

# ***Clostridium difficile*: A Growing Threat In Your Facility**

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**Disclosure: Clorox**

## **Prevention of *C. difficile***

- Role of the environment in transmission
- *C. difficile*
  - Microbiology and epidemiology
  - Environmental contamination
  - Environmental disinfection
  - Hand hygiene
- Norovirus
- MRSA
- Other issues: microfiber, computers, green products

# Disinfection and Sterilization

EH Spaulding believed that how an object will be disinfected depended on the object's intended use.

**CRITICAL** - objects which enter normally sterile tissue or the vascular system or through which blood flows should be **sterile**.

**SEMICRITICAL** - objects that touch mucous membranes or skin that is not intact require a disinfection process (**high-level disinfection [HLD]**) that kills all microorganisms but high numbers of bacterial spores.

**NONCRITICAL** - objects that touch only intact skin require **low-level disinfection**.

# Role of Surfaces in Transmission

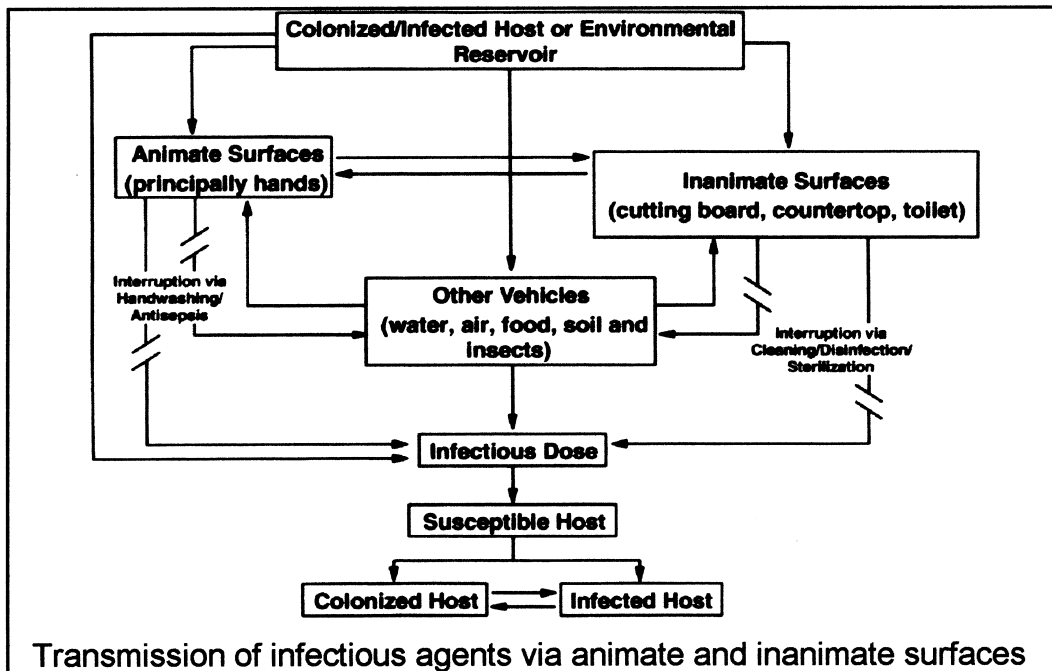
Pathogens implicated in transmission via contaminated noncritical surfaces. Patients C/I with these pathogens contaminate the environment and these pathogens survive in the environment.

- Bacteria
  - Methicillin-resistant *Staphylococcus aureus*
  - Vancomycin-resistant *Enterococcus spp.*
  - *Clostridium difficile*
  - *Acinetobacter* and *P. aeruginosa*
- Viruses
  - Rotavirus
  - Norovirus
  - SARS coronavirus

## Role of the Environment In Transmission

Hota B, Clin Inf Dis 2004;39:1182

Pathogen	Survival	Environmental Data
<i>C. difficile</i>	Months (spores)	3+
VRE	Days to weeks	3+
MRSA	Days to weeks	2-3+
<i>Acinetobacter</i>	33 days	2-3+
<i>P. aeruginosa</i>	7 h	1+

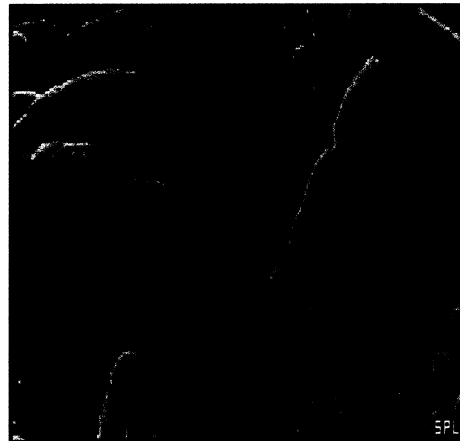


## **Prevention of *C. difficile***

- Microbiology and epidemiology
- Role of the environment in transmission
- Prevention
  - Environmental disinfection
  - Equipment disinfection
  - Hand hygiene

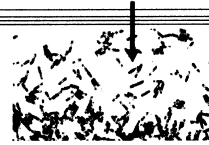
## ***Clostridium difficile*: Microbiology**

- Gram-positive bacillus
- Strict anaerobe
- Spore-forming
- Colonizes human GI tract



## *Clostridium difficile*

- Anaerobic spore-forming bacillus
- *Clostridium difficile* infection (CDI)
- Pseudomembranous colitis, toxic megacolon, sepsis, and death
- Infection control strategies
  - Prevent ingestion of the organisms/spores
    - ◆ Fecal-oral transmission through contaminated environment and hands of healthcare personnel
  - Reduce the chance of developing CDI in the event of ingestion
    - ◆ Minimize antimicrobial exposure – major risk factor for disease
      - suppression of normal flora of the colon



Healthy Colon



Pseudo-membranous colitis

## *Clostridium difficile*: Epidemiology

- Associated with gastrointestinal infection
- *C. difficile* toxin found in the stool of 15-25% of patients with antibiotic-associated diarrhea
- *C. difficile* toxin found in the stool of >95% of patients with pseudomembranous colitis
- Increasing incidence in U.S. (discharge diagnoses)
  - 1996: 31 per 100,000 population
  - 2003: 61 per 100,000 population
- Patients can be contaminated from environmental surfaces, shared instrumentation, hospital personnel hands and infected roommates Clin

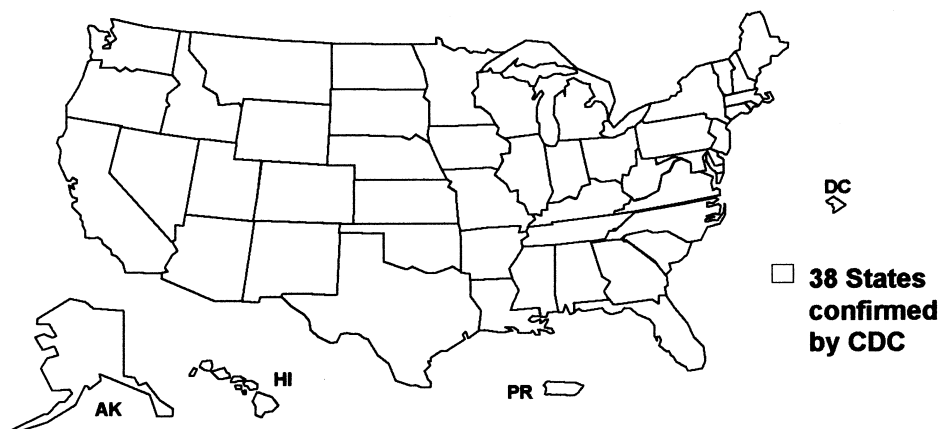
Microbiol Infect 2001;7:405; Clin Micro Rev 2004;17:863; CID 2002;34:346

## Emergence of a HYPERVIRULENT Strain

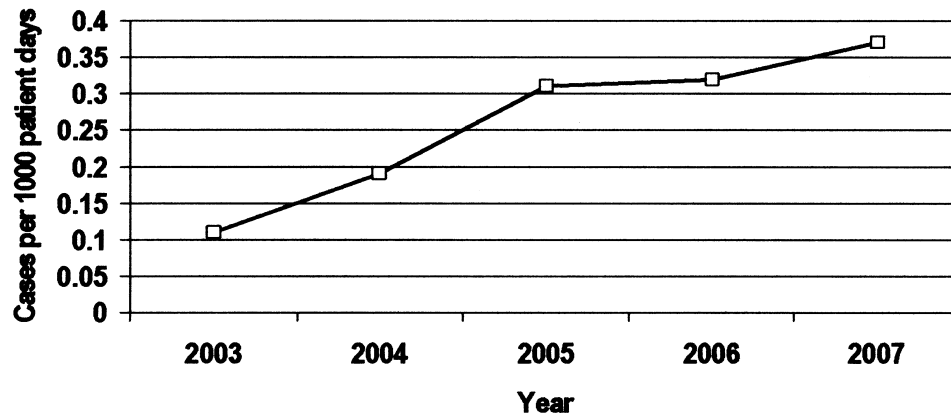
- Epidemic strain in Quebec since 2002
- Spread to United States, United Kingdom and the Netherlands
- Toxinotype III, North American PFGE type 1 (NAP1), PCR-ribotype 027, REA group B1
  - Carries binary toxin gene *cdtB* and an 18-bp deletion in *tcdC*
- Severity of disease due to hyper-production of toxins A (16-fold) and B (23-fold)
- High attributable mortality among elderly patients associated with hyper-virulent strain
- Fluoroquinolone use strongly associated as a risk factor

Pépin J, et al., *CMAJ*. 2005;173:Online1-6.; Warny M, et al. *Lancet*. 2005;366:1079-1084.; Pépin J, et al., *Clin Infect Dis*. 2005;41:1254-1260.

**States with the Epidemic Strain of *C. difficile*  
Confirmed by CDC (N=38), Updated 9 Nov. 2007**



## CDAD Rates At UNC Hospitals



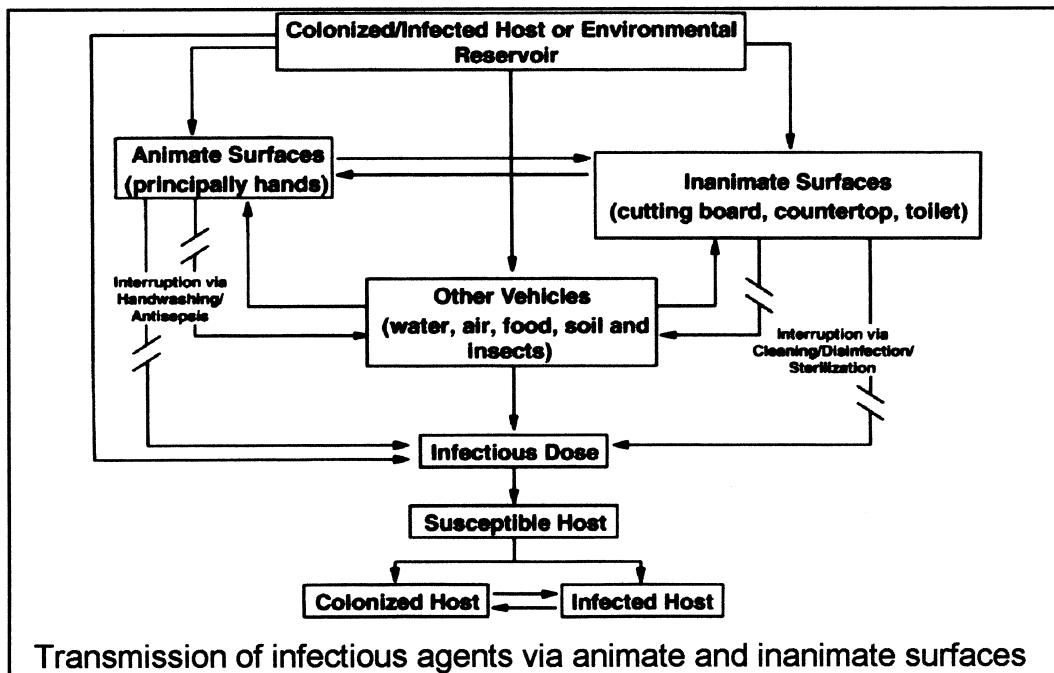
Slide courtesy of Ms. Emily Sickbert-Bennett

## Pathogenesis of CDAD

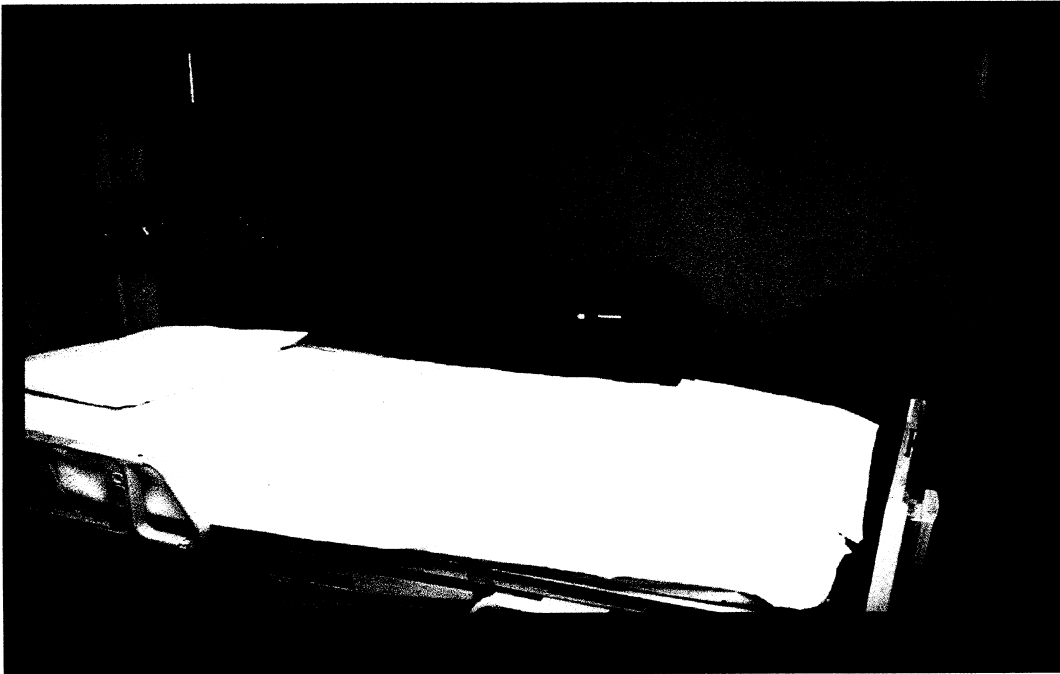
- Colonization of gut by *C. difficile* required for disease
- Disruption of normal flora also required for disease
  - Antibiotic usual culprit
  - Rarely, chemotherapeutic agents can precipitate CDAD
- Virulence factors: toxins A and B
  - Responsible for inflammation, fluid and mucous secretion, and mucosal damage leading to diarrhea or colitis

## ***C. difficile*: Current Problems**

- Increasing prevalence and incidence
- New epidemic strain that hyperproduces toxins A and B
- Introduction of CDAD from the community
- Lack of a completely sensitive and rapid diagnostic test for CDAD
- Absence of a treatment that will prevent recurrence of CDAD
- Inability to effectively treat fulminant CDI
- Inability to prevent CDAD







## ***C. difficile* Environmental Contamination**

Gerding et al Clin Inf Dis 2008;46:S43

- Because *C. difficile* shed in feces, any surface or device that becomes contaminated with feces can serve as a reservoir for *C. difficile* spores.
- Heaviest contamination
  - Floors and bedrails
- Other sites frequently found contaminated
  - Windowsills, commodes, toilets, bedsheets, call buttons, scales, blood pressure cuffs, electronic thermometers, flow-control devices for IV catheter, feeding tube equipment

## Environmental Contamination

### *C. difficile*

- 9.3% (85/910) of environmental cultures positive (floors, toilets, toilet seats) for *C. difficile*. 2.6% (13/497) cultures positive in areas with no known carriers. Kim et al. J Inf Dis 1981;143:42.
- 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. Am J Med 1981;70:907.
- 31.4% of environmental cultures positive for *C. difficile*. Kaatz et al. Am J Epid 1988;127:1289.

## Environmental Contamination

### *C. difficile*

- 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. McFarland et al. NEJM 1989;320:204
- 25% (117/466) of cultures positive (<10 CFU) for *C. difficile*. >90% of sites positive with incontinent patients. Samore et al. Am J Med 1996;100:32.
- 27% (13/48) of samples were positive for *C. difficile*. The NAP1 epidemic strain was found in 5 of 6 facilities. Dubberke et al. AJIC 2007;35:315.

## **Role of the Environment**

### ***C. difficile***

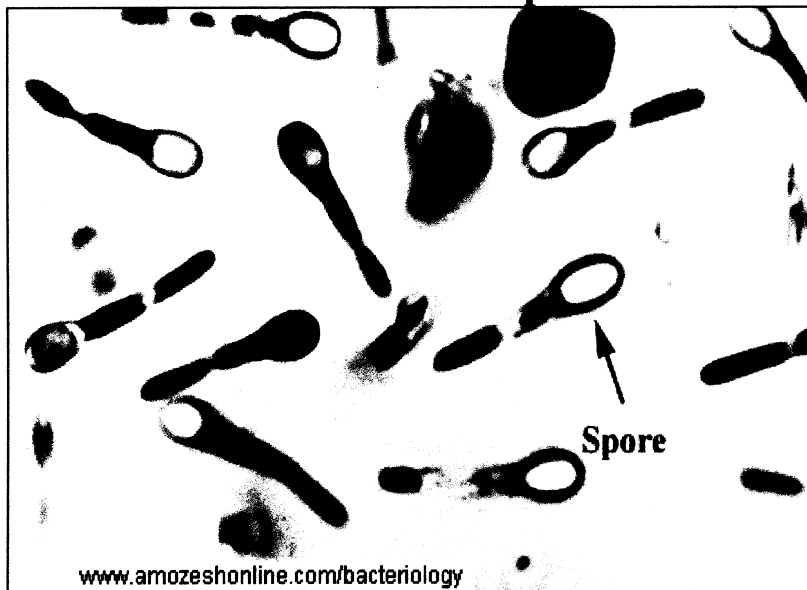
- The presence of *C. difficile* on the hands correlated with the density of environmental contamination. Samore et al. Am J Med 1996;100:32.
  - 0-25% environmental sites positive-0% hand cultures positive
  - 26-50% environmental sites positive-8% hand cultures positive
  - >50% environmental sites positive-36% hand cultures positive
- *C. difficile* incidence data correlated significantly with the prevalence of environmental *C. difficile*. Fawley et al. Epid Infect 2001;126:343.
- Environmental contamination does not play a major role in nosocomial CDAD in some endemic situations. Cohen et al. Clin Infect Dis 1997;24:889.
- 59% of 35 HCWs were *C. difficile* positive after direct contact with culture-positive patients.
- *C. difficile* skin contamination (> 1 site-groin, chest, abdomen, forearms, hands) in patients with CDI high (93%) and was easily acquired by hands. Clin Inf Dis 2008;46:447-50

## **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.
  - Hypersporulation has been shown to be a virulence-associated characteristic of outbreak strains of *C. difficile*.

### **C. difficile spores**



### **Decreasing Order of Resistance of Microorganisms to Disinfectants/Sterilants**

Prions  
Spores  
Mycobacteria  
Non-Enveloped Viruses  
Fungi  
Bacteria  
Enveloped Viruses

## Environmental Disinfection

- Disinfection with a 1:10 dilution of concentrated sodium hypochlorite (i.e., bleach) has been shown to be effective in reducing environmental contamination in patient rooms and in reducing CDI rates in hospital units where the rate of CDI is high.

## Disinfectants and Antiseptics

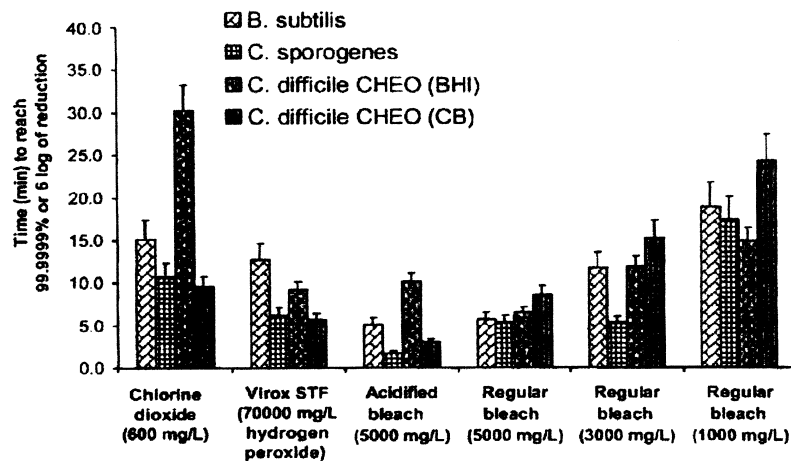
*C. difficile* spores at 20 min, Rutala et al, 2006

- 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 Antiseptics

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

- ~4 log<sub>10</sub> reduction (3 *C. difficile* strains including BI-9)
  - Clorox, 1:10, ~6,000 ppm chlorine (but not 1:50, ~1,200 ppm)
  - Clorox Clean-up, ~1,910 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



**Fig 1.** Times required for the microbicides to inactivate  $\geq 6$  log<sub>10</sub> (99.9999%) of the spores tested.

### **Decreasing Order of Resistance of Microorganisms to Disinfectants/Sterilants**

Prions  
Spores  
Mycobacteria  
Non-Enveloped Viruses  
Fungi  
Bacteria  
Enveloped Viruses

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

- Use of chlorine (500 [79%reduction]-1600 ppm [98%]) 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 cross-over 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*

- Handwashing (soap and water) , contact precautions, and meticulous environmental cleaning with an EPA-registered disinfectant should be effective in preventing the spread of the organism. McFarland et al. NEJM 1989;320:204.
- 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). One application of an effective product covering all surfaces to allow a sufficient wetness for > 1 minute contact time. Dilution of chlorine normally takes 1-3 minutes to dry. We use QUAT for disinfection of patient rooms with sporadic CDI.
- For semicritical equipment, glutaraldehyde (20m), OPA (12m) and peracetic acid (12m) reliably kills *C. difficile* spores using normal exposure times



## **Current Issues**

### ***Clostridium difficile***

- Hydrogen peroxide vapor
- Improve cleaning/disinfecting patient care areas
- Mean sporulation rate after exposure to germicides

## **Effect of Hydrogen Peroxide Vapor (HPV) on *Clostridium difficile* (CD)**

- HPV was injected into sealed wards and individual patient rooms using generators until approx 1 micron film of HP was achieved on the surface
- 5% (8/165) environmental sites cultures before HPV yielded CD compared to none of 155 cultures obtained after HPV
- HPV was effective in eradicating CD environmental contamination that remained following routine cleaning, which included use of dilute bleach

Boyce JM and others. Society of Healthcare Epidemiology of America, 2006 (abstract 156, page 109)

## **Patient Area Cleaning/Disinfecting**

PC Carling et al, SHEA 2007 and ICHE 2008;29:1

- Monitor cleaning performance using an invisible fluorescent targeting method. Rooms (14 high-touch objects) were marked and evaluated after terminal cleaning.
- Results: 1,119 rooms and 13,369 objects were evaluated in 23 hospitals. Mean proportion of objects cleaned was 49%. Following education and process improvement feedback, cleaning improved to 77%
- Conclusion: Substantial opportunity for improving terminal cleaning/disinfecting activities.

## **Disinfection of Patient Area: *C. difficile***

Eckstein et al. BMC Infect Dis 2007;7:61

- Assessed adequacy of cleaning practices in rooms of patients with CDI
- Cultured commonly touched surfaces (bedrails, phones, call buttons, door knobs, bedside tables) in rooms of patients with CDI
- Of 9 rooms of patients with CDI, 100% positive cultures prior to cleaning versus 7 (78%) after cleaning, whereas only 1 had positive cultures after bleach disinfection by research staff
- After educational intervention (stressed high touch objects to be disinfected) , rates of environmental contamination after housekeeping cleaning were significantly reduced (90%→20%)

## Patient Area Cleaning/Disinfecting

- Health care facilities may need to introduce other controls to ensure all surfaces are completely cleaned daily and terminally
  - Checklists (side rail, call box, bedside table, phone, chair, etc)
  - Assignments of responsibility to ensure complete cleaning of all potentially contaminated surfaces. Ensure all surfaces are disinfected and all equipment is assigned (e.g., assign all equipment and environmental surfaces in a patient room to either ES, Nursing, etc)
  - Invisible fluorescent marker (mark high-touch objects and if not cleaned-educate, monitor process improvement, and feedback)

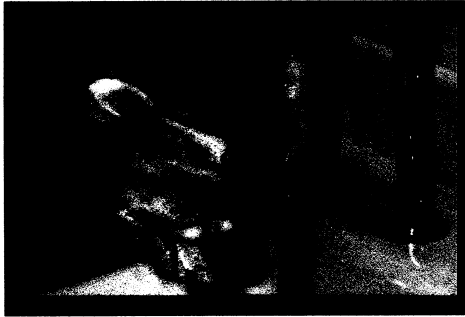
## Mean Sporulation Rates-*C. difficile*

Fawley et al. ICHE 2007;28:920; Wilcox et al. J Hosp Infection 2003;54:109

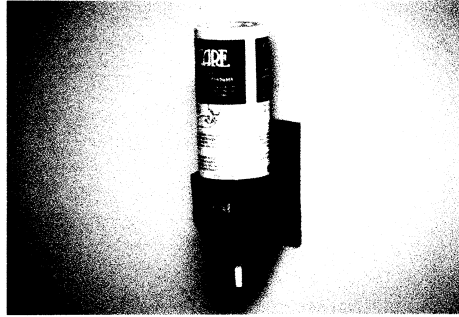
- Outbreak strains have demonstrated the capacity to hypersporulate (~30% of cells) compared with nonoutbreak strains (10%). Exact role in transmission unknown.
- Sporulation rate was 13% for 6 *C. difficile* strains and increased by exposure to detergent (24%), detergent and hypochlorite (24%) and hydrogen peroxide (33%). Rate did not increase after exposure to dichloroisocyanurate. Clinical relevance unknown as *C. difficile* strains exposed to subinhibitory concentrations of the germicides (e.g., 21 ppm chlorine) and increased sporulation may not occur at use concentration (5000 ppm chlorine).

## Antisepsis to Prevent *C. difficile* Infections

YES!!



NO!!



## Hand Hygiene and *C. difficile*



Either soap or CHG works as a handwash  
for removal of *C. difficile*.  
ICHE 1994;15:697.



70% isopropyl showed no inactivation of *C. difficile* spores at exposure times of 5m, 15m, and 30m.  
Wullt et al. ICHE 2003;24:765.



## Disinfectants and Antiseptics

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

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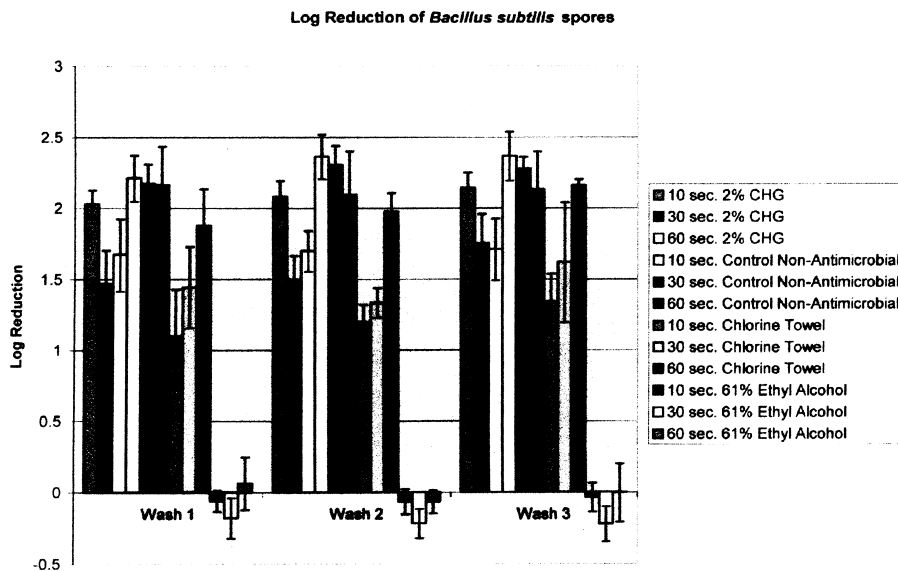
## Hand Hygiene

CDC Guideline, October 2002

- Wash hands with non-antimicrobial soap and water or with antimicrobial soap and water if exposure to *Bacillus anthracis* is suspected or proven. The physical action of washing and rinsing hands under such circumstances is recommended because alcohols, chlorhexidine, iodophors, and other antiseptic agents have poor activity against spores. Category II.

## Hand Hygiene Agents Used to Remove Spores from Contaminated Hands

- Handwashing with soap and water, 2% chlorhexidine gluconate, or chlorine-containing towels reduced the amount of *B. atrophaeus* spore contamination, whereas use of a waterless rub containing ethyl alcohol was not effective in removing spores. Weber et al. JAMA 2003;289:2174.



**Did increased use alcohol-based hand rubs lead to increased rates for *C. difficile*?**

## **Hand Hygiene with Alcohol**

### ***C. difficile***

- Promoting the use of alcohol hand rub, increased incidence of *C. difficile*. Several factors may have influenced outcome (e.g., reduced HW, more specimens sent for toxin detection, etc). King et al. J Hosp Infect 2004;56:S10
- Introducing alcohol based gel, decreased incidence of *C. difficile* associated diarrhea (not statistically significant). Rao et al. J Hosp Infect 2002;50:42
- Introducing an alcohol-based handrub, the incidence of new isolates of *C. difficile* was unchanged. Gordin et al. ICHE 2005;26:650.



## Hand Hygiene with Alcohol

### *C. difficile*

- Introducing an alcohol-based handrub had no effect on *C. difficile* rates. Leischner et al. SHEA 2005.
- Increased alcohol foam use did not result in increased CDAD rates. Elward et al. SHEA 2005.
- Increase use of ABHRs did not increase the incidence of CDAD. Boyce et al. ICHE 2006;27:479

### *C. difficile* and Use of Alcohol-Based Hand Rub

Boyce et al. ICHE 2006; 27:480.

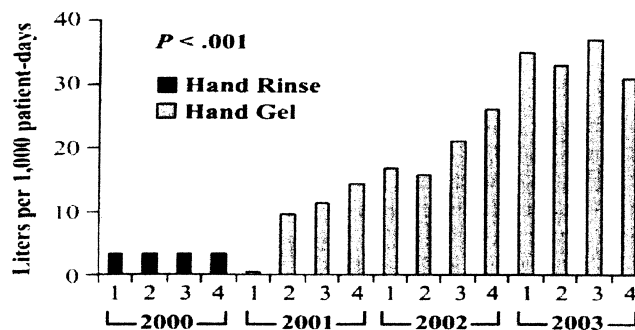
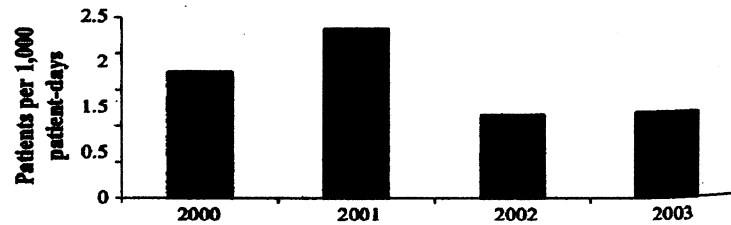


FIGURE 1. Use of alcohol hand rub by healthcare workers, in liters per 1,000 patient-days, per quarter, 2000-2003.

***C. difficile* and Use of Alcohol-Based Hand Rub**  
Boyce et al. ICHE 2006; 27:480.



**FIGURE 2.** Number of patients with 1 or more tests positive for *Clostridium difficile* toxin per 1,000 patient-days, 2000-2003.

**Increased use of ABHRs does not lead to  
increased rates of CDAD**



## CONTACT PRECAUTIONS



*Visitors, including family, must comply with all precautions listed below. Please report to the Nursing Station before entering.*



Perform hand hygiene



Gloves when entering room



Mask when patient coughing, for suctioning, and for wound irrigation



Gown if clothing will touch patient or patient items (for example, bed)

## PRECAUCIONES DE CONTACTO

*Los visitantes deben presentarse primero al puesto de enfermería antes de entrar. Lávese las manos. Póngase guantes al entrar al cuarto.*



## CONTACT PRECAUTIONS



*Visitors, including family, must comply with all precautions listed below. Please report to the Nursing Station before entering.*



Wash hands with soap and water  
Lávase las manos con agua y jabón 10



Gloves when entering room



Mask when patient coughing, for suctioning, and for wound irrigation



Gown if clothing will touch patient or patient items (for example, bed)

### PRECAUCIONES DE CONTACTO

*Los visitantes deben presentarse primero al puesto de enfermería antes de entrar. Lávese las manos. Póngase guantes al entrar al cuarto.*

## Conclusions

### *C. difficile*

#### *Clostridium difficile*

- Have been found in abundance in the environment of individuals with disease
- Have been found on the hands of healthcare workers providing care to affected patients or touching the contaminated environment
- Survive in the environment (months [spores])
- Are relatively resistant to chemical disinfection (including alcohol)
- Have caused outbreaks in hospitals
- Are transmitted by either ingestion or direct inoculation of the GI tract
- Have epidemiological evidence that environmental surface contamination may be a source for infections

## Conclusions

### *C. difficile*

- **Environmental control**
  - In general, changes in disinfectants to eliminate specific pathogens not required.
  - Current high-level disinfection recommendations are adequate to prevent healthcare-associated infections via semicritical items such as endoscopes
  - Because these three agents are resistant to many surface disinfectants, care must be taken to use agents with evidence of efficacy (e.g., hypochlorite-based products). Ensure all surfaces are disinfected and all equipment is assigned.
  - Areas with high rates of *C. difficile* (e.g., 3 cases/1000 patient days) warrant hypochlorite-based products
  - Soap and water should be used preferentially to alcohol-based hands rubs for *C. difficile*.

## Control Measures

### *C. difficile*

- Handwashing (soap and water) , contact precautions, and meticulous environmental cleaning with an EPA-registered disinfectant should be effective in preventing the spread of the organism. McFarland et al. NEJM 1989;320:204.
- 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)
- For semicritical equipment, glutaraldehyde (20m), OPA (12m) and peracetic acid (12m) reliably kills *C. difficile* spores using normal exposure times

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