Preventing C. difficile Infection
Reducing Risk from the Hospital Environment

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Cleaning and disinfection play important roles in preventing *Clostridium difficile* and other HAIs.
C. difficile and Other Multidrug-Resistant Organisms (MDRO)
In 1991, three forces came together to produce the “Perfect Storm.”
We are experiencing a “perfect storm” for *C. difficile* and other MDRO infections

- Long-term survival on surfaces
- Inconsistent use of proven prevention strategies
- Increasing number of high-risk patients
- Contamination of the healthcare environment
- Widespread use of broad-spectrum antibiotics
Healthcare-associated MDRO infections are common in NY State hospitals.

<table>
<thead>
<tr>
<th>Hospital-Onset Infection</th>
<th># of Events in NY State Hospitals, 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. difficile</em> infection</td>
<td>8,890</td>
</tr>
<tr>
<td>MRSA bloodstream infection</td>
<td>850</td>
</tr>
<tr>
<td>Carbapenem-resistant Enterobacteriaceae (CRE) bloodstream infection</td>
<td>249</td>
</tr>
</tbody>
</table>

Between 2010 and 2014, hospital-onset CDI in NY decreased by 32% (8% per year), preventing 10,380 patient infections and saving $98-$139M.
Rates of MDRO infections in New York are significantly worse than in the U.S. overall.

Hospital onset *C. difficile*

9% higher than the national rate

23% of NYS hospitals were significantly worse

Hospital-onset MRSA bacteremia

11% higher than the national rate

11% of NYS hospitals were significantly worse

C. difficile infection (CDI) is usually the result of two unique events.

1. **Exposure to C. difficile**
   - Healthcare facility
   - Community

2. **Alteration of normal GI microbiota**
   - Antibiotics
   - Other medications

The combination of these two events results in:

- **C. difficile infection (CDI)**
  - Mild diarrhea
  - Fulminant colitis
  - Sepsis
  - Septic shock
  - Death
CDI is usually the result of two frequently preventable events.

Exposure to *C. difficile* + Alteration of normal GI microbiota = *C. difficile* infection (CDI)

Environmental cleaning
- Equipment cleaning
- Hand hygiene
- Contact precautions

Antimicrobial stewardship

Healthcare facility

Antibiotics

Mild diarrhea
- Fulminant colitis
- Sepsis
- Septic shock
- Death

Cohen SH. *Infect Control Hosp Epidemiol* 2010; 31:431-55
Dubberke ER. *Infect Control Hosp Epidemiol* 2014;35:628-45
The Health Care Environment
The hospital environment is frequently contaminated with *C. difficile*. 

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**CDI Patient Rooms**
- Contaminated
- Not contaminated

**Items & Surfaces in CDI Patient Rooms**
- Contaminated
- Not contaminated

**Non-CDI Patient Rooms**
- Contaminated
- Not contaminated

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Other MDRO also frequently contaminate the environment.

<table>
<thead>
<tr>
<th>Organism</th>
<th>Setting</th>
<th>Sample Positivity Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methicillin-resistant <em>S. aureus</em> (MRSA)</td>
<td>Hospital</td>
<td>27-73%</td>
</tr>
<tr>
<td>Vancomycin-resistant <em>Enterococcus</em> (VRE)</td>
<td>Hospital</td>
<td>25.2%</td>
</tr>
<tr>
<td>MDR A. <em>baumannii</em></td>
<td>Hospital, LTACH</td>
<td>1.8%-42%</td>
</tr>
<tr>
<td>Carbapenem-resistant <em>K. pneumoniae</em></td>
<td>ICU</td>
<td>8%-67%</td>
</tr>
<tr>
<td>ESBL <em>K. oxytoca</em></td>
<td>ICU</td>
<td>94%</td>
</tr>
<tr>
<td>MDR GNR(^7)</td>
<td>Hospital</td>
<td>4.9%</td>
</tr>
</tbody>
</table>

Palmore T. *Infect Control Hosp Epidemiol* 2011;32:1166-72
Thom KA. *J Clin Microbiol* 2012;50:2140-1
Munoz Price L. *Infect Control Hosp Epidemiol* 2010;31:1074-7
Lemmen SW. *J Hosp Infect* 2004;56:191-7
Friedman ND. *Am J Infect Control* 2013;41:227-31
Ray A. *Infect Control Hosp Epidemiol* 2010;31:1236-41
Bratu S. *Arch Intern Med* 2005;165:1430
Lowe C. *Emerg Infect Dis* 2012;18:1242-7
French GL. *J Hosp Infect* 2004;57:31-7
Many pathogens can survive in the environment for long periods of time.

<table>
<thead>
<tr>
<th>Organism</th>
<th>Duration of Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acinetobacter sp.</td>
<td>3 days-5 months</td>
</tr>
<tr>
<td><em>Clostridium difficile</em> spores</td>
<td>5 months</td>
</tr>
<tr>
<td><em>E. coli</em></td>
<td>1.5 hours-16 months</td>
</tr>
<tr>
<td><em>Enterococcus</em> (VRE, VSE)</td>
<td>5 days-4 months</td>
</tr>
<tr>
<td><em>Klebsiella</em> sp.</td>
<td>2 hours-&gt;30 months</td>
</tr>
<tr>
<td><em>Proteus vulgaris</em></td>
<td>1-2 days</td>
</tr>
<tr>
<td><em>Pseudomonas aeruginosa</em></td>
<td>6 hours-16 months</td>
</tr>
<tr>
<td><em>Serratia marcescens</em></td>
<td>3 days-2 months</td>
</tr>
<tr>
<td><em>S. aureus</em> (including MRSA)</td>
<td>7 days-7 months</td>
</tr>
</tbody>
</table>
Patients admitted to a room in which the prior occupant was colonized or infected are more likely to acquire that MDRO.

*Odds ratio compared to admission to a room in which the prior occupant was not colonized or infected.

Shaughnessy MK. Infect Control Hosp Epidemiol 2011;32:201-6  
Nseir S. Clin Microbiol Infect 2011;17:1201-8  
Huang SS. Arch Intern Med 2006;166:1945-51  
Mitchell BG. J Hosp Infect 2015;91:211-17
Healthcare workers’ hands are often contaminated after caring for patients with *C. difficile* infection.

NOTE: The larger yellow colonies are *C. difficile*.

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Bobulsky GS. *Clin Infect Dis* 2008;46:447-50
Environmental contamination leads to contamination of healthcare workers’ hands.

After 5 seconds of contact with bedrail and bedside table, HCW hand cultures were positive in:

- 53% of occupied rooms
- 24% of vacant, “clean” rooms

The hospital “environment” is more than horizontal surfaces, fixtures, and furniture.

Shared, mobile equipment: BP cuffs, glucometers, stethoscopes, stretchers, wheelchairs, portable ultrasound devices, ECG machines, IV pumps, IV poles, ventilators
Cleaning and Disinfection Strategies
We need to use consistent and precise terminology.

**Cleaning**: removal of all foreign material (soil, organic debris) from objects

**Disinfection**: a process that results in the elimination of many or all pathogenic microorganisms, with the exception of bacterial spores, on inanimate objects

**Contact time** ("wet time"): the length of a time a surface needs to remain wet in order for the disinfectant to achieve the claimed disinfection activity
We need to use consistent and precise terminology.

**Daily cleaning**: cleaning and disinfection of an occupied patient room

**Terminal (discharge) cleaning**: cleaning and disinfection of a room after discharge of the previous patient, in preparation for arrival of the next patient
We need to use consistent and precise terminology.

**High-touch surfaces:** surfaces and items with frequent hand contact

- Bed rails and controls
- Tray table
- IV pole (grab area)
- Call box/button
- Telephone
- Bedside table handle
- Chair
- Room sink
- Light switches
- Inner door knobs
- Bathroom handrails
- Bathroom sink
- Toilet seat, flush handle
- Toilet bedpan cleaner
- Equipment: IV pump control, monitor controls/touch screen/cables, ventilator control panel
Important differences exist among approved hospital disinfectants.

<table>
<thead>
<tr>
<th></th>
<th>Quaternary Ammonium</th>
<th>Hypochlorite (bleach)</th>
<th>Accelerated H₂O₂</th>
<th>Peracetic Acid</th>
<th>Phenolics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bactericidal</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Virucidal</td>
<td>Yes (enveloped viruses)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Fungicidal</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Mycobactericidal</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sporicidal</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Active in presence of organic matter</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Other important characteristics</td>
<td>Some persistent activity</td>
<td>Corrosive, eye and skin irritation, instability after dilution</td>
<td>Environmentally safe, more expensive</td>
<td>Instability after dilution</td>
<td>Tissue irritation, skin depigmentation</td>
</tr>
</tbody>
</table>

Peracetic acid is also known as peroxycetic acid.
Elimination of *C. difficile* spores is a function of disinfectant activity AND physical removal.

Rutala WA. *Infect Control Hosp Epidemiol* 2012;33:1255-8
Standard cleaning and disinfection protocols can eliminate *C. difficile* from the environment.

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Percentage of environmental cultures positive for *C. difficile* before and after cleaning and disinfection with 10% bleach. (9 rooms)
The use of a sporicidal disinfectant may reduce CDI rates in areas with high baseline rates.

Note: there was no change in CDI rates in two other units where baseline rates were lower (1.3-3/1,000 pt-days)
The use of a sporicidal disinfectant may reduce CDI rates in areas with high baseline rates.

A change to bleach was associated with an 85% decrease in hospital-onset CDI in two units with high endemic CDI rates.

Figure 1. *Clostridium difficile* infection incidence for units A and B combined before the intervention (August 1, 2008–July 31, 2009) and after the intervention (August 1, 2009–July 31, 2010). HAI, hospital-acquired infection; INC, overall infection incidence; PD, patient days; PT, patient.
Current guidelines recommend the use of sporicidal disinfectants in some settings.

“Use chlorine-containing cleaning agents or other sporicidal agents to address environmental contamination in areas associated with increased rates of CDI (B-II).”

-SHEA-IDSA Clinical Practice Guidelines, 2010

“Facilities should consider using a 1:10 dilution of [bleach] or other product with EPA-approved claim for C. difficile sporicidal activity…in outbreak and hyperendemic settings in conjunction with other control measures.”

-SHEA/IDSA Practice Recommendation, 2014
The effectiveness of cleaning and disinfection depends on many factors.

- Spectrum of Activity
- Proper concentration
- Contact with all surfaces
- Adequate contact time
- Avoidance of recontamination
- Physical removal (elbow grease)
Improvement in cleaning and disinfection practices can prevent MDRO transmission.

25% lower risk of acquiring MRSA

Elimination of the risk associated with an MRSA-positive prior room occupant

Datta R. Arch Intern Med 2011;171:491-4
“No-touch” environmental disinfection technologies have been developed.

Potential benefits:

- Less reliant on human factors
- Broader application of disinfectant
Ultraviolet (UV) light kills pathogens contaminating the hospital environment.

Mean aerobic colony counts before and after UV light treatment in 20 terminally cleaned patient rooms.

Boyce JM. *Infect Control Hosp Epidemiol* 2011;32:737-42
Further evaluation of the role of no-touch disinfection technology is needed.

Cluster randomized, crossover trial conducted in 9 hospitals.

No difference in CDI or MRSA.*

90% compliance with room cleaning
90% compliance with hand hygiene

*Compared to a Quat alone, VRE incidence was lower in all 3 groups.

Anderson DJ. Benefits of Enhanced Terminal Room (BETR) Disinfection Study. IDWeek 2015. San Diego CA
Hydrogen peroxide vapor kills pathogens contaminating the hospital environment.

*cleaning involved only a detergent

French GL. *J Hosp Infect* 2004;57:31-7
Further evaluation of the role of no-touch disinfection technology is needed.

Note: there was no assessment of adherence to standard protocols.

Passaretti CL. *Clin Infect Dis* 2013;56:27-35

QAC=quaternary ammonium compound
The role of no-touch disinfection technology in routine hospital environmental disinfection has not yet been determined.

May be an **adjunct** to, but not a replacement for, manual cleaning and disinfection.

**Cost** and **logistical issues** must be considered.

More studies, especially those with **clinical outcomes**, are needed.

Weber DJ. *Infect Control Hosp Epidemiol* 2012;33:10-13
Boyce JM. *Infect Control Hosp Epidemiol* 2011;32:737-42
Otter JA. *Am J Infect Control* 2010;38:754-6
Havill NL. *Infect Control Hosp Epidemiol* 2012;33:507-12
Otter JA. *J Clin Microbiol* 2009;47:205-7
Manian FA. *Infect Control Hosp Epidemiol* 2011;32:667-72
Challenges and Barriers
1 out of 2 high-touch surfaces in hospital rooms is not cleaned at discharge.

Year: 2006
Location: 36 hospitals
14 high-touch surfaces

Carling PC. Infect Control Hosp Epidemiol 2008;29:1035-41
Ineffective cleaning and disinfection technique allows pathogens to persist in the environment.

Percentage of environmental cultures positive for *C. difficile* before and after housekeeping cleaning and after research team disinfection with 10% bleach. (9 rooms)

Eckstein et al. *BMC Infect Dis* 2007 7:61
High-touch surfaces are often not significantly cleaner after daily cleaning than before.

24% contaminated with MRSA

16% contaminated with VRE

Bedrails, overbed tables, and remote control were **NOT** significantly cleaner.

Toilet seats and bathroom grab bars were significantly cleaner after daily cleaning.

Boyce JM. *Infect Control Hosp Epidemiol* 2009;30: 678-84
Many high-touch surfaces are often not significantly cleaner after daily cleaning than before.
Shared, mobile equipment is frequently burdened with organic material.
Maintaining a clean and safe hospital environment is a challenge for hospitals everywhere.

- Relevant to a large number and wide variety of items
- Dependent upon many groups and many individuals
- Must be done frequently
- Involves complex tasks
- Relies on individual human behavior

*C. difficile*: spores are resistant to many disinfectants and often require longer contact time than other pathogens
Saying things loudly and repetitively does not usually lead to sustainable improvements.
Human behavior is complex and influenced by many factors.

- Attitude toward the behavior
- Subjective norm
- Perceived behavioral control

Behavior
Human behavior is complex and influenced by many factors.

**Attitude toward the behavior**
- Acceptance/awareness of responsibility
- Impact on patient outcomes
- Impact on the worker

**Diagram**
- Subjective norm
- Behavior
- Perceived behavioral control

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Human behavior is complex and influenced by many factors.

Subjective norm
- Expectations of supervisor
- Expectations of colleagues
  - Institutional culture
  - Feedback

Attitude toward the behavior
Behavior
Perceived behavioral control
Human behavior is complex and influenced by many factors.

Perceived behavioral control
-Training/skill
-Time
-Tools, equipment, supplies

Behavior

Attitude toward the behavior

Subjective norm
Are we doing all that we can to promote and sustain desired behaviors and outcomes?
“Every system is perfectly designed to get the results it gets.”

-Paul Batalden, MD
Making Sustainable Improvements
We need to consistently implement effective practices.

- **Identify** and **integrate** evidence-based interventions
- **Recognize** that behavior is a key variable in sustainable uptake, adoption, and implementation
- **Identify** bottlenecks that impede effective implementation
- **Intervene** to promote change
- **Monitor**
- **Ensure** sustained implementation
We need to understand the barriers and inefficiencies in our systems.
You can’t really understand another person’s experience until you’ve walked a mile in their shoes.

Non-judgmental, objective, impartial observer

Observe activities and interactions (patients, personnel)

Ask non-leading questions in a non-threatening setting

Identify challenges and best practices
You can’t really understand another person’s experience until you’ve walked a mile in their shoes.

Daily and discharge cleaning
Is there clarity about cleaning expectations?
  Who cleans what?
  How frequently should various items be cleaned?
What surfaces are routinely cleaned?
  Bathrooms
  High-touch surfaces near the patient
Is contact time sufficient?
Interruptions?
  Frequency
  Interference with completion of tasks
You can’t really understand another person’s experience until you’ve walked a mile in their shoes.

Communication
Interactions with other housekeepers and supervisors
Interactions with physicians, nurses, and other HCP

Other potential barriers
Concerns for patient comfort/privacy
The presence of patient belongings
Availability of supplies
Assessment of workers’ knowledge, attitudes, and practices may identify opportunities and fixable barriers.

**KAP survey of environmental services workers**

**Brief**
 Developed in collaboration with EVS workers and leaders

**Anonymous**

**Preferred language**

**Completed during shift**
Attitudes and knowledge influence our actions.

- **My work is important to keep patients safe.**
- **I worry that I may get sick from patients.**
- **I worry that cleaning products may be harmful to me.**

72% of respondents expressed interest in more education (HAIs, infection prevention).
The subjective norm influences our actions.

I receive useful feedback.

Nurses show appreciation for the work I do.

Doctors show appreciation for the work I do.

- Strongly Agree/Always
- Agree/Often
- Disagree/Sometimes
- Strongly Disagree/Never
Our perceived behavioral control influences our actions.

I was taught to do discharge cleaning.
I was taught to do daily cleaning.
It is clear what I am responsible for cleaning.
I have enough time to perform discharge cleaning.
I have enough time to perform daily cleaning.

- Strongly Agree/Always
- Agree/Often
- Disagree/Sometimes
- Strongly Disagree/Never
Our perceived behavioral control influences our actions.

While cleaning a room, I am asked to stop so that RN can care for patient.

I'm asked to stop cleaning to assist with another task.

I avoid cleaning near patients so I won't disturb them.

The over bed table is too cluttered to clean during daily cleaning.

- Never
- Sometimes
- Often
- Always

Bernstein D. IDWeek 2015. San Diego, CA
Our actions and words can have a powerful impact on our colleagues.

“Other staff (doctors, nurses, physical therapists) should pick up items after dropping them.”

“Nurses need to be more alert on the mess they make.”

“Don’t rush me, please, because you want the next patient quickly in the room. It makes me compromise my work ethics.”

“Supervisors should give more compliments to the worker to make sure they feel more appreciated.”
We must not forget about equipment that is cleaned by other personnel.
Different challenges may be encountered in cleaning and disinfection of shared, mobile equipment.

*Awareness* of expectations and policies
*Delineation of responsibility* for cleaning items
*Disinfectant availability*
*Compatibility* with electronic equipment
Can you tell if this room is clean or dirty?
Monitoring is an important part of identifying opportunities and sustaining improvement.

Visual Inspection  
Fluorescent Indicators  
ATP Detection  
Microbiologic sampling

http://www.cdc.gov/HAI/toolkits/Environmental-Cleaning-Checklist-10-6-2010.pdf
Each approach to monitoring has its own advantages and disadvantages.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Visual Inspection</th>
<th>Microbiology Culture</th>
<th>Fluorescent Marker</th>
<th>ATP Detection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low cost</td>
<td>✓</td>
<td>+/−</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Rapid turnaround time</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Logistically easy</td>
<td>✓</td>
<td></td>
<td>+/−</td>
<td>+/−</td>
</tr>
<tr>
<td>Objective/quantitative</td>
<td></td>
<td>✓</td>
<td>+/−</td>
<td>✓</td>
</tr>
<tr>
<td>Direct measure of microbial contamination</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automated data capture</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
Assess the impact of your interventions and adjust your approach accordingly.

Percentage positive among cultures of 3 high-touch surfaces experimentally contaminated with non-toxigenic C. difficile.

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Education, monitoring, and feedback improves discharge cleaning.

**Intervention 1**
- Education
- Fluorescent indicator
- Aggregate feedback

**Intervention 2**
- UV device for CDI rooms

**Intervention 3**
- Dedicated CDI cleaning staff
- Direct observation
- Immediate feedback (visual, ATP)

*Sitzlar B. Infect Control Hosp Epidemiol* 2013;34:459-65
Education, monitoring, and feedback improves discharge cleaning.

**Intervention**
Increased disinfectant volume
Education
Immediate feedback

**61% increase** in marker removal

**40% decrease** in MRSA or VRE-positive post-cleaning cultures

Goodman ER. *Infect Control Hosp Epidemiol* 2008;29:593-9
Education, monitoring, and feedback improves daily cleaning.

**Intervention**
Education
Announced monitoring

34% of bedrails
12% of overbed tables
29% of TV remotes had RLU values ≥250

Boyce JM. *Infect Control Hosp Epidemiol* 2009;30:678-84
Improving is hard.
Sustaining improvement can be even harder.
Sustaining improvements can be as difficult as initially making them.

Performance then decreased by 10-20% after the last cycle of feedback.

Year: 2006
Location: 36 hospitals
14 high-touch surfaces

Carling PC. Infect Control Hosp Epidemiol 2008;29:1035-41
Sustained improvement is possible, but it takes work.

**M1**: feedback to EVS administration (quarterly)

**M2**: feedback to EVS administration (monthly)

**M3**: face-to-face feedback to EVS workers (monthly)

**M4**: feedback to supervisors (immediate) and administration (monthly)

**M5**: feedback to supervisors (immediately) and EVS workers (monthly)
Cleaning and disinfection is an important piece of the *C. difficile* and HAI prevention puzzle.
Optimizing cleaning and disinfection practices is critical to our HAI prevention efforts.

**Assess** current status, practices, gaps, and deficits
- Identify causes of gaps and deficits
- Be inclusive

**Design** interventions
- Optimize protocols and products
- Eliminate barriers
- Delineate responsibility
- Educate
- Provide meaningful, actionable feedback

**Monitor** impact

**Build sustainability**