Clostridium difficile Infection (CDI) Prevention Primer

Last reviewed 03/04/16. Disclaimer: The findings and conclusions in this presentation are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.
Outline

- **Background on *Clostridium difficile* Infection (CDI)**
  - Burden
  - Pathogenesis
  - Epidemiology
- **General Infrastructure for CDI Prevention**
- **Basic Practices and Special Approaches for CDI Prevention**
- **Implementing a Practical Approach to CDI Prevention**
- **Resources and References**
Background: Burden, Pathogenesis, Epidemiology
Estimated Annual U.S. Burden

- 453,000 CDI cases¹
  - 293,000 healthcare-associated
    - 107,000 hospital-onset
    - 104,000 nursing home-onset
    - 81,000 community-onset, healthcare-facility associated
  - 160,000 community-associated
    - 82% associated with outpatient healthcare exposure

Overall, 94% of CDI cases related to healthcare

- 29,000 deaths
- $4.8 billion in excess healthcare costs²

Estimated U.S. Burden of CDI, According to the Location of Stool Collection and Inpatient Health Care Exposure, 2011.

**CO-HCA:** Community onset healthcare-associated
**NHO:** Nursing home onset
**HO:** Hospital onset

Healthcare Burden

- *C. difficile* most commonly reported pathogen in 2011 multistate prevalence survey of healthcare-associated infections (HAI)\(^1\)
  - 12.1% of 452 HAIs caused by CDI
  - Rates of CDI per 1,000 discharges have risen through 2013\(^2\)

Pathogenesis of CDI

1. CDI spores survive in the environment for long periods of time. Following ingestion, they traverse the acidic environment of the stomach.

2. Spores germinate within the intestine.

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

4. Toxin A & B Production leads to colon damage +/- pseudomembrane.
Epidemiology: Epidemic Strain

- BI/NAP1/027, toxinotype III
- First emerged in 2000
- Associated with healthcare
- More resistant to fluoroquinolones
- Greater virulence
  - Associated with more severe disease and mortality
  - Increased toxin A and B production
  - Polymorphisms in binding domain of toxin B

Epidemiology: Host Factors

**Advanced age**
- Incidence higher among females, whites, and persons > 65 years\(^1\)
- Death more common in persons > 65 years (5x greater risk)\(^2\)

**Underlying illness and medical history**
- 79% of 7421 patients with CDI had a comorbid condition\(^2\)
- 38% of 585 patients with NAP1 strain had ED visit in previous 12 weeks\(^2\)
- Tube feeds\(^3\)

**Immunosuppression**
- Inflammatory bowel disease\(^2\)
- Immune-suppressive treatment\(^2\)
- Hematological malignancy/stem cell transplant (15-25x greater risk)\(^4\)

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Epidemiology: Modifiable Risk Factors

**Exposure to antibiotics**

High Risk:
- Fluoroquinolones
- 3rd and 4th generation cephalosporins, clindamycin, carbapenems

**Exposure to C. difficile spores**

- Spores can remain viable for months
- Contamination is increased in rooms of patients with active CDI
- Hands of patients and personnel are easily contaminated

**Gastric acid suppression**

- Data, though inconsistent, implicate proton pump inhibitor (PPI) use
- More study is needed to link restriction of PPI use with decreased CDI incidence

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Gastric Acid Suppression and CDI Risk
*Dose Response and Interactions with Antibiotics*

Use of Proton Pump Inhibitors (PPI) and CDI

February 8, 2012 – FDA warning on PPI Use

FDA Drug Safety Communication: *Clostridium difficile*-associated diarrhea can be associated with stomach acid drugs known as proton pump inhibitors (PPIs)

(en Español)
Defining Outbreaks and Hyperendemic CDI

• **What is an outbreak?**
  • Increase in CDI that is greater than expected by chance alone
  • Can be facility-wide, unit specific, or occurring within the community

• **What is hyperendemicity?**
  • Persistently high rates of CDI compared to past rates or compared to similar facilities/units
  • Example: Excess infections above a prevention goal as indicated by the Cumulative Attributable Difference (CAD) metric in an NHSN Targeted Assessment for Prevention (TAP) report

www.cdc.gov/hai/prevent/tap.html
### Data for Action

**Using the CDC Targeted Assessment for Prevention (TAP) Strategy**

<table>
<thead>
<tr>
<th>Target</th>
<th>Assess</th>
<th>Prevent</th>
</tr>
</thead>
</table>
| - Generate TAP Reports using NHSN  
- Identify locations with excess HAIs  
- Engage targeted locations in focused prevention efforts | - Assess targeted locations for potential gaps in infection control | - Use tailored prevention strategies to address identified gaps |

An elevated CDI CAD on a hospital’s TAP report can identify the need to initiate an infection prevention assessment. In many cases, a specific unit or units in the hospital account for the majority of cases.

[www.cdc.gov/hai/prevent/tap.html](http://www.cdc.gov/hai/prevent/tap.html)
Target Units or Facilities with Excess Infections

Identify facilities or units with opportunities for improvement using a TAP Report generated in the National Healthcare Safety Network (NHSN).

TAP Strategy ‘How To’ Guide
for the Individual Facility User
Targeted Assessment for Prevention: Using Data for Action
www.cdc.gov/hai/prevent/tap.html

The Targeted Assessment for Prevention (TAP) Strategy is a framework for quality improvement that offers a focused approach to infection prevention for healthcare facilities, healthcare systems, public health, and quality improvement partners. This strategy can be used to identify facilities and units with a high burden of healthcare-associated infections (HAIs) so that specific gaps in infection prevention can be identified and addressed. The TAP strategy incorporates the TAP reports generated in CDC’s National Healthcare Safety Network (NHSN) along with standardized assessment tools and accompanying implementation strategies.

TAP Strategy ‘How To’ Guide
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www.cdc.gov/hai/prevent/tap.html
Assess Infection Prevention Practices

• Assess policies and practices related to CDI prevention
  – Leadership
  – Training, auditing/feedback
  – Antibiotic stewardship
  – Early detection and isolation
  – Appropriate testing practices
  – Contact Precautions/hand hygiene
  – Environmental cleaning

<table>
<thead>
<tr>
<th>II. Antibiotic Stewardship for CDI Prevention</th>
<th>Response Choices</th>
<th>Comments (and/or “As Evidenced By”)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Does your facility review appropriateness of antibiotics prescribed for treatment of other conditions (e.g., UTI) for patients with new or recent CDI diagnosis?</td>
<td>Yes ☐ No ☐ Unk ☐</td>
<td></td>
</tr>
<tr>
<td>2. Does your facility educate providers about the risk of CDI with antibiotics?</td>
<td>Yes ☐ No ☐ Unk ☐</td>
<td></td>
</tr>
<tr>
<td>3. Does your facility educate patients/family members about the risk of CDI with antibiotics?</td>
<td>Yes ☐ No ☐ Unk ☐</td>
<td></td>
</tr>
<tr>
<td>Does your facility monitor the use of the following antibiotics that are high-risk for CDI:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Fluoroquinolones</td>
<td>Yes ☐ No ☐ Unk ☐</td>
<td></td>
</tr>
<tr>
<td>5. 3rd/4th generation cephalosporins?</td>
<td>Yes ☐ No ☐ Unk ☐</td>
<td></td>
</tr>
<tr>
<td>Does your facility use strategies to reduce the use of the following antibiotics that are high-risk for CDI:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Fluoroquinolones</td>
<td>Yes ☐ No ☐ Unk ☐</td>
<td></td>
</tr>
<tr>
<td>7. 3rd/4th generation cephalosporins?</td>
<td>Yes ☐ No ☐ Unk ☐</td>
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# Prevent Infections with Tailored Measures

## II. Antibiotic Stewardship

<table>
<thead>
<tr>
<th>Example Resources</th>
<th>Websites</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Get Smart for Healthcare – Implementation Resources</strong>&lt;br&gt;Resources to assist in the implementation of hospital antibiotic stewardship programs, including guidelines, assessment tools, conceptual models, and a sample inter-facility infection control transfer form, from CDC</td>
<td><a href="http://www.cdc.gov/getsmt/healthcare/implementation.html">http://www.cdc.gov/getsmt/healthcare/implementation.html</a></td>
</tr>
</tbody>
</table>

| **Get Smart for Healthcare – Stewardship Program Examples**<br>Links to hospital stewardship programs at various hospitals, success stories, and an interactive collection of charts and maps summarizing national and subnational data on antimicrobial use and resistance (Resistance Map), from CDC | [http://www.cdc.gov/getsmt/healthcare/programs.html](http://www.cdc.gov/getsmt/healthcare/programs.html) |

| **Get Smart for Healthcare - Checklist for Core Elements of Hospital Antibiotic Stewardship Programs**<br>A checklist to evaluate hospital antibiotic stewardship programs, from CDC | [Checklist for Core Elements of Hospital Antibiotic Stewardship Programs](http://www.cdc.gov/getsmt/healthcare/programs.html) | [Get Smart for Healthcare | CDC](http://www.cdc.gov/getsmt/healthcare/programs.html) |

| **Antimicrobial Stewardship Toolkit**<br>Best practices from an Antimicrobial Stewardship Collaborative, from the Greater New York Hospital Association and the United Hospital Fund | [http://www.shea-online.org/Portals/0/GNYHA_Antimicrobial_Stewardship_Toolkit_FINALv2%20Dec2011.pdf](http://www.shea-online.org/Portals/0/GNYHA_Antimicrobial_Stewardship_Toolkit_FINALv2%20Dec2011.pdf) |


## III. Early Detection and Isolation, Appropriate Testing

<table>
<thead>
<tr>
<th>Example Resources</th>
<th>Websites</th>
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</thead>
<tbody>
<tr>
<td><strong>Algorithms for Prevention and Management of Clostridium difficile Infections in Long-term Care Facilities</strong>&lt;br&gt;Decision-making strategies for enhancing early recognition, testing, and isolation of patients with CDI in long-term care facilities, from the Minnesota Department of Public Health</td>
<td><a href="http://www.health.state.mn.us/divs/idepc/diseases/cdiff/hcp/ltcalgorithms.pdf">http://www.health.state.mn.us/divs/idepc/diseases/cdiff/hcp/ltcalgorithms.pdf</a></td>
</tr>
</tbody>
</table>

| **C. difficile Infection Change Package: Preventing C. difficile Transmission and Infection**<br>Compilation of tools, including algorithms for testing and diarrhea decision trees that align with appropriate isolation and testing guidelines (pgs. 12, 13), from the Health Research & Educational Trust (HRET), American Hospital Association (AHA), and Partnership for Patients | [http://www.hret-hen.org/topics/cdi/13-14/2014-CDIChangePackage508.pdf](http://www.hret-hen.org/topics/cdi/13-14/2014-CDIChangePackage508.pdf) |

| **Bristol Stool Form Scale**<br>Scale tool that provides an objective way to differentiate between various types of stool forms and recognize diarrhea, from the National Institutes of Health (NIH) | [http://bowelcontrol.nih.gov/bristol.aspx](http://bowelcontrol.nih.gov/bristol.aspx) |
General Infrastructure for CDI Prevention
Leadership

- Need to understand organizational culture and change it when it hinders performance\(^1\)
- Direct evidence linking leadership to infection rates is limited but consistent themes have been identified\(^2\)

**Leadership traits that may assist in preventing infections\(^3\):**

- Proactive, positive, visible
- Supportive of change
- Clear responsibilities
- Clear policies

**Leadership traits that may be associated with risk\(^2\):**

- Reactive
- Laissez faire management style
- Failure to assign responsibility and maintain accountability
- Wide span of control

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Capacity

Capacity may be affected by complex management issues

**Low Nurse Staffing Ratios**
- Nurse to patient staffing ratios inversely associated with healthcare-associated infections (UTI and SSI).¹

**High Occupancy**
- Inpatient wards with occupancy rates of 80-90% had CDI rates 56% higher than during baseline occupancy rates (0-69%).²

**Feeling Overwhelmed**
- Stress and chaos associated with poorer infection prevention practices.³

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Healthcare personnel education and competencies are foundational to successful performance

- **Hand Hygiene**
  - Appropriate selection and use of products

- **Patient Placement**
  - Knowledge of signs and symptoms to initiate transmission-based precautions

- **Personal Protective Equipment**
  - Appropriate selection of PPE
  - Procedures to don, doff, and dispose of PPE

- **Patient Transport**
  - Appropriate interventions for transport
  - Notification of receiving caregivers within and outside of facility upon transfer

Sustainable Quality Improvement

Participants in The Institute for Healthcare Improvement 100,000 Lives Campaign believed that data feedback, buy in, hardwiring (incorporation into daily activities), and leadership support were essential to sustainability.

- **Planning**
  Choose interventions that produce great benefit.

- **Engagement**
  Senior leaders provide cohesive vision.
  Midlevel and frontline caregivers desire to achieve positive patient outcomes.

- **Audits and Feedback**
  Frontline caregivers “meet the measures that matter.”
  Measures define success.

General Infrastructure

**Surveillance and Ongoing Measurement**

Process and outcome measures should be collected using ongoing, longitudinal methods with regular feedback to healthcare personnel.¹

### Process Measures
- Prospective, actionable, useful for feedback about unit implementation of prevention measures²
- Examples include:
  * Appropriate Isolation
  * Hand hygiene and PPE adherence

### Outcome Measures
- Useful to target assessments and prevention measures
- Examples include:
  * Hospital-onset CDI
  * Community-onset, healthcare facility-associated CDI

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Basic Practices and Special Approaches for CDI Prevention
Overview

- **Basic practices** are prevention measures that should be in place at all times.
- **Facilities should consider adopting some or all of the special approaches whenever ongoing opportunities for improvement are identified or as indicated by risk assessment.**

<table>
<thead>
<tr>
<th>Basic Practices</th>
<th>Special Approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appropriate use of antimicrobials</td>
<td>Antimicrobial stewardship program</td>
</tr>
<tr>
<td>Hand hygiene per CDC/WHO recommendations</td>
<td>Hand hygiene with soap and water after glove removal following care of CDI patients</td>
</tr>
<tr>
<td></td>
<td>Measure healthcare personnel adherence</td>
</tr>
<tr>
<td>Contact Precautions for CDI patients</td>
<td>Presumptive Contact Precautions while laboratory results are pending</td>
</tr>
<tr>
<td></td>
<td>Measure healthcare personnel adherence</td>
</tr>
<tr>
<td>Cleaning and disinfection of equipment and environment</td>
<td>Use of EPA-approved sporicidal disinfectant</td>
</tr>
<tr>
<td>Laboratory-based alert system for immediate notification to IP and clinical personnel of newly diagnosed CDI patients</td>
<td>Assess adequacy of room cleaning</td>
</tr>
<tr>
<td>CDI surveillance, analysis, and reporting</td>
<td></td>
</tr>
<tr>
<td>Educate healthcare personnel, patients, and families</td>
<td></td>
</tr>
</tbody>
</table>

Antimicrobial Stewardship
Antimicrobial Stewardship

Exposure to any antimicrobial is the single most important risk factor for *C. difficile* infection (CDI).

- Antibiotic exposure has lasting impact on the microbiome.
  - Risk of CDI is elevated (7-10 fold) during and in the 3 months following antimicrobial therapy\(^1,2\)
  - 85-90% of CDI occurs within 30 days of antimicrobial exposure\(^1\)

- Target high risk antibiotics for CDI prevention
  - Fluoroquinolones\(^3\)
  - 3rd/4th generation cephalosporins, carbapenems\(^2\)

Seven Core Elements of Antimicrobial Stewardship

1. Leadership Commitment
   *Dedicating necessary human, financial, technological resources*

2. Accountability
   *Appointing a single leader (physician or pharmacist) responsible for program outcomes*

3. Drug Expertise
   *A single dedicated pharmacist with responsibility to improve antibiotic use*

4. Tracking
   *Monitoring antibiotic prescribing and resistance patterns*

5. Reporting
   *Feedback of information on antibiotic use and resistance to frontline providers*

6. Education
   *Ongoing education of clinicians about resistance and optimal prescribing*

7. Action
   *Implementing at least one recommended action*

http://www.cdc.gov/getsmart/healthcare/implementation/core-elements.html
Currently 39% (1,642/4,184) of U.S. hospitals have an antibiotic stewardship program with all 7 core elements.

The national goal is 100% of hospitals by 2020.

http://www.cdc.gov/getsmart/healthcare/evidence.html
Leaders Committed to Antibiotic Stewardship

Consider making your organization’s commitment to Antibiotic Stewardship public on the CDC Website.

Examples:

• **Hospital Corporation of America** has committed to continue current collaborations with CDC about this issue, develop and implement new clinical decision support and real-time antibiogram tracking to rapidly respond to lab results, catch bug-drug mismatches, implement strategy to prevent health-care associated infections in adult intensive care unit patients, and strengthen national efforts to identify and report cases of antibiotic resistance.

• **The Joint Commission** has committed to include stewardship as part of onsite surveys.

Stewardship Approach: Feedback

Non-restrictive feedback resulted in statistically significant reductions in incident CDI.

Reductions in CDI attained through antimicrobial stewardship surpassed those attained through infection control measures.

Stewardship Approach: Restriction

Restricting the use of ceftriaxone was associated with reduced rates of CDI.

**Fig. 1** Hospital-acquired methicillin-resistant *Staphylococcus aureus* (MRSA), *Clostridium difficile* and extended-spectrum β-lactamase (ESBL)-producing coliform rates following a restrictive antibiotic policy in a district general hospital over 2 years. pt/occ.bds, patient-occupied bed-days; DDDs, defined daily doses.
Early Detection and Isolation
Early Detection and Isolation

1) Focus testing on patients with clinically significant diarrhea, without other identified causes

• ≥ 3 liquid bowel movements (type 7) in 24 hours
• Stool conforms to shape of container

2) Utilize presumptive Contact Precautions until infectious causes are ruled out

The Bristol Stool Chart assists in objectively identifying stool characteristics

*presumptive use of Contact Precautions is a special approach

Patient and Family Education

**Educate**

- Patient education at the time of isolation is a critical intervention to reduce stress and anxiety\(^1\)
- Patient educational background may influence the preferred mode of education\(^2\)

**Engage**

- 94 of 100 patients believed that information about their infection would help them make choices that resulted in better care\(^2\)

**Empower**

- Patients more likely to speak up to ensure adherence with hand hygiene if explicitly empowered to do so by healthcare personnel\(^3\)

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Contact Precautions and Hand Hygiene
Contact Precautions (CP)

- Contamination of the environment is highest prior to treatment\(^1\)

- **Presumptive CP**, while CDI test results are pending, may be used as a special approach whenever indicated by risk assessment\(^2\)

- Patients who have been treated may have asymptomatic shedding\(^3\)

- **Prolonging the duration of CP** until discharge is a special approach based on evidence of continued shedding of spores after diarrhea resolves (especially up to 4 weeks after treatment ends)\(^2\)

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Contact Precautions

• Don gown and gloves upon room entry¹

• Use disposable or dedicated patient care equipment¹,²
  • Electronic thermometers have been associated with transmission

• Communicate Contact Precautions²,³
  • at room entrance
  • at handoff
  • during transfers


Cohorting of CDI Patients

• Private rooms are preferred for patients with fecal incontinence\(^1\)

• Cohorting of patients\(^1,2\)
  • Cohort patients with same multidrug-resistant organisms only
  • Ensure healthcare personnel follow appropriate isolation practices when moving between patients
    • Perform hand hygiene when donning or doffing PPE
    • Gloves and gowns must be changed and HH performed between each patient

Elements of a Multi-Modal Program to Improve Hand Hygiene

A robust, ongoing hand hygiene program should be in place

<table>
<thead>
<tr>
<th>Program Component</th>
<th>Action Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ongoing monitoring of HAI incidence</td>
<td>Setting specific feedback about incident CDI</td>
</tr>
<tr>
<td>Administrative support and leadership</td>
<td>Clear policies and messages about hand hygiene</td>
</tr>
<tr>
<td>Multidisciplinary team</td>
<td>Members of administration, clinical leaders, and front line staff collaboration to increase adherence</td>
</tr>
<tr>
<td>Ensure accessibility of supplies</td>
<td>Point of care hand hygiene should be within arms reach of healthcare personnel</td>
</tr>
<tr>
<td>Reinforce behavior and accountability</td>
<td>Contests, incentives, recognition tickets, notice letters, personnel action</td>
</tr>
<tr>
<td>Provision of reminders</td>
<td>Posters, just-in-time training, inclusion in checklists</td>
</tr>
<tr>
<td>Ongoing monitoring of adherence and feedback on compliance</td>
<td>Direct observation, product use monitoring, real-time feedback, monthly posting on adherence,</td>
</tr>
</tbody>
</table>

Hand Hygiene and Care of the Patient with CDI

- **Hand hygiene** policies should promote preferential use of alcohol-based hand rub (ABHR) over soap and water in all clinical situations except when hands are visibly soiled (e.g., blood, body fluids) or after caring for a patient with known or suspected *C. difficile* or norovirus during an outbreak or if endemic rates are high.

- Strict adherence to **glove use** is the most effective means of preventing hand contamination with *C. difficile* spores\(^1\)
  - Spores not killed by ABHR and may be difficult to remove even with thorough hand washing\(^2,3\)
  - Although there have been no studies demonstrating a decrease in CDI infection with use of soap and water as opposed to ABHR\(^4\), because ABHR is not effective against spores, facilities may consider routine use of soap and water after glove removal during care of patients with *C. difficile* infection even absent an outbreak.

- **Measuring compliance** is a basic practice and critical to success
  - Ensure technique is good and re-educate if lapses identified

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# Soap and Water vs. Alcohol Hand Rub

<table>
<thead>
<tr>
<th>Interventions compared</th>
<th>Mean log reduction (95% CI), log$_{10}$ CFU/mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm water and plain soap</td>
<td>No hand hygiene</td>
</tr>
<tr>
<td>Warm water and plain soap</td>
<td>Alcohol-based handrub</td>
</tr>
<tr>
<td>Cold water and plain soap</td>
<td>No hand hygiene</td>
</tr>
<tr>
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</tbody>
</table>

Data from 2000-2003 show **no association** between alcohol-based hand rub (ABHR) use and increase in CDI rates.
Importance of Gloves

Since spores may be difficult to remove from hands even with hand washing, **strict adherence to glove use**, and Contact Precautions in general, should be emphasized for preventing *C. difficile* transmission via the hands of healthcare personnel.
Importance of Gloving

• Environmental contamination may be increased during outbreaks and in locations with hyperendemicity\(^1\)

• Glove use is most effective means of preventing contamination of the hands of HCPs with \textit{C. difficile} spores from symptomatic patients

• Universal gloving is a special approach for use when indicated by risk assessment\(^2\)

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A randomized trial of soap and water wash versus alcohol hand rub shows soap and water are more effective at removal of *C. difficile* spores on patient hands.

**Figure 1:** Percent of patient hands with positive *Clostridium difficile* cultures.
Environmental Cleaning and Disinfection
Key Principles

- There is no substitute for meticulous cleaning\textsuperscript{1,2,3}
- Cleaning reduces spores in the environment\textsuperscript{2}
- Disinfectants with a sporicidal claim inactivate spores\textsuperscript{2}
- Monitoring and feedback optimize performance\textsuperscript{1}
- Policies should clearly define who is responsible for cleaning and disinfecting environmental surfaces and equipment\textsuperscript{4}

<table>
<thead>
<tr>
<th>Cleaning</th>
<th>The removal of organic debris using vigorous wiping and or scrubbing until all visible soil is removed\textsuperscript{1}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disinfection</td>
<td>Removal or inactivation of some or all pathogens on inanimate objects\textsuperscript{1}</td>
</tr>
</tbody>
</table>

Mitigating Risks Through Environmental Cleaning and Disinfection

High touch items

- Facilities must ensure adequate cleaning of high touch surfaces in the patient environment.
- Examples:
  - Bed rails
  - Restroom hand rails
  - Bed side tables
  - See CDC checklist for full list*

Disinfectant preparation

- Facilities must ensure proper preparation and use of disinfectants.
  - Including appropriate:
    - Dilution
    - Storage
    - Application
    - Contact Time

Proper use of disinfectants

- Factors that influence disinfectant effectiveness:
  - Porosity of surface
  - Crevices or ridges
- Facilities must ensure cross contamination is avoided

Environmental Contamination

- Patients with asymptomatic carriage may be an important source of environmental contamination\(^1\)
- Patients that have been treated may continue to shed spores\(^2\)

In a cross sectional survey of 6 facilities\(^3\):

- NAP1 strain recovered at each facility
- All rooms housing a CDI patient yielded positive cultures for \textit{C. difficile}
- 4/12 (33\%) of rooms without a CDI patient yielded positive cultures for \textit{C. difficile}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{Figure.png}
\caption{Figure from Sethi, 2010}
\end{figure}

\begin{flushleft}
\begin{enumerate}
\end{enumerate}
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Spore Removal

• Meticulous cleaning with any cleaner/disinfectant reduces the number of spores in the environment\(^1\)
• However, greater reduction and inactivation of spores is achieved when a sporicidal agent is used\(^1\)
• Removal of spores influenced by contact time (duration of wetness) and texture of surface being cleaned\(^2\)

<table>
<thead>
<tr>
<th>Technique</th>
<th>Reduction in Spores</th>
<th>Dry Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wiping with any disinfectant</td>
<td>&gt; 2.9 (\log_{10})</td>
<td>2-6 minutes</td>
</tr>
<tr>
<td>Spraying (no wipe) with sporicide</td>
<td>3.4 (\log_{10})</td>
<td>28-40 minutes</td>
</tr>
<tr>
<td>Wiping with sporicide</td>
<td>3.9 (\log_{10})</td>
<td>2-6 minutes</td>
</tr>
</tbody>
</table>

EPA-Approved Disinfectants Effective Against *C. difficile*

- Before-after intervention studies demonstrated benefit of sporicidal disinfectants in units with high endemic CDI rates\(^1\)
- Environmental contamination indirectly increases risk of cross contamination, likely via the hands of healthcare personnel\(^2\)

When using sporicidal disinfectants\(^1\):
- Avoid toxicity to patients and environmental services staff
- Avoid damage to equipment
- Ensure method to communicate when sporicidal disinfectants should be used

A current list of EPA-approved disinfectants with sporicidal claim is available at: [http://www.epa.gov/pesticide-registration/list-k-epas-registered-antimicrobial-products-effective-against-clostridium](http://www.epa.gov/pesticide-registration/list-k-epas-registered-antimicrobial-products-effective-against-clostridium)

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Inactivation of *C. difficile* Spores

Sporicidal disinfectants most effective in reducing CDI when endemic rates are high.

**Bone Marrow Transplant Unit**

CDI Rates/ 1000 pt. days:
- Pre intervention: **8.6**
- Intervention: **3.3**
- Post-intervention: **8.1**

**No reduction:**
- Neurosurgical ICU: **3.0**
- General medical ward: **1.3**

CDI rates in bone marrow transplant unit

Reducing CDI Using a Sporicidal Wipe for Cleaning

- Before/after study in two high-risk medical wards
- Intervention:
  - Daily and terminal cleaning of all rooms with ATP monitoring before/after (similar pass rate)
  - Quaternary ammonium compound before
  - Hypochlorite wipes with 10 minute contact time after
- Results: 24.2 to 3.6 cases per 10,000 patient-days (85% decline)

Evaluating Cleanliness

Objective assessment of cleaning assists in optimizing performance\textsuperscript{1,2}

- Monitoring of surfaces using florescent gel resulted in significant improvements in cleaning
- Educational interventions with environmental services staff resulted in sustained improvement

# Methods of Evaluating Cleanliness

## Evaluating Patient Zone Environmental Cleaning

<table>
<thead>
<tr>
<th>Method</th>
<th>Ease of Use</th>
<th>Identifies Pathogens</th>
<th>Accuracy</th>
<th>Useful for Teaching</th>
<th>Use in Programmatic Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct observation</td>
<td>Low</td>
<td>No</td>
<td>Variable</td>
<td>Yes</td>
<td>Difficult</td>
</tr>
<tr>
<td>Culture swab</td>
<td>High</td>
<td>Yes</td>
<td>High</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Agar culture system</td>
<td>Moderate</td>
<td>Possible</td>
<td>Moderate</td>
<td>No</td>
<td>Possible*</td>
</tr>
<tr>
<td>Fluorescent system</td>
<td>High</td>
<td>No</td>
<td>High</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>ATP Bioluminescence</td>
<td>High</td>
<td>No</td>
<td>Variable</td>
<td>Yes</td>
<td>Possible*</td>
</tr>
</tbody>
</table>

* Measures cleanliness at that moment but **NOT** the process of cleaning
Using ATP Bioluminescence To Evaluate Cleanliness

Facilities using Adenosine Triphosphate (ATP) bioluminescence to monitor cleaning should carefully consider the range and diversity of results.

Researchers, using a convenience sample of 500 surfaces, determined:

- 378 (76%) surfaces had fluorescent marker removed
- 225 (45%) had ATP bioluminescence measurement indicating cleanliness
- 384 (77%) had aerobic colony counts indicating cleanliness

<table>
<thead>
<tr>
<th>Method</th>
<th>Pro</th>
<th>Con</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluorescent Gel</td>
<td>Easy to apply – Stable in Environment</td>
<td>Requires application before cleaning and reassessment after cleaning</td>
</tr>
<tr>
<td></td>
<td>Removal accurately signifies cleaning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evaluates cleaning process</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Effective training tool for ES staff</td>
<td></td>
</tr>
<tr>
<td>ATP Bioluminescence</td>
<td>Ease of use</td>
<td>Does not evaluate cleaning process</td>
</tr>
<tr>
<td></td>
<td>Evaluates current cleanliness</td>
<td>ATP failures may not correlate with fluorescent gel or CFU counts</td>
</tr>
<tr>
<td></td>
<td>Effective training tool for ES staff</td>
<td>Disinfectants may confound results</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Facility and surface specific benchmarks may be needed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Specificity ~ 57%</td>
</tr>
</tbody>
</table>

Ultraviolet Light and Hydrogen Peroxide Fogging

- Data currently insufficient to recommend inclusion of these methods in a CDI prevention program

- Standard room cleaning and disinfection found to be suboptimal when UV disinfection was used
  - Consistent cleaning attributed to 2 interventions:
    - Dedicated team
    - Supervisory housekeeping staff or IP staff checked rooms post cleaning

Effectiveness of no-touch disinfection technologies in preventing CDI requires further evaluation.

Appropriate Testing and Laboratory Practices
Guidance from the American Society for Microbiology

• Toxin A/B enzyme immunoassays have low sensitivity and should not be used as stand alone tests.¹

• Highly sensitive screening tests like glutamate dehydrogenase antigen assays (GDH) should have positive results confirmed.

• Nucleic acid amplification that detects *C. difficile* toxin genes may be used as a stand alone test.

• Repeat testing, testing of formed stool, and testing for cure should be avoided.²

*Regardless of testing method, ensure appropriate testing to optimizing test performance!*

Typical Diagnostic Algorithm for Detection of Toxigenic *C. difficile* in Stool

1. **Enzyme Immunoassay**
   - GDH Positive
   - GDH Negative

2. **CCNA or NAAT**
   - Negative
   - Positive

- **Report**
  - Positive Result
  - Negative Result
Understanding Predictive Value

True prevalence in the population tested for *C. difficile* greatly impacts predictive value of diagnostic tests.

Figure 1: Effect of varying prevalence on the PPV and NPV of a theoretical *Clostridium difficile* toxin assay with a sensitivity of 92% and a specificity of 97%. NPV = negative predictive value, PPV = positive predictive value.

Repeat Testing

- Testing with a low sensitivity test and repeat testing are not recommended\(^1\)
  - Results in increased false positive results
  - Pseudo-outbreaks related to false positives and repeated testing have been identified\(^2,3\)

<table>
<thead>
<tr>
<th>Test Sequence</th>
<th>EIA</th>
<th>qPCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tested, n</td>
<td>True Positive, n</td>
<td>PPV</td>
</tr>
<tr>
<td>First</td>
<td>1000</td>
<td>73</td>
</tr>
<tr>
<td>Second</td>
<td>903</td>
<td>18</td>
</tr>
<tr>
<td>Third</td>
<td>863</td>
<td>7</td>
</tr>
<tr>
<td>Fourth</td>
<td>835</td>
<td>1</td>
</tr>
<tr>
<td>Fifth</td>
<td>814</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>100+</td>
<td>107</td>
</tr>
</tbody>
</table>

\(\text{EIA} = \text{enzyme immunoassay}; \text{PPV} = \text{positive predictive value}; \text{qPCR} = \text{quantitative real-time polymerase chain reaction.}\)

* In this model, there are 1000 tested participants and \(C.\) difficile prevalence in the test population is 10%. Patients with negative results have tests repeated sufficiently to ensure that all true-positive results are captured. Assumptions for EIA: sensitivity = 73.3%; specificity = 97.6%; and test performance does not change when repeated (6). Assumptions for qPCR: sensitivity = 93.3%; specificity = 97.4%; and test performance does not change when repeated (6).

\(\dagger\) Overall PPV = 0.48.

\(\ddagger\) Overall PPV = 0.67.

Guidance for Appropriate Testing

Tools that guide clinical decision making, such as algorithms, can assist in ensuring appropriate testing.

Example of a CDI decision tool from Vanderbilt University Medical Center

2. Vanderbilt University Medical Center: http://www.mc.vanderbilt.edu/documents/infectioncontrol/files/Guidance%20for%20Providers%20FINAL%202011.pdf
### NHSN CDI Risk Adjusted SIR
Accounts for More Sensitive Testing

Variables from Final Model to be included for Risk Adjustment in SIR Calculation

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td></td>
</tr>
<tr>
<td>Facility Bed Size</td>
<td>&gt; 245</td>
</tr>
<tr>
<td></td>
<td>101-245</td>
</tr>
<tr>
<td></td>
<td>≤ 100</td>
</tr>
<tr>
<td>Teaching Type</td>
<td>Major</td>
</tr>
<tr>
<td></td>
<td>Graduate</td>
</tr>
<tr>
<td></td>
<td>Limited &amp; Non</td>
</tr>
<tr>
<td>CDI Test Type</td>
<td>NAAT (PCR)</td>
</tr>
<tr>
<td></td>
<td>EIA</td>
</tr>
<tr>
<td></td>
<td>All Other</td>
</tr>
<tr>
<td>Prevalence</td>
<td>Continuous (no CO-HCFA)</td>
</tr>
</tbody>
</table>

Data Sources and Submission

- CDI test type, facility bed size, and teaching type are collected on the required Annual Facility Survey

Implementing a Practical Approach to CDI Prevention
Targeted Assessment for Prevention (TAP) Strategy

CDI TAP reports available in NHSN

Work ongoing to use CO-CDI and other data sources to identify CDI cases from nursing homes and other community sources

Target facilities/units

Assess gaps in infection prevention in targeted areas

Prevent infections by implementing interventions to address the gaps

www.cdc.gov/hai/prevent/tap.html
CDI Risk Assessment

• Conduct a risk assessment annually and whenever CDI goals are not met
  • Use CDC’s Targeted Assessment for Prevention (TAP) Strategy
  • Pairing the results of a CDI facility assessment with the CDI Implementation Tool allows facilities to implement infection prevention strategies that most directly meet their needs.
CDI Case Review

- Review each CDI case (e.g., root cause analysis)
- Examine temporal and spatial relationships between cases to determine units at risk for transmission due to community-onset or hospital-onset CDI cases.

The CDI Implementation Tool includes a template for CDI Case Review

<table>
<thead>
<tr>
<th>FEEDBACK</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NHSN Resources for MDRO and <em>C. difficile</em> Infection Module</strong></td>
</tr>
<tr>
<td>Protocols and training for National Healthcare Safety Network and the collection of CDI incidence data for reporting and feedback, from CDC</td>
</tr>
<tr>
<td><strong>CDI Cause Analysis</strong></td>
</tr>
<tr>
<td>Worksheet for reviewing CDI cases and adherence to facility policies and practices, including antibiotic review log, from the Massachusetts Coalition for the Prevention of Medical Errors</td>
</tr>
</tbody>
</table>

www.cdc.gov/hai/prevent/tap.html
A Coordinated Response

A coordinated response is more effective than independent efforts¹

Partners in Prevention:
The state and local health department and other state partners can assist and provide opportunities to extend efforts across the continuum of care

Figure from CDC Vitals Signs: http://www.cdc.gov/vitalsigns/stop-spread/index.html

¹ Slayton et al. MMWR 2015; 64(30): 826-831.
References
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