium and Low Touch Surfaces. Huslage, Rutala, Gergen, Weber. ICHE. 2010;31:850-3

No correlation between touch frequency and microbial contamination

Surface	Before Cleaning Mean CFU/Rodac	After Cleaning Mean CFU/Rodac	Significance
High	71.9 (Cl 46.5-97.3)	9.6	High=Low High=Medium
Medium	44.2 (CI 28.1-60.2)	9.3	Medium=Low
Low	56.7 (Cl 34.2-79.2)	5.7	

UNC HEALTH CARE ISOLATION SIGN FOR PATIENTS WITH NOROVIRUS OR *C. difficile*

- Use term Contact-Enteric Precautions
- Requires gloves and gown when entering room
- Recommends hand hygiene with soap and water (instead of alcoholbased antiseptic)
- Information in English and Spanish



ANTISEPSIS TO PREVENT C. difficile INFECTIONS

Yes

No stal

Either soap or CHG works as a handwash 70% isopropyl showed no inactivation of C. difficile spores at exposure times of for removal of C. difficile. 5m, 15m, and 30m. ICHE 1994;15:697. Wullt et al. ICHE 2003;24:765.

What are the data for soap and water versus alcohol-based hand rubs for *C. difficile* spores? Hand Hygiene with Soap and Water Is Superior to Alcohol Rub and Antiseptic Wipes for Removal of *C. difficile*

(Oughton et al. Infect Control Hosp Epidemiol 2009; 30:939)

Objective: Evaluate HH methods for efficacy in removing *C. difficile*

- Design: Randomized crossover comparison among 10 volunteers experimentally contaminated by 1.4x10⁵ *C. difficile* (62% spores)
- Methods: Interventions were evaluated for mean reduction
- Conclusion: Handwashing with soap and water showed the greatest efficacy in removing *C. difficile* and should be performed preferentially over the use of alcohol-based hand rubs when contact with *C. difficile* is suspected or likely

C. difficile after Hand Hygiene Interventions

(Oughton et al. Infect Control Hosp Epidemiol 2009; 30:939)

Intervention	Mean Count, log ₁₀ CFU/ml
Warm water and plain soap, 10s	1.99
Cold water and plain soap, 10s	1.90
Warm water and antibacterial (CHG) soap, 10s	2.31
Antiseptic (PCMX) hand wipe, 15s	3.25
Alcohol-based handrub, 15s	3.74
No intervention	3.82

The Role of the Environment in Disease Transmission

• Over the past decade there has been a growing appreciation that environmental contamination makes a contribution to HAI with MRSA, VRE, *Acinetobacter*, norovirus and *C. difficile*

 Inadequate terminal cleaning of rooms occupied by patients with MDR pathogens places the next patients in these rooms at increased risk of acquiring these organisms

Thoroughness of Environmental Cleaning Carling et al. ECCMID, Milan, Italy, May 2011



NEW APPROACHES TO ROOM DECONTAMINATION Supplements Surface Disinfection



Rutala, Weber. ICHE. 2011;32:743

	Sterinis	Steris	Bioquell	Tru-D
Abbreviation	DMHP (dry mist HP)	VHP (vaporized HP)	HPV (HP vapor)	UV-C
Active agent	Stenusil (5% HP, <50 ppm silver cations)	Vaprox (35% HP)	35% HP	UV-C irradiation at 254 nm
Application	Aerosol of active solution	Vapor, noncondensing	Vapor, condensing	UV irradiation, direct and reflected
Aeration (removal of active agent from enclosure)	Passive decomposition	Active catalytic conversion	Active catalytic conversion	Not necessary
Sporicidal efficacy	Single cycle does not inacti- vate <i>Bacillus atrophaeus</i> BIs; ~4-log ₁₀ reduction in <i>Clostridium difficile</i> [*] and incomplete inactivation in situ	Inactivation of Geoba- cillus stearothermo- philus BIs	Inactivation of <i>G. stearother- mophilus</i> BIs; >6-log ₁₀ re- duction in <i>C. difficile</i> ^a in vitro and complete inacti- vation in situ	1.7–4-log₁₀ reduction in <i>C. difficile</i> * in situ
Evidence of clinical impact	None published	None published	Significant reduction in the incidence of <i>C. difficile</i>	None published

TABLE 1. Comparison of Room Decontamination Systems That Use UV Irradiation and Hydrogen Peroxide (HP)

NOTE. Adapted from Otter and Yezli.18 BIs, biological indicators; VRE, vancomycin-resistant Enterococcus.

* All C. difficile experiments were done with C. difficile spores.

LECTURE OBJECTIVES

- Understand the impact of *C. difficile*
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C. difficile: Prevention Measures

- New Enteric Contact Isolation sign-promote soap and water and sporicidal disinfectant
- Enhanced nursing education-ICLs
- Daily/terminal bleach disinfection of all *C. difficile* patient rooms
- Bleach wipes-shared equipment
- Monitoring thoroughness of cleaning
- Isolation until no symptoms and end of treatment

C. difficile: Prevention Measures

- Use fidaxomicin in selected CDI patients to reduce recurrences
- Prescribe and use antibiotics carefully
- Follow surgical prophylaxis guidelines (max 24h)
- Test for *C. difficile* when patients have diarrhea while on antibiotics or recent antibiotics (60d)
- Use new PCR test as part of diagnostic algorithm (which increases sensitivity of diagnosis)

CONCLUSIONS

- Contaminated environment likely important for *C. difficile*
- Some disinfectants are effective but surfaces must be thoroughly wiped to eliminate environmental contamination
- 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, hand hygiene, and institution of Isolation Precautions

disinfectionandsterilization.org

THANK YOU!

