Clostridium difficile (CDI) Infections Toolkit

Activity C: ELC Prevention Collaboratives

Carolyn Gould, MD MSCR

Cliff McDonald, MD, FACP

Division of Healthcare Quality Promotion

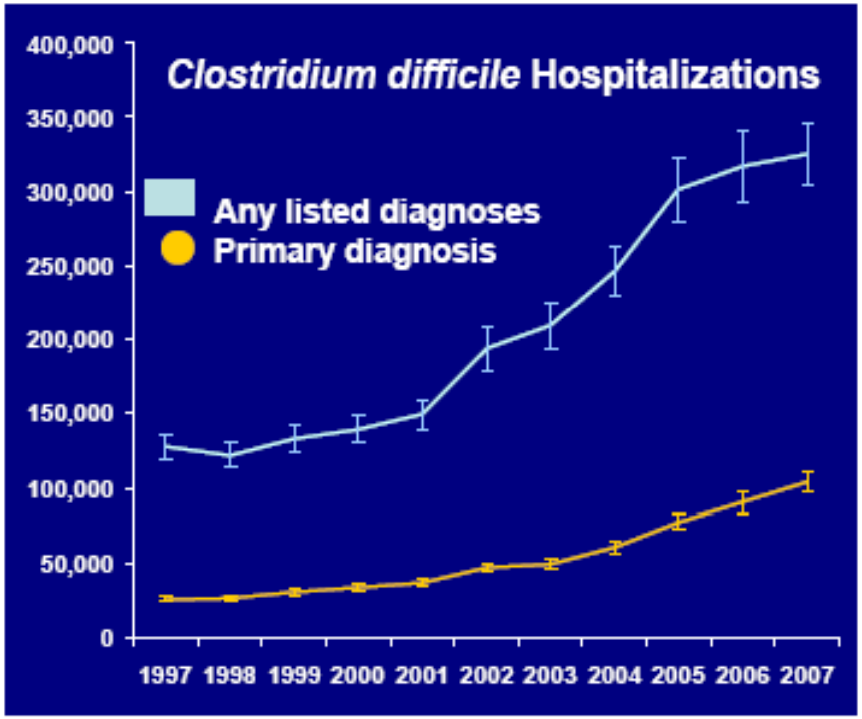
Centers for Disease Control and Prevention

Draft - 12/23/09 --- Disclaimer: The findings and conclusions in this presentation are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.

Outline

- **Background**
  - Impact
  - HHS Prevention Targets
  - Pathogenesis
  - Epidemiology
- **Prevention Strategies**
  - Core
  - Supplemental
- **Measurement**
  - Process
  - Outcome
- **Tools for Implementation/Resources/References**

Background: Impact



- Hospital-acquired, hospital-onset cases 165,000, $1.3 billion in excess costs, and 9,000 deaths annually
- Hospital-acquired, post-discharge (up to 4 weeks) 50,000, $0.3 billion in excess costs, and 3,000 deaths annually
- Nursing home-onset cases 263,000, $2.2 billion in excess costs, and 16,500 deaths annually

Campbell et al. Infect Control Hosp Epidemiol. 2009:30:523-33.

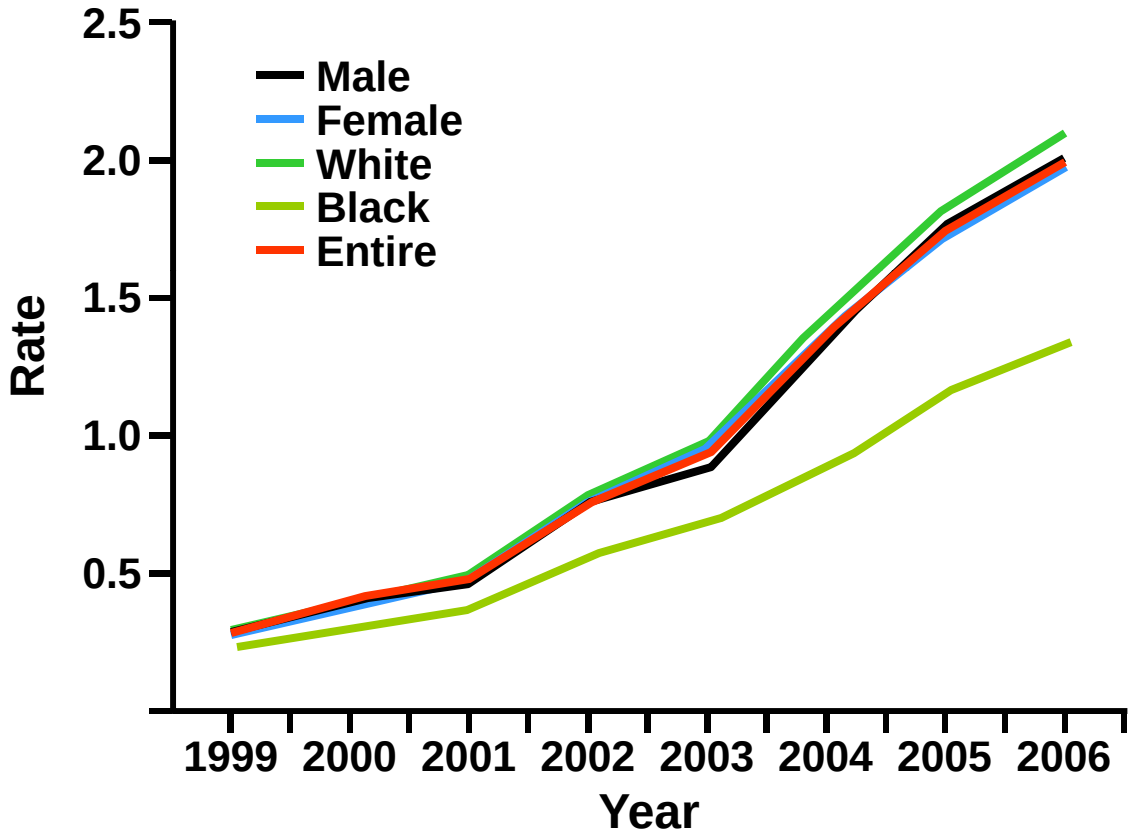
Dubberke et al. Clin Infect Dis. 2008;46:497-504.

Dubberke et al. Emerg Infect Dis. 2008;14:1031-8.

Elixhauser et al. HCUP Statistical Brief #50. 2008.

Background: Impact

Age-Adjusted Death Rate* for Enterocolitis Due to *C. difficile*, 1999–2006



***Per 100,000 US standard population**

Heron et al. Natl Vital Stat Rep 2009;57(14).
Available at http://www.cdc.gov/nchs/data/nvsr/nvsr57/nvsr57_14.pdf

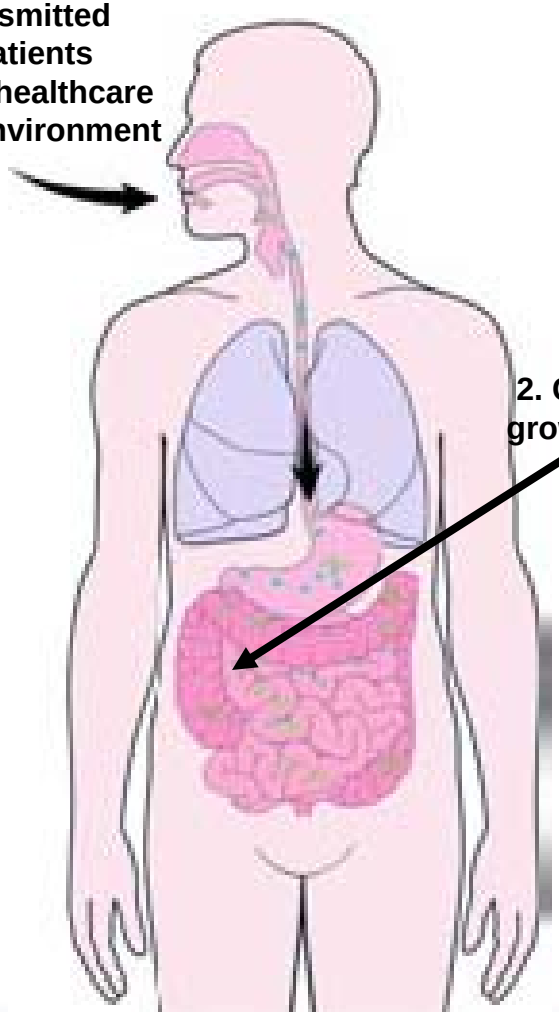
Background: HHS Prevention Targets

- **Case rate per 10,000 patient-days as measured in NHSN**
  - National 5-Year Prevention Target: 30% reduction
- **Because little baseline infection data, also track administrative data for ICD-9-CM coded *C. difficile* hospital discharges**
  - National 5-Year Prevention Target: 30% reduction

http://www.hhs.gov/ophs/initiatives/hai/prevtargets.html

Background: Pathogenesis of CDI

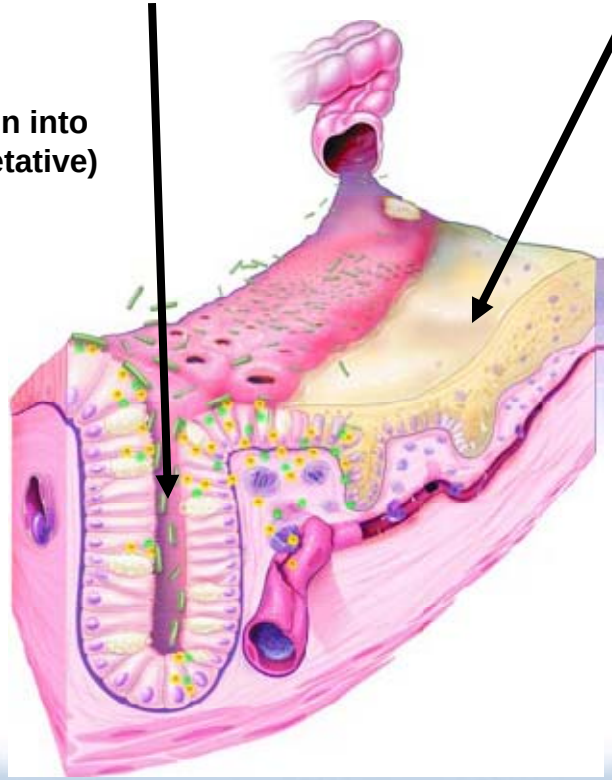
1. Ingestion of spores transmitted from other patients via the hands of healthcare personnel and environment



2. Germination into growing (vegetative) form

3. Altered lower intestine flora (due to antimicrobial use) allows proliferation of *C. difficile* in colon

4. Toxin A & B Production leads to colon damage +/- pseudomembrane



Sunenshine et al. Cleve Clin J Med. 2006;73:187-97.

Background: Epidemiology

Current epidemic strain of *C. difficile*

- BI/NAP1/027, toxinotype III
- Historically uncommon
  - Epidemic since 2000
  - Increased resistance to fluoroquinolones
- More virulent
  - Increased toxin A and B production
  - Polymorphisms in binding domain of toxin B
  - Increased sporulation

McDonald et al. N Engl J Med. 2005;353:2433-41.
Warny et al. Lancet. 2005;366:1079-84.
Stabler et al. J Med Micro. 2008;57:771–5.
Akerlund et al. J Clin Microbiol. 2008;46:1530–3.

Background: Epidemiology

Risk Factors

- Antimicrobial exposure
- Acquisition of *C. difficile*
- Advanced age
- Underlying illness
- Immunosuppression
- Tube feeds
- ? Gastric acid suppression

Main modifiable risk factors

Prevention Strategies

- **Core Strategies**
  - High levels of scientific evidence
  - Demonstrated feasibility
- **Supplemental Strategies**
  - Some scientific evidence
  - Variable levels of feasibility

*The Collaborative should at a minimum include core prevention strategies. Supplemental prevention strategies also may be utilized. Hospitals should not be excluded from participation if they already have ongoing interventions using supplemental prevention strategies. Project coordinators should carefully track which prevention strategies are being utilized by participating facilities.

Prevention Strategies: Core

- Contact Precautions for duration of diarrhea
- Hand hygiene in compliance with CDC/WHO
- Cleaning and disinfection of equipment and environment
- Laboratory-based alert system for immediate notification of positive test results
- Educate about CDI: HCWs, housekeeping, administration, patients, families

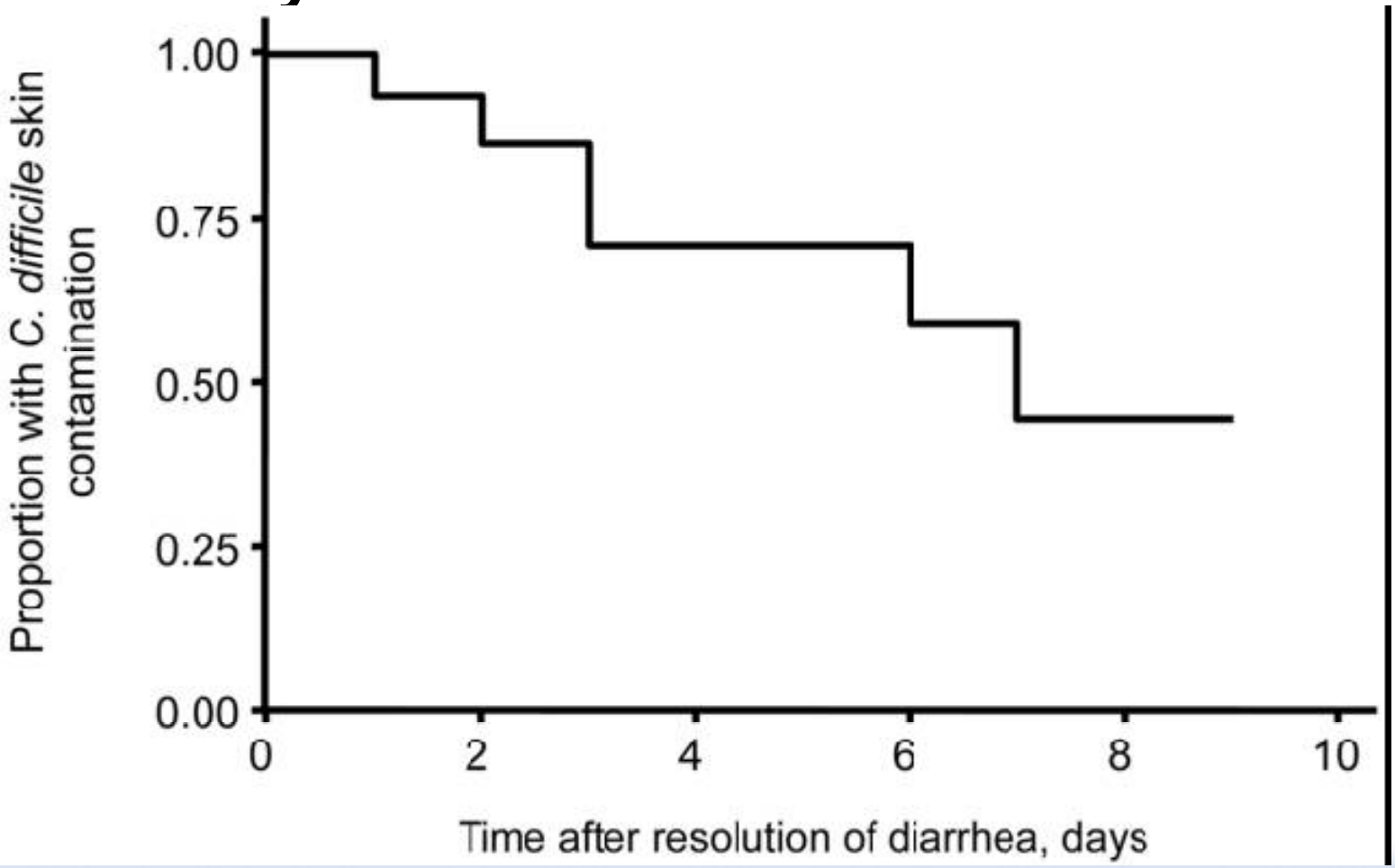
http://www.cdc.gov/ncidod/dhqp/id_CdiffFAQ_HCP.html
Dubberke et al. Infect Control Hosp Epidemiol 2008;29:S81-92.

Prevention Strategies: Supplemental

- Extend use of contact precautions beyond duration of diarrhea
- Presumptive isolation for symptomatic patients pending confirmation of CDI
- Evaluate and optimize testing
- Implement soap and water for hand hygiene before exiting room of a patient with CDI
- Implement universal glove use on units with high CDI rates
- Use sodium hypochlorite (bleach) – containing agents for environmental cleaning
- Implement an antimicrobial stewardship program

Prevention Strategies: Supplemental

Rationale for considering extending isolation beyond duration of diarrhea



Bobulsky et al. Clin Infect Dis 2008;46:447-50.

Prevention Strategies: Supplemental

Consider presumptive isolation for patients with ≥ 3 unformed stools within 24 hours

- Patients with CDI may contaminate environment and hands of healthcare personnel pending results of diagnostic testing
- CDI responsible for only ~30-40% of hospital-onset diarrhea
- However, CDI more likely among patients with ≥3 unformed (i.e. taking the shape of a container) stools within 24 hours
  - Send specimen for testing and presumptively isolate patient pending results
  - Positive predictive value of testing will also be optimized if focused on patients with ≥3 unformed stools within 24 hours
  - Exception: patient with possible recurrent CDI (i.e. isolate and test following first unformed stool)

Prevention Strategies: Supplemental

Evaluate and optimize test-ordering practices and diagnostic methods

- Most laboratories have relied on Toxin A/B enzyme immunoassays
  - Low sensitivities (70-80%) lead to low negative predictive value
- Despite high specificity, poor test ordering practices (i.e. testing formed stool or repeat testing in negative patients) may lead to many false positives
- Consider more sensitive diagnostic paradigms but apply these more judiciously across the patient population
  - Employ a highly sensitive screen with confirmatory test or a PCR-based molecular assay
  - Restrict testing to unformed stool only
  - Predominantly from patients with ≥ 3 unformed stools within 24 hours
  - Require expert consultation for repeat testing within 5 days

Peterson et al. Ann Intern Med 2009;15:176-9.

Prevention Strategies: Supplemental Hand Hygiene – Soap vs. Alcohol gel

- Alcohol clearly not effective in eradicating *C. difficile* spores
- One hospital study found that from 2000-2003, despite increasing use of alcohol hand rub, there was no concomitant increase in CDI rates.
- Discouraging alcohol gel use may undermine overall hand hygiene program with untoward consequences for HAIs in general.

Boyce et al. Infect Control Hosp Epidemiol 2006;27:479-83.

Prevention Strategies: Supplemental Hand Washing: Product Comparison

Product	Log10 Reduction
Tap Water	0.76
4% CHG antimicrobial hand wash	0.77
Non-antimicrobial hand wash	0.78
Non-antimicrobial body wash	0.86
0.3% triclosan antimicrobial hand wash	0.99
Heavy duty hand cleaner used in manufacturing environments	1.21*

* Only value that was statistically better than others

"These results reinforce the need for contact precautions including gloving when caring for a CD infected patient; and the importance of environmental cleaning and disinfection to reduce environmental spore burden."

Edmonds, et al. Presented at: SHEA 2009; Abstract 43.

Prevention Strategies: Supplemental
Glove Use

Glove use has the

strongest evidence for preventing

C. difficile transmission via the hands

of healthcare workers

Johnson et al. Am J Med 1990;88:137-40.

Glove Use

Rationale for considering universal glove use on units with high CDI rates

- Although the magnitude of their contribution is uncertain, asymptomatic carriers have a role in transmission
- Practical screening tests are not available
- There may be a role for universal glove use as a special approach to reducing transmission on units with longer lengths of stay and high endemic CDI rates
- Focus enhanced environmental cleaning strategies and avoid shared medical equipment on such units as well

Prevention Strategies: Supplemental Environmental Cleaning

- Bleach can kill spores, whereas other standard disinfectants cannot.
- Limited data suggest cleaning with bleach (1:10 dilution prepared fresh daily) reduces *C. difficile* transmission
- Two before-after intervention studies demonstrated benefit of bleach cleaning in units with high endemic CDI rates
- Therefore, bleach may be most effective in reducing burden where CDI is highly endemic

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

Wilcox et al. J Hosp Infect 2003;54:109-14.

Prevention Strategies: Supplemental Environmental Cleaning

Assess adequacy of cleaning before changing to new cleaning product such as bleach

- Ensure that environmental cleaning is adequate and high-touch surfaces are not being overlooked
- One study targeted cleaning using a fluorescent environmental marker which showed:
  - only 47% of high-touch surfaces in 3 hospitals were cleaned.
  - sustained improvement in cleaning of all objects, especially in previously poorly cleaned objects following educational interventions with the environmental services staff
- The use of environmental markers is a promising method to improve cleaning in hospitals.

Carling et al. Clin Infect Dis 2006;42:385-8.

Prevention Strategies: Supplemental

Audit and feedback targeting broad-spectrum antibiotics

- A prospective, controlled interrupted time-series analysis in 3 acute medical wards for the elderly people in the UK demonstrated the impact of antimicrobial management on reducing CDI.
  - Introduced a narrow-spectrum antibiotic policy
  - Reinforced using feedback
  - Associated with significant changes in targeted antibiotics and a significant reduction in CDI

Fowler et al. J Antimicrob Chemother 2007;59:990-5.

Summary of Prevention Measures

Core Measures

- Contact Precautions for duration of illness
- Hand hygiene in compliance with CDC/WHO
- Cleaning and disinfection of equipment and environment
- Laboratory-based alert system
- CDI surveillance
- Education

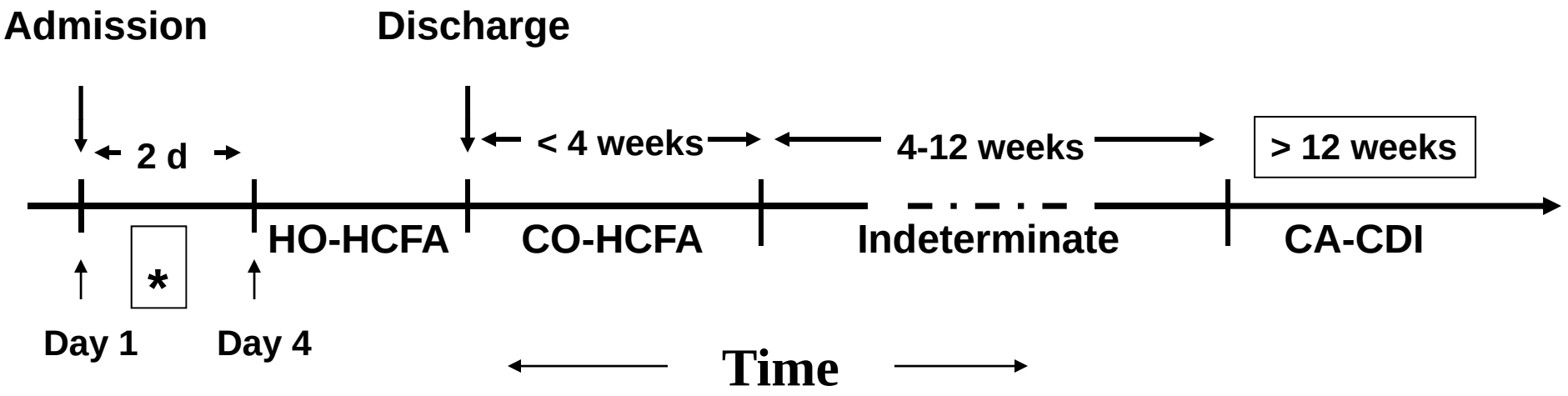
Supplemental Measures

- Prolonged duration of Contact Precautions
- Presumptive isolation
- Evaluate and optimize testing
- Soap and water upon exiting CDI room
- Universal glove use on units with high CDI rates
- Bleach for environmental disinfection
- Antimicrobial stewardship program

Measurement: Process Measures

- **Core Measures:**
  - Measure compliance with CDC/WHO recommendations for hand hygiene and contact precautions
  - Assess adherence to protocols and adequacy of environmental cleaning
- **Supplemental Measures**:
  - Intensify assessment of compliance with process measures
  - Track use of antibiotics associated with CDI in a facility

Measurement: Outcome
Categorize Cases by location and time of onset†



HO: Hospital (Healthcare) onset
CO-HA: Community Onset Healthcare-associated
CA: Community Associated

*** Depending upon whether patient was discharged within previous 4 weeks, CO-HA vs. CA**

† Onset defined in NHSN LabID Event by specimen collection date

Modified from CDAD Surveillance Working Group. Infect Control Hosp Epidemiol 2007;28:140-5.

Measurement: Outcome
Utilize NHSN CDAD Module

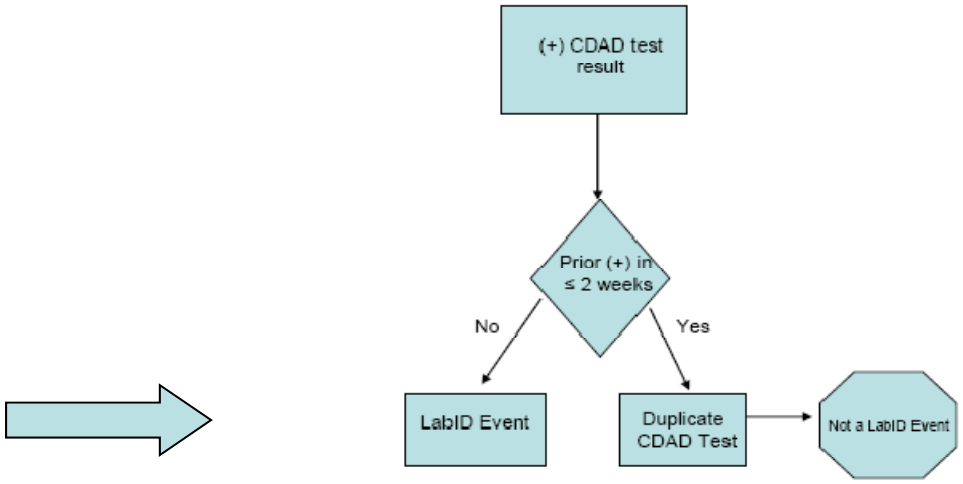
NHSN Laboratory-identified MDRO or CDAD Event

OMB No. 0920-0
Exp. Date: 03-31-2

*required for saving Facility ID:		Event #:
*Patient ID:		Social Security #:
Secondary ID:		
Patient Name, Last:	First:	Middle:
*Gender: M F		*Date of Birth:
Ethnicity (Specify):		Race (Specify):
Event Details		
*Event Type: LabID		*Date Specimen Collected:
*Specific Organism Type: (Check one) ☐MRSA ☐MSSA ☐VRE ☐MDR-*Klebsiella* ☐MDR-*Acinetobacter* ☐*C. difficile*		
*Outpatient: Yes No		*Specimen Source:
*Date Admitted	*Location:	*Date Admitted

Measurement: Outcome
Focus on Laboratory Identified (LabID) Events in NHSN

Figure 2. CDAD Test Result Algorithm for Laboratory-Identified (LabID) Events



Measurement: Outcome

NHSN Reporting: Definitions

Based on data submitted to NHSN, LabID Events are categorized as:

- **Incident:** specimen obtained >8 weeks after the most recent LabID Event
- **Recurrent:** specimen obtained >2 weeks and ≤ 8 weeks after most recent LabID Event

Measurement: Outcome

NHSN Reporting: Definitions

Incident cases further characterized based on date of admission and date of specimen collection:

- **Healthcare Facility-Onset (HO):** LabID Event collected >3 days after admission to facility (i.e., on or after day 4)

- **Community-Onset (CO):** LabID Event collected as an outpatient or an inpatient ≤3 days after admission to the facility (i.e., days 1, 2, or 3 of admission)

- **Community-Onset Healthcare Facility-Associated (CO-HCFA):** CO LabID Event collected from a patient who was discharged from the facility ≤4 weeks prior to date stool specimen collected

Measurement: Outcome

Calculating CDI Incidence Rates

- **Facility CDI Healthcare Facility-Onset Incidence Rate** = Number of all Incident HO CDI LabID Events per patient per month / Number of patient days for the facility x 10,000

- **Facility CDI Combined Incidence Rate** = Number of all Incident HO and CO-HCFA CDI LabID Events per patient per month / Number of patient days for the facility x 10,000

Evaluation Considerations

- **Assess baseline policies and procedures**
- **Areas to consider**
  - **Surveillance**
  - **Prevention strategies**
  - **Measurement**
- **Coordinator should track new policies/practices implemented during collaboration**

Standardized questions forthcoming

References

- Dubberke ER, Butler AM, Reske KA, et al. attributable outcomes of endemic Clostridium difficile-associated disease in nonsurgical patients. Emerg Infect Dis 2008;14:1031-8.

- Dubberke ER, Reske KA, Olssen MA, et al. Short- and long term attributable costs of Clostridium difficile-associated disease in nonsurgical inpatients. Clin Infect Dis 2008:46:497-504.

- Edmonds S, Kasper D, Zepka C, et al. Clostridium difficile and hand hygiene: spore removal effectiveness of handwash products. Presented at: SHEA 2009; Abstract 43.

References

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- Fowler S, Webber A, Cooper BS, et al. Successful use of feedback to improve antibiotic prescribing and reduce Clostridium difficile infection: a controlled interrupted time series. J Antimicrob Chemother 2007;59:990-5.

- Heron MP, Hoyert DLm Murphy SL, et al. Natl Vital Stat Rep 2009;57(14). US Dept of Health and Human Services, CDC; 2009. Available at http://www.cdc.gov/nchs/data/nvsr/nvsr57/nvsr57_14.pdf

References

- Johnson S, Gerding DN, Olson MM, et al. Prospective, controlled study of vinyl glove use to interrupt Clostridium difficile nosocomial transmission. Am J Med 1990;88:137-40.

- Mayfield JL, Leet T, Miller J, et al. Environmental control to reduce transmission of Clostridium difficile.. *Clin Infect Dis* 2000;31:995–1000.

- McDonald LC, Killgore GE, Thompson A, et al. An epidemic, toxin gene–variant strain of Clostridium difficile. N Engl J Med. 2005;353:2433-41.

References

- McDonald LC, Coignard B, Dubberke E, et al. Ad Hoc CDAD Surveillance Working Group. Recommendations for surveillance of Clostridium difficile-associated disease. Infect Control Hosp Epidemiol 2007; 28:140-5.

- Oughton MT, Loo VG, Dendukuri N, et al. Hand hygiene with soap and water is superior to alcohol rum and antiseptic wipes for removal of Clostridium difficile.Infect Control Hosp Epidemiol 2009; 30:939-44.

- Peterson LR, Robicsek A. Does my patient have Clostridium difficile infection? Ann Intern Med 2009;15:176-9

- Riggs MM, Sethi AK, Zabarsky TF, et al. Asymptomatic carriers are a potential source for transmission of epidemic and nonepidemic Clostridium difficile strains among long-term care facilty residents. Clin Infect Dis 2007; 45:992–8.

References

- SHEA/IDSA Compendium of Recommendations. Infect Control Hosp Epidemiol 2008;29:S81–S92. http://www.journals.uchicago.edu/doi/full/10.1086/591065

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References

- Warny M, Pepin J, Fang A, Killgore G, et al. Toxin production by and emerging strain of Clostridium difficile associated with outbreaks of severe disease in North America and Europe. *Lancet.* 2005;366:1079-84.

- Wilcox MF, Fawley WN, Wigglesworth N, et al. Comparison of the effect of detergent versus hypochlorite cleaning on environmental contamination and incidence of Clostridium difficile infection. J Hosp Infect 2003:54:109-14.

Additional resources

SHEA/IDSA Compendium of Recommendations

S81 INFECTION CONTROL AND HOSPITAL EPIDEMIOLOGY OCTOBER 2008, VOL. 29, SUPPLEMENT 1

SUPPLEMENT ARTICLE: SHEA/IDSA PRACTICE RECOMMENDATION

Strategies to Prevent *Clostridium difficile* Infections in Acute Care Hospitals

Erik R. Dubberke, MD; Dale N. Gerding, MD; David Classen, MD, MS; Kathleen M. Arias, MS, CIC; Kelly Podgorny, RN, MS, CPHQ; Deverick J. Anderson, MD, MPH; Helen Burstin, MD; David P. Calfee, MD, MS; Susan E. Coffin, MD, MPH; Victoria Fraser, MD; Frances A. Griffin, RRT, MPA; Peter Gross, MD; Keith S. Kaye, MD; Michael Klompas, MD; Evelyn Lo, MD; Jonas Marschall, MD; Leonard A. Mermel, DO, ScM; Lindsay Nicolle, MD; David A. Pegues, MD; Trish M. Perl, MD; Sanjay Saint, MD; Cassandra D. Salgado, MD, MS; Robert A. Weinstein, MD; Robert Wise, MD; Deborah S. Yokoe, MD, MPH

CDI Checklist Example

***Clostridium difficile* Infection (CDI) Checklist**

Hospital interventions to decrease the incidence and mortality of healthcare-associated *C. difficile* infections

Prevention Checklist

• When an MD, PA, NP, or RN suspects a patient has CDI:

Physician, Physician Assistant, or Nurse Practitioner:
- ☐ Initiate *Contact Precautions Plus*
- ☐ Order stool *C. difficile* toxin testing
- ☐ Discontinue non-essential antimicrobials
- ☐ Discontinue all anti-peristaltic medications

Registered Nurse:
- ☐ Obtain stool sample for *C. difficile* toxin test
- ☐ Place patient in single-patient room
- ☐ Place *Contact Precautions Plus* sign on patient's door
- ☐ Ensure that gloves and gowns are easily accessible from patient's room
- ☐ Place dedicated stethoscope in patient's room
- ☐ Remind staff to wash hands with soap and water following patient contact

Microbiology Laboratory Staff Person:
- ☐ Call relevant patient floor with positive *C. difficile* toxin test result
- ☐ Provide daily list of positive test results for Infection Control

Infection Control Practitioner:
- ☐ Check microbiology results daily for positive *C. difficile* toxin results
- ☐ Call relevant floor to confirm that patient with positive *C. difficile* toxin results is in a single-patient room and that the *Contact Precautions Plus* sign is on the patient's door
- ☐ Flag the patient's *C. difficile* status in the hospital's clinical information system or in the patient's paper chart
- ☐ Alert housekeeping that the patient is on *Contact Precautions Plus*

Environmental Services Staff Person:
- ☐ Prior to discharge cleaning, check for *Contact Precautions Plus* sign on the patient's door
- ☐ If *Contact Precautions Plus* sign is on the door, clean the room with a bleach-based cleaning agent
- ☐ Confirm for supervisor that bleach-based cleaning agent was used for discharge cleaning for every patient on *Contact Precautions Plus*

Treatment Checklist

• When an MD, PA, or NP diagnoses mild CDI: *All of the following criteria are present: diarrhea (<6 BM/day), no fever, WBC< 5,000, no peritoneal signs, and no evidence of sepsis*

Physician, Physician Assistant, or Nurse Practitioner:
- ☐ Initiate oral metronidazole at dose 500mg every 8 hours
- ☐ If no clinical improvement by 48-72 hours after diagnosis, treat patient as moderate CDI
- ☐ Continue therapy for at least 14 days total and at least 10 days after symptoms have abated

• When an MD, PA, or NP diagnoses moderate CDI: *At least one of the following criteria is present: diarrhea (6-12 BM/day), fever (A° C>38.5°C), WBC 15,000-25,000, or transly visible stable lower gastrointestinal bleeding*

Physician, Physician Assistant, or Nurse Practitioner:
- ☐ Initiate oral vancomycin at dose 250mg every 6 hours
- ☐ If no clinical improvement by 48 hours, add IV metronidazole at dose 500mg every 8 hours
- ☐ Consider obtaining infectious disease consultation
- ☐ Consider obtaining abdominal CT scan
- ☐ Continue therapy for at least 14 days total and at least 10 days after symptoms have abated

• When an MD, PA, or NP diagnoses severe CDI: *At least one of the following criteria is present: diarrhea (>12 BM/day), fever >38.5°C, WBC >25,000, hemodynamic instability, marked & continuous abdominal pain, ileus, absence of bowel sounds, evidence of sepsis, or intensive care unit level of care required*

Physician, Physician Assistant, or Nurse Practitioner:
- ☐ Obtain immediate infectious disease consultation
- ☐ Obtain immediate general surgery consultation
- ☐ Obtain abdominal CT scan
- ☐ Initiate oral vancomycin at dose 250mg every 6 hours together with IV metronidazole at dose 500mg every 6 hours
- ☐ Following consultation with general surgery regarding its use, consider rectal vancomycin
- ☐ Ask general surgery service to assess the need for colectomy

Abbreviations: MD=medical doctor, PA=physician assistant, NP=nurse practitioner, RN=registered nurse, BM=bowel movement, WBC=white blood cell count, CT=computed tomography, IV=intravenous

FIGURE 1. *Clostridium difficile* infection checklist at Brigham and Women's Hospital.

Dubberke et al. Infect Control Hosp Epidemiol 2008;29:S81-92.
Abbett SK et al. Infect Control Hosp Epidemiol 2009;30:1062-9.

Additional Reference Slides

- The following slides may be used for presentations regarding CDI.
- Explanations are available in the notes section of the slides.

Prevention Strategies: Supplemental

Rationale for Soap and Water: Lack of efficacy of alcohol-based handrub against *C. difficile*

Interventions compared		Mean log reduction (95% CI), $\log_{10}$ CFU/mL
Intervention 1	Intervention 2	
Warm water and plain soap	No hand hygiene	2.14 (1.74–2.54)
Warm water and plain soap	Alcohol-based handrub	2.08 (1.69–2.47)
Cold water and plain soap	No hand hygiene	1.88 (1.48–2.28)
Cold water and plain soap	Alcohol-based handrub	1.82 (1.43–2.22)
Warm water and plain soap	Antiseptic hand wipe	1.57 (1.18–1.96)
Warm water and antibacterial soap	No hand hygiene	1.51 (1.12–1.91)
Warm water and antibacterial soap	Alcohol-based handrub	1.46 (1.06–1.85)
Cold water and plain soap	Antiseptic hand wipe	1.31 (0.92–1.71)
Warm water and antibacterial soap	Antiseptic hand wipe	0.94 (0.55–1.34)
Warm water and plain soap	Warm water and antibacterial soap	0.63 (0.23–1.02)
Antiseptic hand wipe	No hand hygiene	0.57 (0.17–0.96)
Antiseptic hand wipe	Alcohol-based handrub	0.51 (0.12–0.91)
Cold water and plain soap	Warm water and antibacterial soap	0.37 (−0.03 to 0.76)
Warm water and plain soap	Cold water and plain soap	0.26 (−0.14 to 0.66)
Alcohol-based handrub	No hand hygiene	0.06 (−0.34 to 0.45)

Oughton et al. Infect Control Hosp Epidemiol 2009;30:939-44.

Prevention Strategies: Supplemental

Hand Hygiene – Alcohol Hand Rub Use 2000-2003

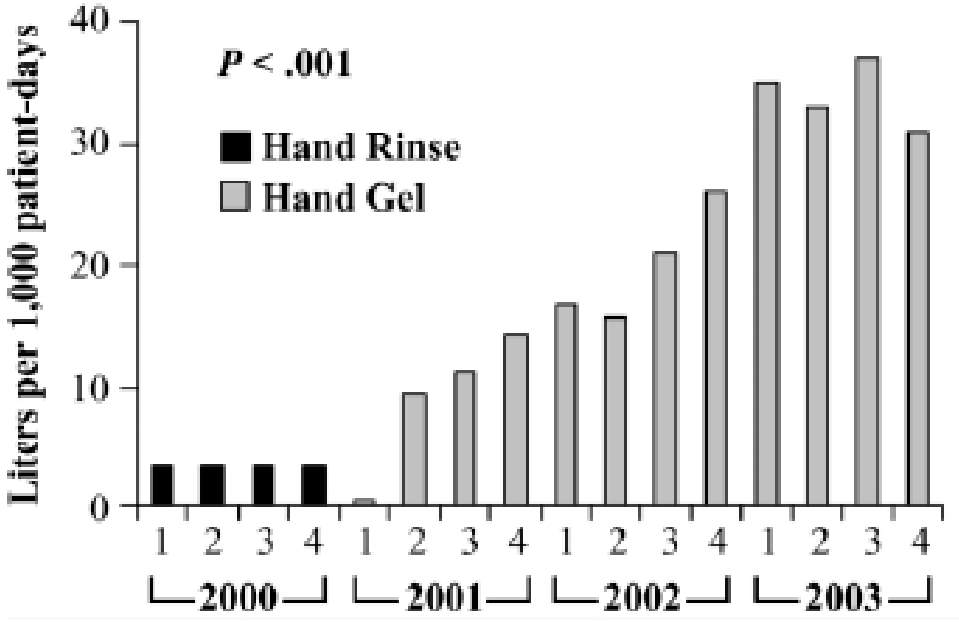


FIGURE 1. Use of alcohol hand rub by healthcare workers, in liters per 1,000 patient-days, per quarter, 2000-2003.

Boyce et al. Infect Control Hosp Epidemiol 2006; 27:479-83.

Prevention Strategies: Supplemental

Hand Hygiene – CDI Rates 2000-2003

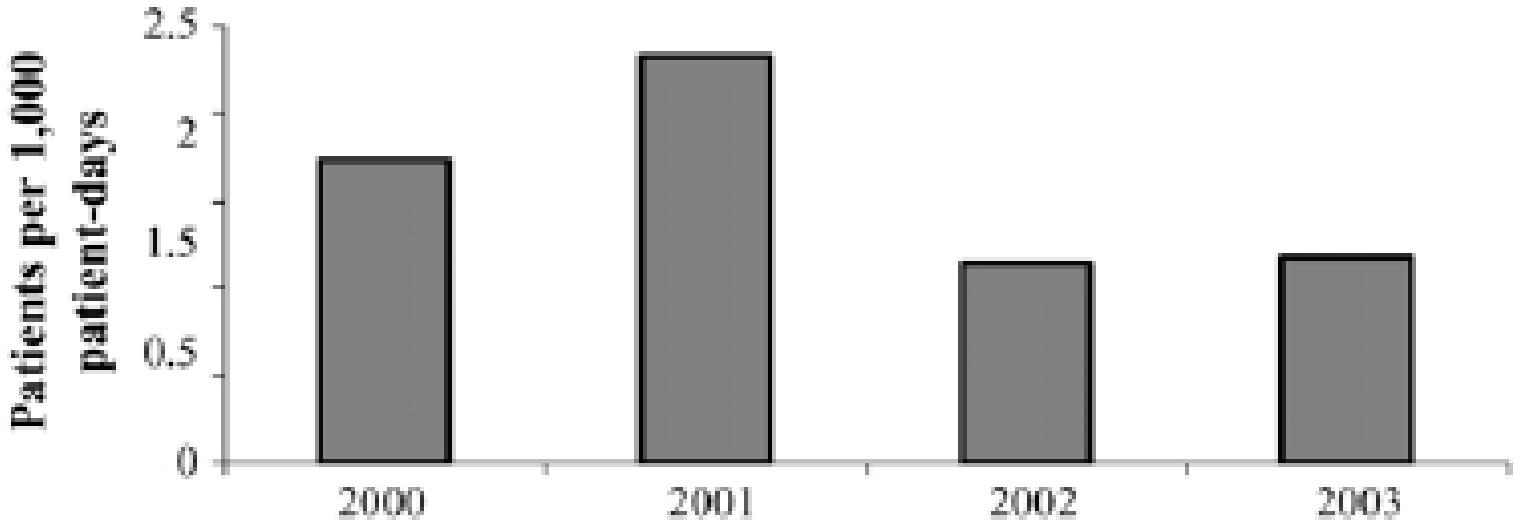


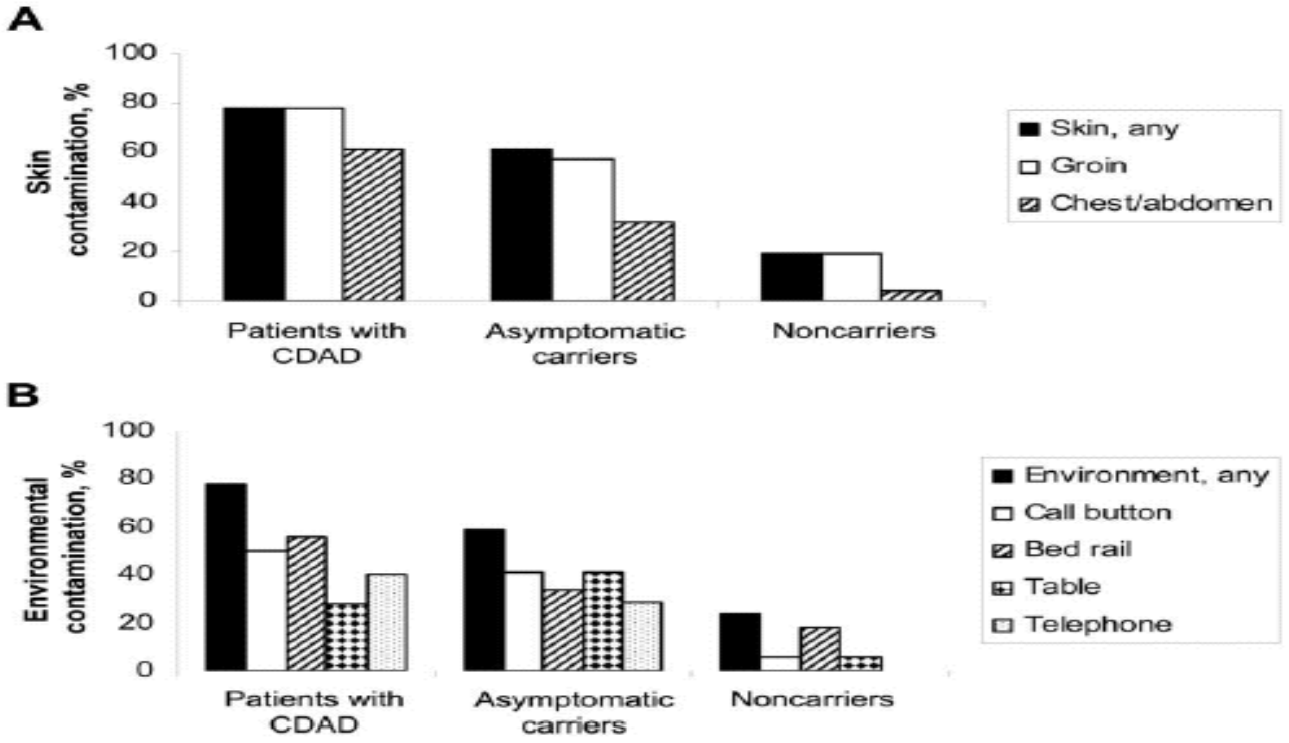
FIGURE 2. Number of patients with 1 or more tests positive for *Clostridium difficile* toxin per 1,000 patient-days, 2000-2003.

Boyce JM et al. Infect Control Hosp Epidemiol 2006; 27:479-83.

Prevention Strategies: Supplemental

Glove Use

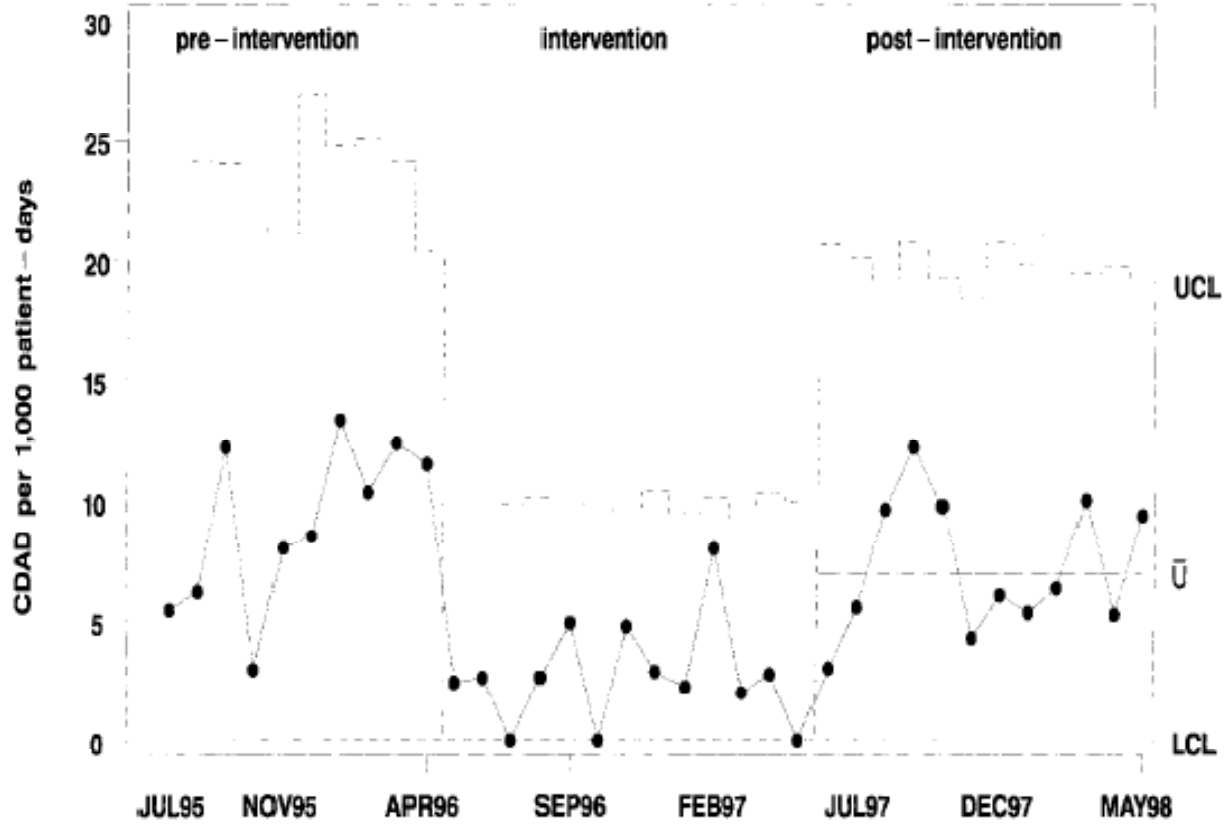
Glove Use Role of asymptomatic carriers? Rationale for universal glove use on units with high CDI rates



Riggs et al. Clin Infect Dis 2007;45:992–8.

Prevention Strategies: Supplemental Environmental Cleaning

How Much Can be Achieved via Environmental Decontamination?



Mayfield et al. Clin Infect Dis 2000;31:995–1000.

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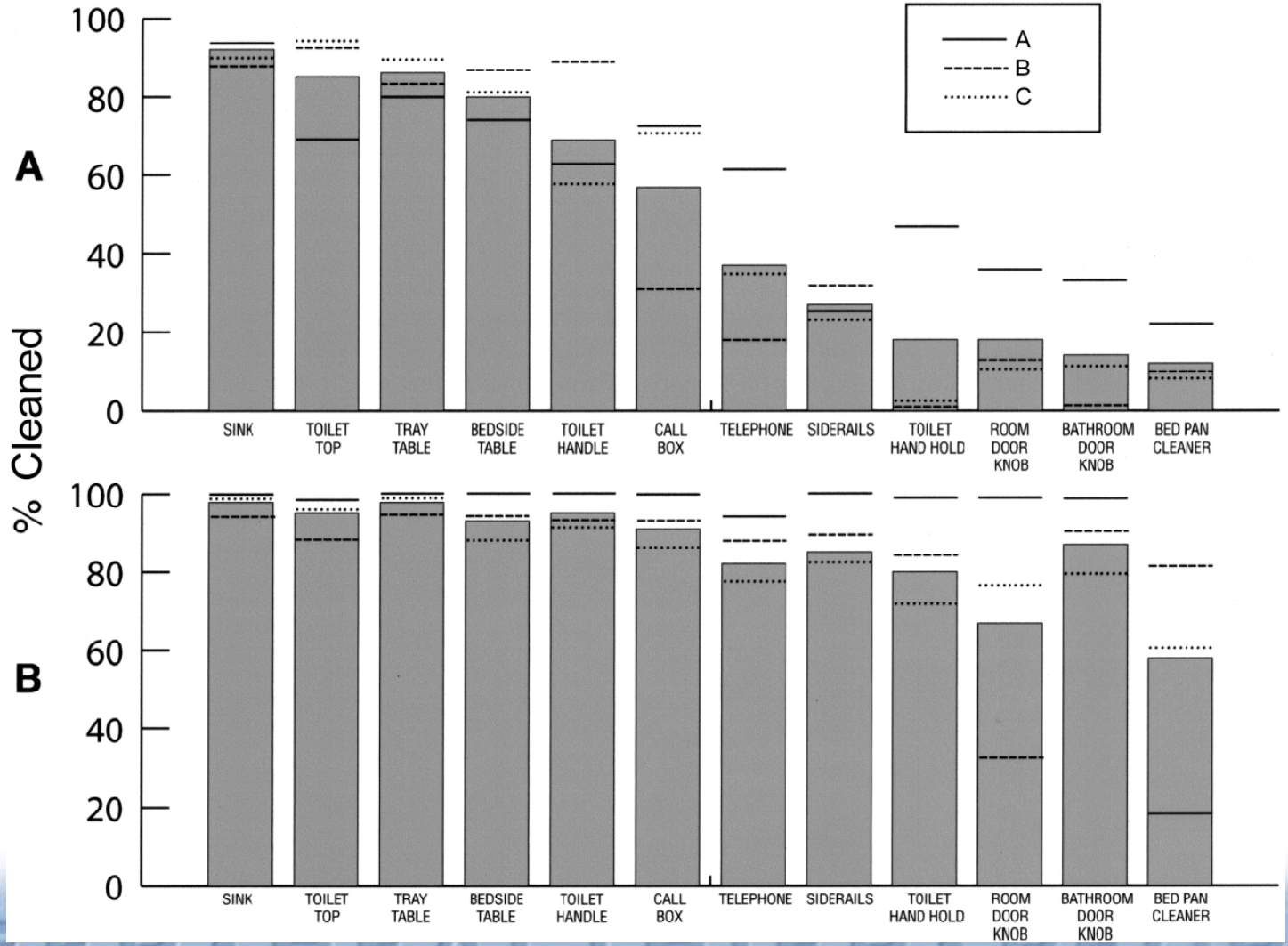
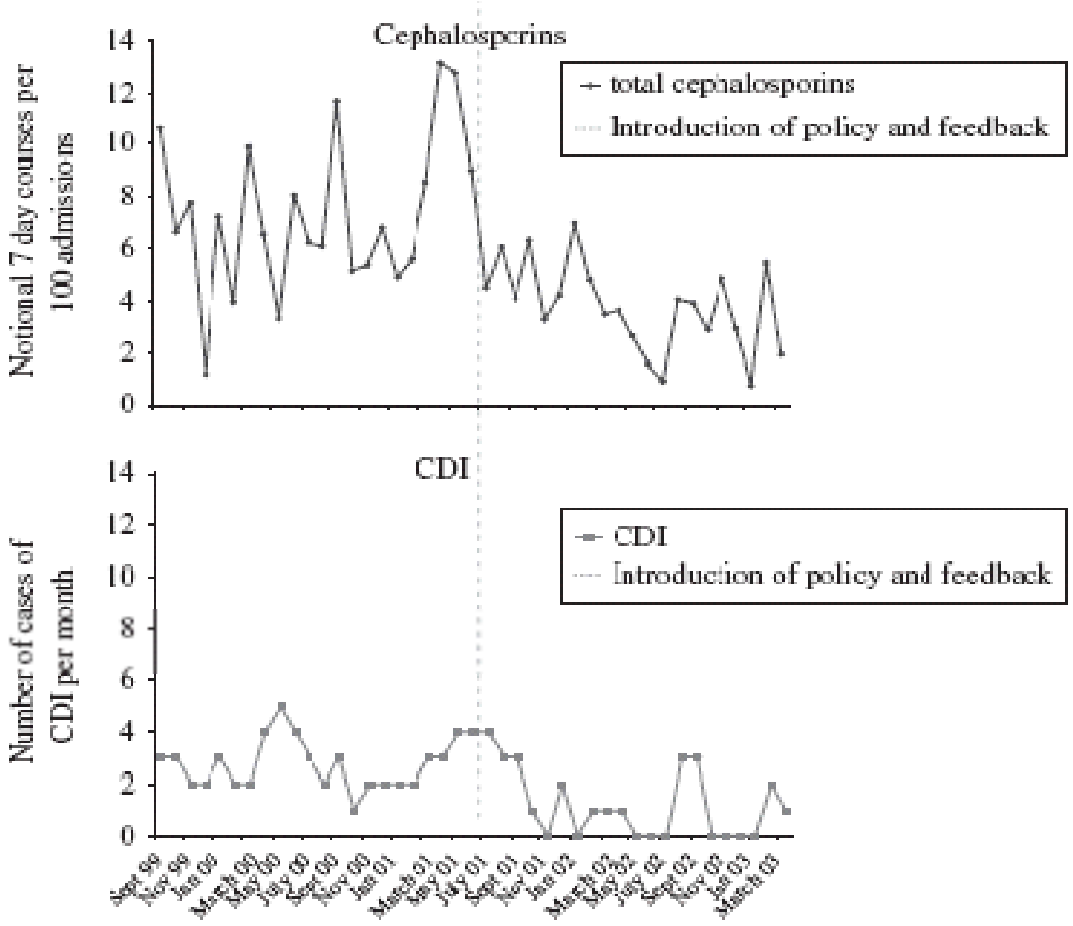
Assess adequacy of cleaning before changing to new cleaning product



Carling et al. Clin Infect Dis 2006;42:385-8.

Prevention Strategies: Supplemental
Audit and feedback targeting broad-spectrum antibiotics



Fowler et al. J Antimicrob Chemother 2007;59:990-5.