Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

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DISCLOSURES
2018-2019

- Consultations
  - ASP (Advanced Sterilization Products), PDI
- Honoraria
  - PDI, ASP, 3M
- Scientific Advisory Board
  - Kinnos
- Grants
  - CDC, CMS
www.disinfectionandsterilization.org
C. difficile is now the most common healthcare-associated pathogen in the US

C. difficile colitis is a serious disease especially in older adults with frequent morbidity and substantial mortality

Our institution set an organizational goal to reduce our CDI rates by 10%
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Schultz et al. J Clin Microbiol 2018;56

- Multidisciplinary group met on a monthly basis to organize and coordinate our efforts

- Group included:
  - Hospital Epidemiology
  - Performance Improvement and Patient Safety
  - Clinical Microbiology
  - Antimicrobial Stewardship
  - Pharmacy
  - Infectious Diseases
Group included (continued):

- Environmental Services
- Nursing
- Patient Equipment
- Hospital Administration

The group implemented multiple interventions and monitored the progress of each intervention with process measures.
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The interventions fell into eight categories

- Diagnostic stewardship
- Electronic tools to enhance diagnostic stewardship
- Education
- Enhanced isolation precautions
- Hand hygiene
- Environmental cleaning and disinfection
- Antimicrobial stewardship
- Pharmaceutical interventions
Majority of the interventions were novel for our facility

But some (e.g., hand hygiene) focused on sustained existing interventions that were already in place within our facility
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With the advent of highly sensitive nucleic acid amplification tests (NAATs), testing standards are necessary to ensure that the patient’s clinical status warrants testing for CDI.

Since 2009, use two-step glutamate dehydrogenase (GDH)/toxin immunochromatographic assay, if discordant, arbitrated by NAAT

Microbiology enforced C. difficile testing only for unformed, liquid stool and restricted testing for children less than 12m with ped ID approval
Testing for C. diff when not indicated can harm your patient

Some patients are colonized with C. diff but do not have active infections. Testing a patient without symptoms may result in:

- Unnecessary antibiotics (and side effects)
- Avoidable isolation precautions
- Increased lengths of stay
- Higher healthcare costs for patients (and hospitals)

When should I test my patient for C. diff?

- ≥3 liquid stools within 24 hours, without another known medical reason
- No laxatives within past 48 hours*

*If patient has unexplained fever, abdominal pain, AND leukocytosis, testing may be indicated.

Follow Epic process instructions for timing after previous tests. Testing not recommended for patients under age 2.

While caring for a patient with C. diff,

REMEMBER:

- Wash hands with soap and water only
- Practice Antimicrobial Stewardship
- Follow Enteric Precautions
- Clean room & equipment with bleach wipes
- Ensure room cleaned with UV at discharge

Visit the C. diff page on the Intranet (under Infection Prevention) for more info
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Modified Electronic Record (Epic) To Create Automated Prompts Based on Lab Testing Standards for Clinicians Ordering C. difficile Testing (not hard stops, significant diarrhea)
Modified Electronic Record (Epic) To Create Automated Best Practice Advisories within Epic to Inform HCPs of the Lab Testing Standards
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**Education**

- Update of *C. difficile* testing per hospital policy was disseminated to physician leadership
- RNs empowered to place an order for *C. difficile* testing for symptomatic patients
- Intended to expedite testing on symptomatic patients when appropriate in order to initiate isolation and treatment
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**Enhanced Isolation Precautions**

- Patients with known or suspected CDI are placed on Enteric Precautions (enhanced version of CP)
- Enteric Precautions requires a private room, gloves when entering the room, disposable gown/gloves for patient contact or clothing may contact room surfaces, and hand hygiene with soap and water
- Visitors are also required to wear a gown and gloves and perform hand hygiene require
UNC Health Care Isolation Sign for Patients with C. difficile

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

Rutala WA, Weber DJ, HICPAC. www.cdc.gov

Most Resistant

Spores  \((C. \text{ difficile})\)

Mycobacteria  \((M. \text{ tuberculosis})\)

Non-Enveloped Viruses  \((\text{norovirus, HAV, polio})\)

Fungi  \((\text{Candida, Trichophyton})\)

Bacteria  \((\text{MRSA, VRE, Acinetobacter})\)

Enveloped Viruses  \((\text{HIV, HSV, Flu})\)

Most Susceptible
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
Enhanced Isolation Precautions

- HE increased the duration of Enteric Precautions from cessation of antibiotic therapy to 30 days after the cessation of antibiotic therapy, based on persistent stool, skin and environmental contamination after CDI

- This change was periodically monitored staff and visitor compliance with point prevalence surveys
RATIONALE FOR PROLONGED CONTACT ENTERIC ISOLATION OF PATIENTS WITH CDI

Skin (chest and abdomen) and environment (bed rail, bedside table, call button, toilet seat)

Sethi AK, et al. ICHE 2010;31:21-27
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CLEAN IN, CLEAN OUT

Hand Hygiene Compliance Program Update
Overall Clean In, Clean Out Compliance
Shewhart Control Chart

<table>
<thead>
<tr>
<th>Month</th>
<th>Number of Observations</th>
<th>Number of Unique Observers</th>
<th>Overall Compliance Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>October</td>
<td>6983</td>
<td>758</td>
<td>82.6</td>
</tr>
<tr>
<td>November</td>
<td>6236</td>
<td>687</td>
<td>84.9</td>
</tr>
<tr>
<td>December</td>
<td>5101</td>
<td>547</td>
<td>88.3</td>
</tr>
<tr>
<td>January</td>
<td>7041</td>
<td>732</td>
<td>88.4</td>
</tr>
<tr>
<td>February</td>
<td>6776</td>
<td>752</td>
<td>88.0</td>
</tr>
</tbody>
</table>

CL 86.35%
UCL 92.86%
LCL 79.84%
Hand hygiene remained consistently high (>90%) hand hygiene compliance
The interventions fell into eight categories

- Diagnostic stewardship
- Electronic tools to enhance diagnostic stewardship
- Education
- Enhanced isolation precautions
- Hand hygiene
- Environmental cleaning and disinfection
- Antimicrobial stewardship
- Pharmaceutical interventions
Environmental Contamination

- 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

- 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.
FREQUENCY OF ENVIRONMENTAL CONTAMINATION
AND RELATION TO HAND CONTAMINATION

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

Proving That Environmental Contamination Is Important in *C. difficile* Transmission

- Environmental persistence (Kim et al. JID 1981;143:42)
- 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 $\Rightarrow$ epidemic CDI (Kaatz et al. AJE 1988;127:1289)
- Improved disinfection $\Rightarrow$ endemic CDI (Boyce et al. ICHE 2008;29:723)
Factors Leading to Environmental Transmission of *Clostridioides difficile*

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

- Enhanced cleaning practices in enteric precautions included the use of an EPA-registered disinfectant with sporicidal during daily cleans and at patient discharge.
- ES staff also used UV-C machines to terminally disinfect patient rooms after CD following patient discharge.
- The thoroughness of CD was monitored on a regular basis with the application of fluorescent dye on surfaces
- A second multidisciplinary group created to standardize CD plan for both patient rooms and pieces of patient equipment throughout the hospital.
Effective Surface Decontamination

Product and Practice = Perfection
C. difficile spores
C. difficile Spores
EPA-Registered Products

- List K: EPA’s Registered Antimicrobials Products Effective Against C. difficile spores, April 2014
- [http://www.epa.gov/oppad001/list_k_clostridium.pdf](http://www.epa.gov/oppad001/list_k_clostridium.pdf)
- 34 registered products; most chlorine-based, some HP/PA-based, PA with silver
- New 4% hydrogen peroxide
### Exposure time ≥ 1 min

<table>
<thead>
<tr>
<th>Germicide</th>
<th>Use Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethyl or isopropyl alcohol</td>
<td>70-90%</td>
</tr>
<tr>
<td>Chlorine</td>
<td>100ppm (1:500 dilution)</td>
</tr>
<tr>
<td>Phenolic</td>
<td>UD</td>
</tr>
<tr>
<td>Iodophor</td>
<td>UD</td>
</tr>
<tr>
<td>Quaternary ammonium (QUAT)</td>
<td>UD</td>
</tr>
<tr>
<td>QUAT with alcohol</td>
<td>RTU</td>
</tr>
<tr>
<td>Improved hydrogen peroxide (HP)</td>
<td>0.5%, 1.4%</td>
</tr>
<tr>
<td>PA with HP, 4% HP, chlorine (<em>C. difficile</em>)</td>
<td>UD</td>
</tr>
</tbody>
</table>

UD=Manufacturer’s recommended use dilution; others in development/testing-electrolyzed water; polymeric guanidine; cold-air atmospheric pressure plasma (Boyce Antimicrob Res IC 2016. 5:10)
Effective Surface Decontamination

Product and Practice = Perfection
Thoroughness of Environmental Cleaning
Carling et al.  ECCMID, Milan, Italy, May 2011

Mean = 32%

| = 95 % CI

DAILY CLEANING
TERMINAL CLEANING

>110,000
Objects
EVALUATION OF HOSPITAL ROOM ASSIGNMENT AND ACQUISITION OF CDI

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

Shaughnessy MK, et al. ICHE 2011;32:201-206
Wipes
Cotton, Disposable, Microfiber, Cellulose-Based, Nonwoven Spunlace

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

Effectiveness of Different Methods
Rutala, Gergen, Weber. ICHE 2012;33:1255-58

<table>
<thead>
<tr>
<th>Technique (with cotton)</th>
<th>C. difficile Log$_{10}$ Reduction (1:10 Bleach)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturated cloth</td>
<td>3.90</td>
</tr>
<tr>
<td>Spray (10s) and wipe</td>
<td>4.48</td>
</tr>
<tr>
<td>Spray, wipe, spray (1m), wipe</td>
<td>4.48</td>
</tr>
<tr>
<td>Spray</td>
<td>3.44</td>
</tr>
<tr>
<td>Spray, wipe, spray (until dry)</td>
<td>4.48</td>
</tr>
<tr>
<td>5500 ppm chlorine pop-up wipe</td>
<td>3.98</td>
</tr>
<tr>
<td>Non-sporicidal wipe</td>
<td>$&gt;2.9$</td>
</tr>
</tbody>
</table>
Daily disinfection of high-touch surfaces (vs cleaned when soiled) with sporicidal disinfectant (PA) 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.
Thoroughness of Environmental Cleaning
Carling et al. ECCMID, Milan, Italy, May 2011

Mean = 32%

Objects >110,000

Mean = 32%
MONITORING THE EFFECTIVENESS OF CLEANING
Cooper et al. AJIC 2007;35:338

- Visual assessment-not a reliable indicator of surface cleanliness
- ATP bioluminescence-measures organic debris (each unit has own reading scale, <250-500 RLU)
- Microbiological methods-<2.5CFUs/cm²-pass; can be costly and pathogen specific
- Fluorescent marker-transparent, easily cleaned, environmentally stable marking solution that fluoresces when exposed to an ultraviolet light (applied by IP unbeknown to EVS, after EVS cleaning, markings are reassessed)
Thoroughness of Environmental Cleaning

Hospitals can improve their thoroughness of terminal room disinfection through fluorescent monitoring.
Fluorescent marker is a useful tool in determining how thoroughly a surface is wiped and mimics the microbiological data better than ATP.
These interventions (effective surface disinfection, thoroughness indicators) not enough to achieve consistent and high rates of cleaning/disinfection

No Touch
(supplements but do not replace surface cleaning/disinfection)
“NO TOUCH” APPROACHES TO ROOM DECONTAMINATION
(UV/VHP~20 microbicidal studies, 12 HAI reduction studies; will not discuss technology with limited data)
Table 2. Clinical trials of ‘no touch’ methods: UV devices and hydrogen peroxide systems

<table>
<thead>
<tr>
<th>Year, author</th>
<th>Device/system</th>
<th>Study design</th>
<th>Setting</th>
<th>Selected results*</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016, Vianna et al. [44]</td>
<td>UV-PX</td>
<td>Before–after</td>
<td>Community hospital</td>
<td>Facility wide: ↓C. difficile, ↓all MDROs (MRSA, VRE, CDI)</td>
</tr>
<tr>
<td>2015, Horn and Otter [45]</td>
<td>HP vapor</td>
<td>Before–after</td>
<td>Hospital</td>
<td>↓CDI, ↓VRE, ↓ESBL GNB</td>
</tr>
<tr>
<td>2015, Anderson et al. [46]</td>
<td>UV-C</td>
<td>RCT</td>
<td>9 hospitals</td>
<td>↓All MDROs (MRSA, VRE, CDI)</td>
</tr>
<tr>
<td>2015, Pegues et al. [47]</td>
<td>UV-C</td>
<td>Before–after</td>
<td>Academic center</td>
<td>↓CDI</td>
</tr>
<tr>
<td>2015, Nagaraja et al. [48]</td>
<td>UV-PX</td>
<td>Before–after</td>
<td>Academic center</td>
<td>↓CDI</td>
</tr>
<tr>
<td>2015, Miller et al. [49]</td>
<td>UV-PX</td>
<td>Before–after</td>
<td>Nursing home</td>
<td>↓CDI</td>
</tr>
<tr>
<td>2014, Mitchell et al. [50]</td>
<td>Dry HP vapor</td>
<td>Before–after</td>
<td>Hospital</td>
<td>↓MRSA colonization and infection</td>
</tr>
<tr>
<td>2014, Haas et al. [51]</td>
<td>UV-PX</td>
<td>Before–after</td>
<td>Academic center</td>
<td>↓CDI, ↓MRSA, ↓VRE, ↓MDRO GNB, all MDROs</td>
</tr>
<tr>
<td>2013, Manian et al. [52]</td>
<td>HP vapor</td>
<td>Before–after</td>
<td>Community hospital</td>
<td>↓CDI</td>
</tr>
<tr>
<td>2013, Passaretti et al. [53]</td>
<td>HP vapor</td>
<td>Prospective cohort</td>
<td>Academic center</td>
<td>↓VRE, ↓all MDROs (MRSA, VRE, CDI)</td>
</tr>
<tr>
<td>2013, Levin et al. [54]</td>
<td>UV-PX</td>
<td>Before–after</td>
<td>Community hospital</td>
<td>↓CDI, ↓MRSA, ↓VRE, ↓MDRO GNB, all MDROs</td>
</tr>
<tr>
<td>2011, Cooper et al. [55]</td>
<td>HP vapor</td>
<td>Before–after (2 cycles)</td>
<td>Hospitals</td>
<td>↓CDI (cases; incidence not significant)</td>
</tr>
<tr>
<td>2008, Boyce et al. [56]</td>
<td>HP vapor</td>
<td>Before–after</td>
<td>Community hospital</td>
<td>↓CDI</td>
</tr>
</tbody>
</table>

CDI, *Clostridium difficile* infection; ESBL, extended spectrum beta-lactamase producers; GNB, Gram negative bacteria; HP, hydrogen peroxide; MDRO, multidrug-resistant organism; MRSA, meticillin-resistant *Staphylococcus aureus*; UV-C, ultraviolet light – C; UV-PX, ultraviolet light – pulsed xenon; VRE, vancomycin-resistant *Enterococcus*.

*All listed results were statistically significant (see reference for more details).*

EFFICACY OF UVC AT TERMINAL DISINFECTION TO REDUCE HAIs
(A = C. difficile, B = VRE; UV effective in preventing VRE and C. difficile)

Marra AR, et al. ICHE 2018;39:20-31
New Strategy
(not employed in referenced paper)
Asymptomatic carriers contribute to *C. difficile* transmission

1. Curry SR. Clin Infect Dis 2013 (29% of hospital-associated CDI cases linked to carriers by MLVA); 2. Blixt T. Gastroenterol 2017;152:1031 (exposure to carriers increased CDI risk); 3. Longtin Y. JAMA Int Med 2016 (screening for and isolating carriers reduced CDI by 63%); 4. Samore MH. Am J Med 1996;100:32 (only 1% of cases linked to asymptomatic carriers - roommates and adjacent rooms - by PFGE/REA); 5. Eyre DW. PLOS One 2013;8:e78445 (18 carriers: no links to subsequent CDI cases); 6. Lisenmyer K. Clin Infect Dis 2018 (screening and isolation of carriers associated with control of a ward outbreak); 7. Paquet-Bolduc B. Clin Infect Dis 2018 (unit-wide screening and isolation of carriers not associated with shorter outbreak durations vs historical controls); 8. Donskey CJ. Infect Control Hosp Epidemiol 2018 (14% of healthcare-associated CDI cases linked to LTCF asymptomatic carriers); 9. Kong LY. Clin Infect Dis 2018 (23% of healthcare-associated CDI linked to carriers vs 42% to CDI cases and 35% to carriers or cases)
Interventions focused on CDI rooms

CDI rooms

Sporicidal disinfection only in CDI rooms

Non-CDI rooms

Interventions addressing CDI cases and asymptomatic carriers

Sporicidal disinfection in CDI and non-CDI rooms
Use of Sporicidal Disinfectant on *C. difficile* spore Contamination in non-*C. difficile* Infection Rooms

Wong et al. AJIC, 2019

The percentage of rooms contaminated with *C. difficile* was significantly reduced during the period with a sporicidal product was used 5% vs 24%. Results suggest sporicidal disinfectant in all postdischarge rooms could potentially be beneficial in reducing the risk for *C. difficile* transmission from contaminated surfaces.
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Antimicrobial stewardship (AS) and pharmacy intervention

- Reducing the use of unnecessary antibiotics is crucial in preventing CDI
- AS program (ID MD, ID PharmD, CM) provided support through antimicrobial surveillance, audits and feedback
- AS program worked to reduce 3rd and 4th generation cephalosporins and fluoroquinolones
- Guidelines for proton pump inhibitors (lowest dose possible for shortest time) presented to pharmacists, ICU MDs and nurse leaders
Antimicrobial Stewardship and Pharmacy Interventions

- Antimicrobial stewardship goal was to reduce the days of therapy per 1,000 patients days of third and fourth generation.
- Cefepime, ceftazidime, and levofloxacin use all decreased significantly.
- Clindamycin days of therapy were also reduced.
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Results

- 11.0 infections per 10,000 patient days → 6.30 infections per 10,000 patient days
- Decrease of 42.7%
- 100 fewer infections potentially saved our facility >$300,000
- None of the interventions implemented in this bundle required an additional financial investment
Health-Care Facility-Onset C. difficile LabID Rates and Novel Interventions, 2015-2017
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Eight interventions:

- Diagnostic stewardship
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- Antimicrobial stewardship
- Pharmaceutical interventions
Achieved a statistically significant reduction of 42.7% in our healthcare-facility onset *C. difficile* infections by forming a multidisciplinary group to implement and monitor eight key categories of infection prevention.
THANK YOU!
www.disinfectionandsterilization.org
Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

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Audits and surveys

- Increased compliance with use of UVC at discharge CD for Enteric Precautions rooms
- ES audits of CD compliance with fluorescent dye on inpatient room touchpoints showed high monthly compliance
- High HCP compliance (93%) with PPE in Enteric Precaution rooms
- Reduced days of therapy per 1000 patient days of 3rd, 4th generation cephalosporin and fluoroquinolone
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**Provider Compliance (abstracted from EMR)**
- No previous positive test in the last 14 days
- No previous negative test in the last 7 days
- No laxatives or stool softeners administered in the 48 hours prior to testing
- Loose stools documented
Clinicians and laboratory personnel agree at the institutional level to not submit stool specimens on patients receiving laxatives and to submit stool specimens only from patients with unexplained and new onset ≥ 3 unformed stools in 24 h for testing for CDI.

Yes

NAAT alone OR stool toxin test* as part of a multiple step algorithm (i.e. GDH plus toxin; GDH plus toxin, arbitrated by NAAT; or NAAT plus toxin) rather than a nucleic acid amplification test (NAAT) alone.

No

Stool toxin test* as part of a multiple step algorithm (i.e. GDH plus toxin; GDH plus toxin, arbitrated by NAAT; or NAAT plus toxin) rather than a nucleic acid amplification test (NAAT) alone.

*Approved stool EIA toxin tests vary widely in sensitivity. Laboratories should choose a toxin test with sensitivity in the upper range of sensitivity as reported in the literature [146-149, 156].

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. (CDC and SHEA).

- 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.
TRANSFER OF C. DIFFICILE SPORES BY NONSPORICIDAL WIPES AND IMPROPERLY USED HYPOCHLORITE WIPES

- Study design: *In vitro* study that assessed efficacy of different wipes in killing of *C. difficile* spores (5-log$_{10}$)
  - Fresh hypochlorite wipes
  - Used hypochlorite wipes
  - Quaternary ammonium wipes
- Results (4$^{th}$ transfer)
  - Quat had no efficacy (3-log$_{10}$ spores)
  - Fresh hypochlorite worked
  - Used hypochlorite transferred spores in lower concentration (0.4-log$_{10}$ spores)

Practice + Product = Perfection

### DIAGNOSTIC TESTS FOR CDI

**Table 3. Summary of Available Tests for *Clostridium difficile* Infection, in Decreasing Order of Sensitivity**

<table>
<thead>
<tr>
<th>Test</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Substance Detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toxigenic culture</td>
<td>High</td>
<td>Low(^a)</td>
<td><em>Clostridium difficile</em> vegetative cells or spores</td>
</tr>
<tr>
<td>Nucleic acid amplification tests</td>
<td>High</td>
<td>Low/moderate</td>
<td><em>C. difficile</em> nucleic acid (toxin genes)</td>
</tr>
<tr>
<td>Glutamate dehydrogenase</td>
<td>High</td>
<td>Low(^a)</td>
<td><em>C. difficile</em> common antigen</td>
</tr>
<tr>
<td>Cell culture cytotoxicity neutralization assay</td>
<td>High</td>
<td>High</td>
<td>Free toxins</td>
</tr>
<tr>
<td>Toxin A and B enzyme immunoassays</td>
<td>Low</td>
<td>Moderate</td>
<td>Free toxins</td>
</tr>
</tbody>
</table>

\(^a\)Must be combined with a toxin test.