

Environmental Management of *Clostridium difficile*

Dr. Lynne Schulster, Centers for Disease Control

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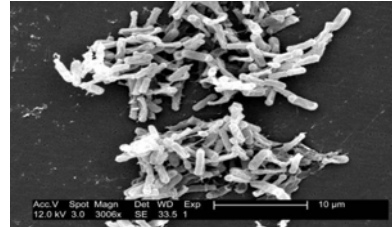
Lynne Schulster, PhD, M(ASCP)
Division of Healthcare Quality Promotion
Centers for Disease Control and Prevention
Atlanta, Georgia

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Clostridium difficile

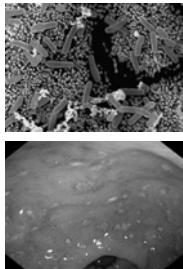
Disclaimer: The findings and conclusions in this presentation are those of the author and do not necessarily represent any determination or policy of the Centers for Disease Control and Prevention (CDC).



CDC Public Health Image Library (L. Wiggs, J. Carr)

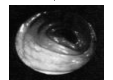
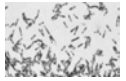
Objectives for Today's Presentation

- Epidemiology and surveillance
- Epidemic strains
- Mode of transmission
- Environmental contamination
- Spores and antimicrobial resistance
- Disinfectant studies
- Environmental (housekeeping) control measures in outbreaks
- General recommendations

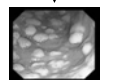


Clostridium difficile

- Anaerobic spore-forming bacillus
- *Clostridium difficile*-associated disease (CDAD)
 - Diarrhea
 - Pseudomembranous colitis, toxic megacolon, sepsis, and death
- Fecal-oral transmission
 - Fecal contamination
 - Environment, devices, and hands of healthcare personnel
- Antimicrobial exposure is major risk factor for disease
 - Acquisition and growth of *C. difficile*
 - Suppression of normal flora of the colon
- Clindamycin, penicillins, and cephalosporins

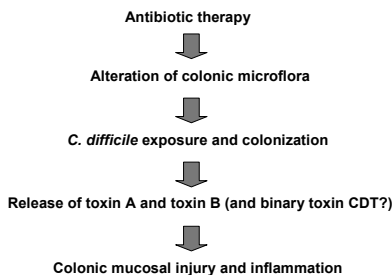


Healthy colon



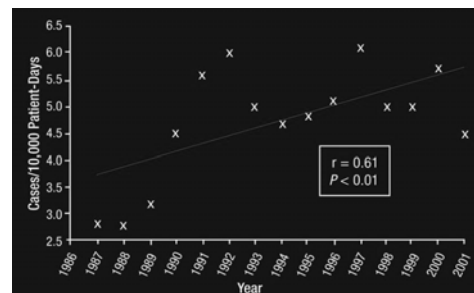
Pseudo-membranous colitis

Pathogenesis of *C. difficile* Diarrhea and Colitis



Adapted from: Kelly CP, LaMont JT. *Ann Rev Med* 1998; 49: 375-90.

Annual CDAD Rates, US Hospitals with >500 Beds, Intensive Care Unit Surveillance Component, NNIS



From: Archibald LK, Banerjee SN, Jarvis WR. *J Infect Dis* 2004; 189: 1585-9.

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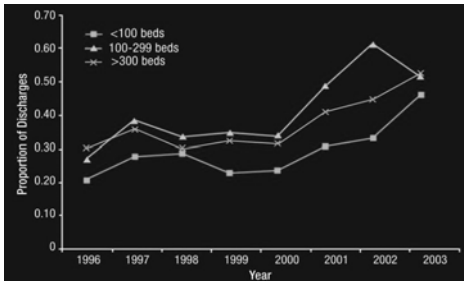
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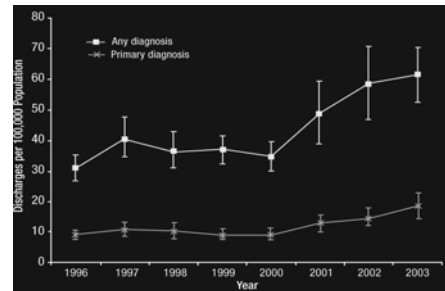
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Proportion of US Short Stay Hospital Discharges with *C. difficile* Listed as Any Diagnosis by Hospital Bed Size



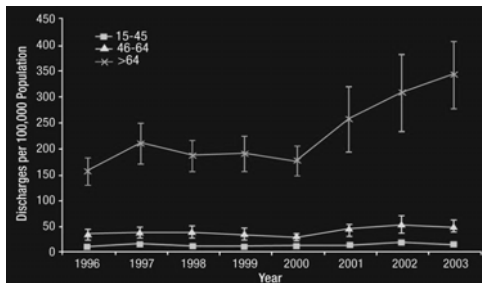
From: McDonald LC, et al. *Emerg Infect Dis.* 2006; 12(3): 409-15

National Estimates of US Short-Stay Hospital Discharges: *C. difficile* as First-Listed or Any Diagnosis



From: McDonald LC, et al. *Emerg Infect Dis.* 2006; 12(3): 409-15.

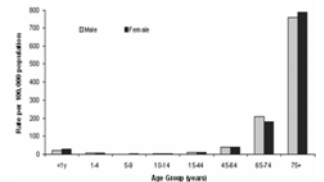
Rates of US Short Stay Hospital Discharges with *C. difficile* Listed as Any Diagnosis by Age



From: McDonald LC, et al. *Emerg Infect Dis.* 2006; 12(3): 409-15.

Age and Sex-Specific Rates of *C. difficile*: UK in 2005

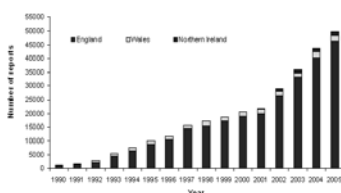
- Compiled from lab reports under voluntary reporting
- Age specific rates:
 - Age group 45-64
 - 40/100,000 population
 - Age group 65-74
 - 195/100,000 population
 - Age group ≥ 75
 - 780/100,000 population



From: Health Protection Agency, UK (accessed 3/21/07 at: http://www.hpa.org.uk/infections/topics_az/clostridium_difficile/)

UK Voluntary Surveillance for *C. difficile*: Positive Lab Samples 1990- 2005

- *C. difficile* isolated from fecal specimens
- 49,850 reports of positive cultures in 2005
 - 13.5% increase compared to 2004
 - 15% increase in England
 - 9% decrease in Wales



From: Health Protection Agency, UK (accessed 3/21/07 at: http://www.hpa.org.uk/infections/topics_az/clostridium_difficile/)

Potential Reasons for Increased CDAD Incidence and Severity

- Changes in underlying host susceptibility
- Changes in antimicrobial prescribing
- New strain with increased virulence
- Changes in infection control practices

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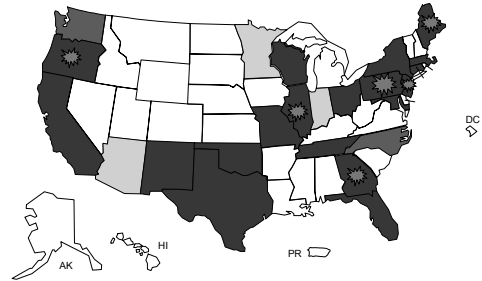
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Challenges Posed by Emerging Epidemic Strains of *C. difficile*

- Emergence of a new epidemic strain
 - Toxinotype III or "BI" by REA
 - Distinct from "J" strain of 1989-1992¹
 - Binary toxin as a possible virulence factor
 - In addition to toxins A and B containing
 - 18 bp deletion in *tcdC* gene
 - Could lead to increased toxin production (18-fold for toxin A, 23-fold for toxin B) observed by Warny et al.²
 - Increased resistance to fluoroquinolones
- Appears responsible for increase in cases
- May be responsible for increase in disease severity

1. Warny M, et al. *Lancet* 2005; 366: 1079-84.
2. Johnson S, et al. *N Engl J Med* 1999; 341: 1645-51.

States with the Epidemic Strain of *C. difficile* Confirmed by CDC and Hines VA labs (N=23), Updated 2/9/2007



Comparison of Molecular Characteristics of 2 *C. difficile* Isolates with Historical Standard-Type Strains and a Recently Recognized Epidemic Strain, by Selected Characteristics, OH and PA, 2005

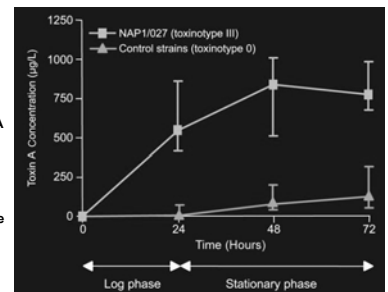
Characteristic	Standard Strain	Epidemic Strain	Ohio Strain	Pennsylvania Strain
Toxinotype	0	III	IX	XIV/XV
PFGE* pattern	< 80% related to NAP1 [†]	NAP1	85% related to NAP1	64% related to NAP1
Binary toxin	-	+	+	+
18 bp deletion in <i>tcdC</i>	-	+	-	+

*Pulsed-field gel electrophoresis.
[†]North American pulsed-field type 1.

From: McDonald LC, et al. *N Engl J Med* 2005; 353: 2433-41. See also CDC. *MMWR*. 2005;54:1201-5.

Increased Toxin A Production *in vitro*

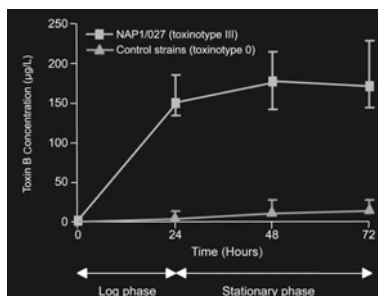
In vitro production of toxin A by *C. difficile* isolates. Median concentration and IQRs are shown. *C. difficile* strains included 25 toxinotype 0 and 15 NAP1/027 strains (toxinotype III) from various locations.



From: Warny M, et al. *Lancet* 2005; 366: 1079-84.

Increased Toxin B Production *in vitro*

In vitro production of toxin B by *C. difficile* isolates. Median concentration and IQRs are shown. *C. difficile* strains included 25 toxinotype 0 and 15 NAP1/027 strains (toxinotype III) from various locations.



From: Warny M, et al. *Lancet* 2005; 366: 1079-84.

Proposed Case Definitions for Surveillance Purposes

- CDAD case-patient: patient with symptoms of diarrhea or toxic megacolon with (+) result of a lab assay and/or endoscopic or histopathological evidence of pseudomembrane colitis
- Recurrent CDAD: repeated episodes within 8 weeks of each other
- Severe CDAD: CDAD-associated admission to an ICU, colectomy, or death within 30 days post onset

Note: Case-patients categorized by the setting in which *C. difficile* infection was acquired

From: McDonald LC, et al. *Infect Control Hosp Epidemiol* 2007; 28: 140-5.

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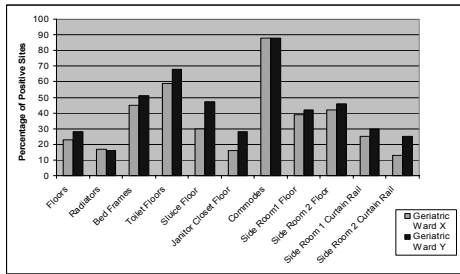
Where Has *C. difficile* Contamination Been Found?

- Nath SK, et al. *Infect Control Hosp Epidemiol* 1994; 15: 382-9.
 - Patient Care Areas (ICU, hematologic oncology, medical units):
 - Toilet seat and bowl, floor by beds, pt. washroom floor, paper towel dispenser, table top
 - Dirty Utility Rooms:
 - Bedpan hopper, steam flusher, floor, waste container
 - Healthcare Workers:
 - Shoes
- 29% (7/24) environmental isolates matched the predominant toxigenic epidemic type from cases.

Where Has *C. difficile* Contamination Been Found?

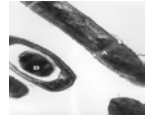
- Pulvirenti JJ, et al. *Infect Control Hosp Epidemiol* 2002; 23: 641-7.
 - Patient-Care Areas (HIV unit, ID unit):
 - Floors, bed rails, common toilets, portable toilets, communal blood pressure cuff
 - Positive environmental cultures:
 - Cook County Hospital: 14.7% (24/286)
 - Rush Presbyterian St. Luke's Med Center: 2.9% (3/104)
 - Outbreak strain (CD1A) at Cook County Hospital was detected in the environment 1 month after index outbreak patient was identified

Frequency of *C. difficile* Culture Positive Sites in Study Areas



From: Wilcox MH, et al. *J Hosp Infect* 2003; 54: 109-14

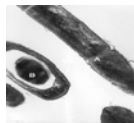
Bacterial Spores and Antimicrobial Resistance



- Dormancy is a form of resistance
- Characteristics that contribute to resistance:
 - Proteinaceous coat
 - Low water content in the central core
 - Nucleic acid protection by small acid-soluble proteins
 - Low permeability of inner spore membranes
 - DNA repair upon germination

From: Young SB, Setlow P. *J Appl Microbiol* 2003; 95: 54-67.

Bacterial Spores: Inactivation by Oxidative Germicides

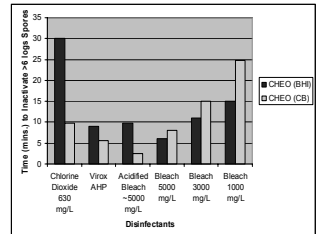


- Bacillus subtilis* spores
- Hypochlorite and chlorine dioxide
- Effect of hypochlorite on spores
 - Renders spores defective in germination due to damage to the spore inner membrane
 - Nutrient germinant receptors and cortex lytic enzymes also severely damaged
- Effect of chlorine dioxide on spores
 - Damages spore inner membrane
 - Germination starts but does not progress

From: Young SB, Setlow P. *J Appl Microbiol* 2003; 95: 54-67.

Activity of Selected Oxidative Germicides Against *C. difficile* Spores

- Strong oxidative disinfectants can inactivate high numbers of spores
- Contact time 10-15 mins.
- Occupational hazards with acidified bleach and 5000 mg/L FC bleach (chlorine gas)
- Can be used to manage an identified problem, but should not be used on a routine basis because of corrosiveness and hazards to workers and patients
- Clean to minimize organic soil amounts before disinfecting



From: Perez J, et al. *Am J Infect Control* 2005; 33: 320-5.

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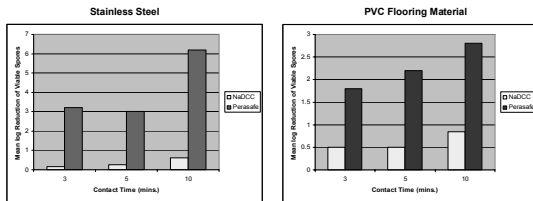
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Effects of Perasafe® and Sodium Dichloroisocyanurate (NaDCC) Against *C. difficile* Spores

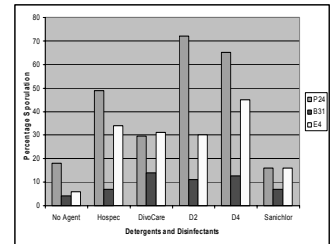


- NaDCC: 1000 mg/L, chlorine-releasing agent
- Perasafe: Peroxygen system (peracetyl ions, hydrogen peroxide, acetic acid); equivalent to peracetic acid at 0.26%

From: Block C. *J Hosp Infect* 2004; 57: 144-8.

Cleaning Agents and Their Impact on *C. difficile*

- Epidemic (P24), clinical (B31), and environmental (E4) strains; fecal emulsions
- Sub-inhibitory concentrations of chemicals
- Chlorine-containing products: DivoCare, Sanichlor
- Non-chlorine containing products: Hospec, D2, D4
- Increased levels of sporulation in the presence of sub-inhibitory concentrations of cleaning agents
- P24 produced more spores in the presence of the non-chlorinated products



From: Wilcox MH, Fawley WN. *Lancet* 2000; 356: 1324

Environmental Infection Control Measures in Recent Outbreaks

- Surprisingly few details!
- Educate patient-care staff and housekeepers
- Use of chlorine-based, oxidative cleaners and disinfectants
- Target frequently touched surfaces
- Increase frequency of cleaning
- Pre-clean if surfaces visibly soiled



Importance of Hand Hygiene

- *Most common mode of transferral of pathogens is via the hands!*
- Infections acquired in healthcare



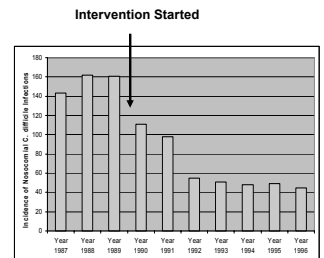
Indications for Hand Hygiene

- When hands are visibly dirty, contaminated, or soiled, wash with non antimicrobial or antimicrobial soap and water.
- If hands are not visibly soiled, use an alcohol-based handrub for routinely decontaminating hands.
- After glove removal during outbreaks of CDAD, hands should be washed with non antimicrobial or antimicrobial soap and water

Guideline for Hand Hygiene in Health-care Settings. *MMWR* 2002; vol. 51, no. RR-16.

Effect of Multiple Intervention Measures: *C. difficile*

- Isolation policy
- Monthly education program for all healthcare workers
- Phenolic disinfectant
- Antimicrobial soap for handwashing
- Centralized sterilization department
- Cart washer installation
- Active surveillance program



From: Zafar AB, et al. *Am J Infect Control* 1998; 26: 588-93

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Best Practices for *C. difficile* Management: Canada

- All horizontal surfaces in the room and all items within patient reach cleaned 2X daily with hospital grade disinfectant
- Focus on frequently touched items
- Applying disinfectants
 - Pour into cleaning cloths, avoid putting cloths into disinfectant solutions
 - No spray applications
 - Change cloths and mops frequently
 - Disposable toilet brushes
- Discharge/transfer cleaning
- Use hypochlorite disinfectants after cleaning when ongoing transmission of *C. difficile* is evident
- Educate staff re: cleaning protocols, precautions
- Audit tool/checklists should be used to monitor cleaning
- Floors are not a significant source of transmission of *C. difficile* and do not require special cleaning procedures

From: Ministry of Health and Long-Term Care/Public Health Division/ Provincial Infectious Diseases Advisory Committee, Toronto, Canada: *Best Practices Document for the Management of Clostridium difficile in All Health Care Settings*, April 2006

Guidance on Environmental Management of *C. difficile*: UK

- Increase the frequency of cleaning in areas with CDAD patients
- Add chlorine-based disinfectant to regimen
- Pay particular attention to toilets, bathrooms, and areas around sluices, commodes, and bedpan washer units, floors in these areas
- Floors, fittings, bedside furniture
- Terminal cleaning/disinfection with chlorine-based disinfection
 - Consideration given to treatments with either vaporized hydrogen peroxide, ozone, or steam

From: UK Dept. of Health: *Healthcare Associated Infections, in Particular Infections Caused by Clostridium difficile*, 7 December 2006 (accessed 3/21/07 at: http://www.dh.gov.uk/en/Publicationsandstatistics/Lettersandcirculars/Dearcolleagueletters/DH_063090)

Additional Guidance from the UK

- May 2006: High Impact Intervention for the Reduction of *Clostridium difficile*
 - <http://dh.gov.uk/PolicyandGuidance/HealthandSocialCareTopics/HealthcareAcquiredInfection/HealthcareAcquiredGeneralInformation/SavingLivesDeliveryProgramme/fs/en>
- National guidance on *C. difficile* associated infection
 - http://hpa.org.uk/infections/topics_az/clostridium_difficile/C_diff_report1994.pdf

Recommendations for Hospitals

- Hospitals should conduct surveillance for CDAD
 - Recently proposed surveillance recommendations¹
- Early diagnosis and treatment important for reducing severe outcomes and should be emphasized
 - Subset of epidemic isolates tested: metronidazole susceptible
- Strict infection control: CDC Fact Sheet²
 - Contact precautions for CDAD patients
 - An environmental cleaning and disinfection strategy
 - Hand-washing with CDAD patients in outbreak
- Further research needed
 - Role for antimicrobial controls in stemming this epidemic

¹McDonald et al. *Infect Control Hosp Epidemiol* 2007; 28:140-145

²See CDC *C. difficile* Fact Sheets: <http://www.cdc.gov/ncidod/dhqp/>

CDC's "EIC" Guideline 2003

- Environmental Services



Where Can I Find the EIC Guidelines?

- Part II Recommendations:
 - MMWR 2003; 52 (RR-10): 1-44
 - Errata: MMWR 2003; 52 (42): 1025-6
- Full text version:
 - www.cdc.gov/ncidod/dhqp/gl_environmentinfection.html
- Print version (ASHE):
 - www.hospitalconnect.com/ashe/resources/Importantresources.html

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US Environmental Protection Agency (EPA) and *C. difficile*

- Registered disinfectants with label claims for *C. difficile* reflect data for vegetative phase bacteria
- No registered sporicides available for environmental (housekeeping) surface treatment
- Antimicrobials Division in 2007 will work to develop new guidelines for approving disinfectant label claims against *C. difficile* spores



Acknowledgments

Thanks to:

- L. Clifford McDonald, MD, FACP, FSHEA in the Division of Healthcare Quality Promotion, CDC for slides and summary of emerging epidemic strains of *C. difficile*
- Public health professionals around the world for their efforts to develop guidance to prevent and control this infectious disease

Thank You!

Division of Healthcare Quality Promotion
Centers for Disease Control and Prevention

"Protect patients, protect health care personnel, and promote safety, quality, and value in the health care delivery system"

The Next Few Teleclasses

- | | |
|----------|--|
| April 12 | <i>Who's Afraid of the CIC Exam?</i> (a FREE teleclass)
... with Sharon MacDonald and Sharon Krystofiak, CBIC |
| April 19 | <i>Bacterial Resistance to Biocides in the Healthcare Environment</i>
... with Dr. Jean Yves Maillard, University of Cardiff, UK |
| April 25 | <i>Making Infection Control Really Work</i>
... with Prof. Seto Wing Hong, University of Hong Kong |
| April 26 | <i>Environmental Surveillance for Infection Control</i>
... with Andrew Streifel, University of Minnesota |
| May 8 | <i>Panton-Valentine Leucocidin Producing S. aureus</i>
... with Brenda Dale & Adam Brown, National Health Service, UK |

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