

Educational Module for Nurses in Long-term Care Facilities: Preventing and Managing *Clostridium difficile* Infections

Clostridium difficile (*C. difficile*) causes a wide range of illness - from uncomplicated diarrhea to life-threatening inflammation of the colon.

This module:

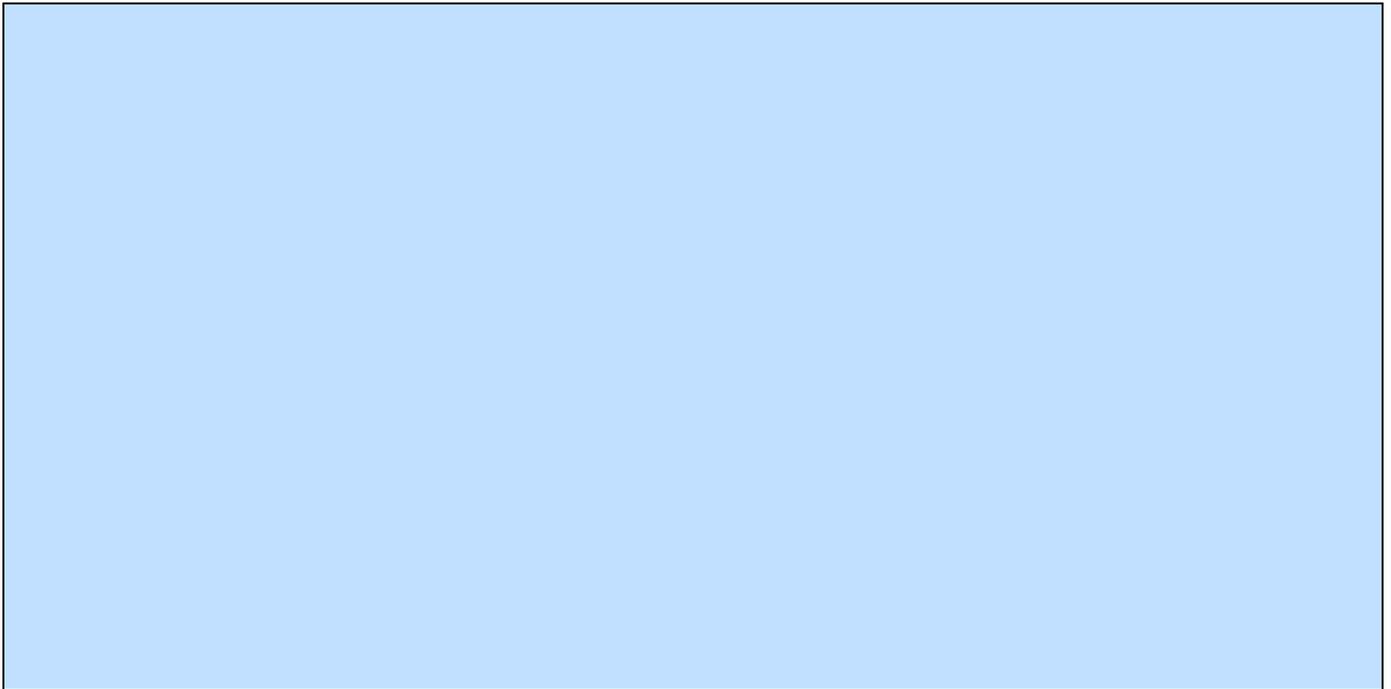
- Describes the association between antibiotic use and the development of *C. difficile* infection (CDI)
- Describes the transmission of *C. difficile* bacteria
- Provides infection prevention and control strategies to reduce *C. difficile* transmission within long-term care facilities



Pre-test

1. List at least two characteristics of the *Clostridium difficile* bacterium.
2. Identify at least one important risk factor for the development of CDI in long-term care residents.
3. State the difference between colonization and infection with *C. difficile* bacteria.
4. Describe at least three strategies to prevent the transmission of *C. difficile* bacteria in long-term care facilities.

Objectives



Introduction

- There are many pathogens responsible for causing diarrheal illness in humans. Of concern to healthcare facilities are:
 - Norovirus
 - *E. coli* 0157:H7 and other Shiga toxin-producing *E. coli*
 - Rotavirus
 - *Clostridium difficile*
- *C. difficile* bacteria cause *C. difficile* infection (CDI), a major cause of antibiotic-associated and healthcare-associated diarrhea
- Elderly (>65 years) are at highest risk for morbidity and mortality from CDI
- *C. difficile* bacteria can cause a wide range of clinical symptoms
- The incidence and severity of CDI has increased - possibly due to a new epidemic strain

Clostridium difficile bacteria

C. difficile bacteria are anaerobic, spore-forming, gram-positive bacilli that live in the human intestinal tract. These bacteria were named with the Latin term "difficile" because they are difficult to culture in the laboratory.

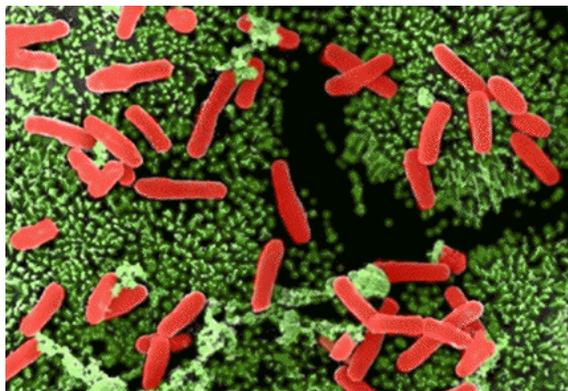
C. difficile bacteria produce spores that are difficult to remove from the environment and surfaces (e.g., commode, door knob, bed rail, etc.).

C. difficile bacteria cause disease by producing two toxins, Toxin A (an enterotoxin) and/or Toxin B (a cytotoxin).

While not all strains of *C. difficile* bacteria produce toxins, a toxin-producing (i.e. toxigenic) strain of *C. difficile* bacteria must be present to cause disease.

A new strain of *C. difficile* bacteria has emerged, known as BI/NAP1/027, toxinotype III, sometimes referred to as simply 'NAP1'. This strain, though historically uncommon, has been epidemic in the United States since 2000. Features of this new strain include:

- More resistant
 - Increased resistance to fluoroquinolone antibiotics
- More virulent
 - Presence of a third toxin (binary toxin)
 - Increased production of toxins A and B (due to a mutation causing the deletion of a toxin regulating gene, *tcdC*)

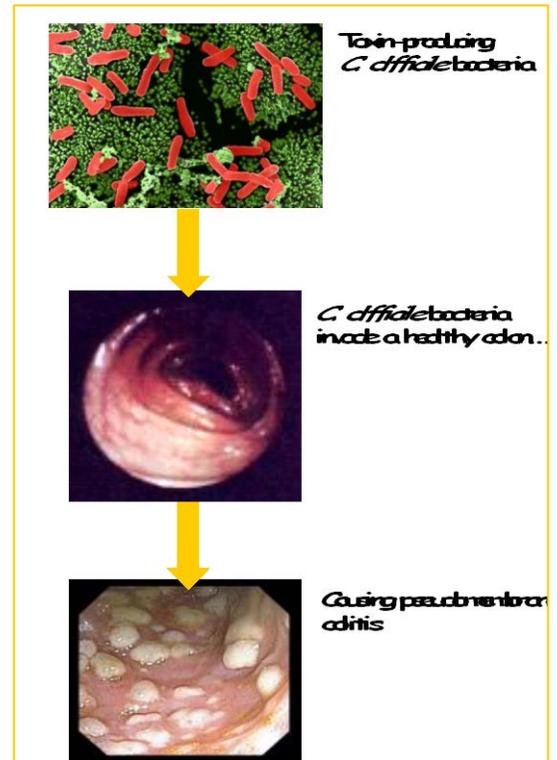


Pathogenesis of CDI

The colon is home to hundreds of types of bacteria that perform important digestive functions. Bacteria that ordinarily live in the digestive tract are called the normal bowel flora. Normal bowel flora may include *C. difficile* bacteria. When a person takes antibiotics the normal bowel flora is disrupted and *C. difficile* bacteria overgrow.

In order for *C. difficile* bacteria to cause symptoms, the following must occur:

1. Disruption of the normal bowel flora (most commonly due to exposure to antibiotics)
2. Exposure to spores or vegetative bacteria from a toxigenic *C. difficile* strain; and
3. Host factors or strain virulence factors are present.



CDI Symptoms

Symptoms of CDI usually begin during or shortly after starting a course of antibiotics, but can be delayed for as long as 8 to 12 weeks following antibiotic use. After disruption of the normal bowel flora by antibiotics, *C. difficile* and other pathogenic bacteria may multiply. All antibiotics increase the risk of infection with *C. difficile* bacteria although clindamycin, cephalosporins, penicillins, and fluoroquinolones are most often associated with *C. difficile* infection.

C. difficile can produce a spectrum of clinical manifestations, ranging from asymptomatic colonization to severe infection resulting in death.

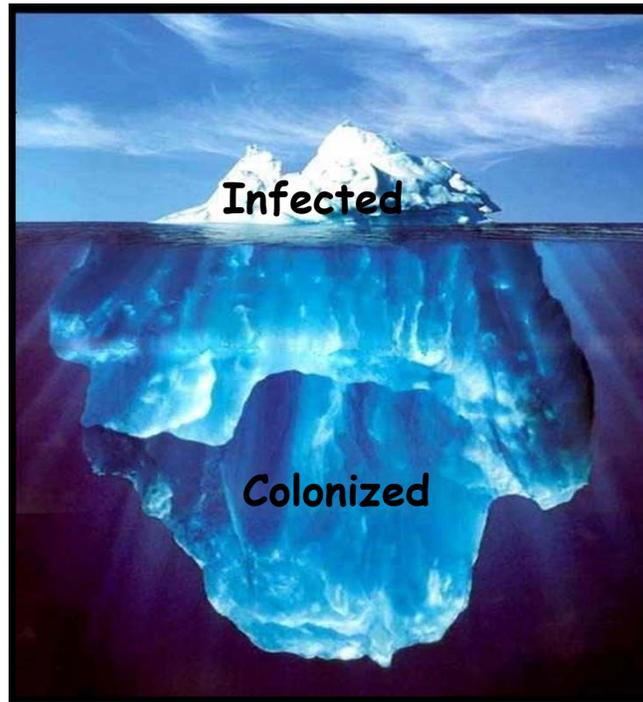
Clinical symptoms

- Watery diarrhea
 - Most common symptom
- Fever
- Abdominal cramps

Severe disease

- Pseudomembranous colitis
- Toxic megacolon
- Perforations of the colon
- Sepsis
- Elevated white blood cell count (leukocytosis)
 - May be an early warning sign for fulminant infection even in the absence of other symptoms
- Death

C. difficile colonization vs. *C. difficile* infection



This iceberg graphically represents colonization versus infection. The “tip of the iceberg” represents only those residents known to be infected. Residents who are colonized carry the bacteria but do not have signs of infection.

- Infected and colonized residents can shed the bacteria into the environment (e.g. commodes, rectal thermometers, etc.).
- *C. difficile* spores remain on surfaces and inanimate objects for long periods of time.
 - If other staff or residents touch these surfaces or inanimate objects and then touch their mouth or anything that goes into their mouth, they become exposed to the bacteria
- *C. difficile* is easily spread within a facility when healthcare workers do not follow infection prevention and control practices or perform adequate hand hygiene.
 - Bacteria can be transmitted to other residents, even those who have not had exposure to antibiotics

Rates of *C. difficile* colonization are higher than rates of infection. Chronic colonization may be protective against the development of clinical symptoms.

Risk factors for CDI

Antibiotic exposure is the major risk factor for developing CDI

- More than 90% of all cases of CDI occur during or after antibiotic treatment
- Essentially all antibiotics can increase the risk of CDI, but broad-spectrum antibiotics are more likely to be associated with CDI.
 - Antibiotics change normal bowel flora, allowing *C difficile* bacteria to multiply. A person can be at risk for developing CDI up to 12 weeks after the antibiotic is stopped because it can take this long for normal bowel flora to return.
- Some studies show that fluoroquinolones (e.g., ciprofloxacin) due to their widespread use are most likely to be associated with CDI. However, any antibiotic can disrupt the intestinal flora and increase the risk for CDI.

In addition to antibiotic use, characteristics of LTCF residents that may increase their risk for CDI include:

- Advanced age (> 65 years)
- Use of nasogastric or gastrostomy feeding tubes
- Gastric acid suppression (due to use of antacids, proton pump inhibitor or histamine-2 antagonist)
- Severe underlying medical, immunocompromising conditions

While most of these risk factors are not modifiable, healthcare workers play a critical role in assessing residents and communicating status changes to prescribers in a timely manner. This can contribute to the early recognition of CDI and implementation of infection prevention and control practices to prevent spread of CDI to other residents. Additionally, accurate assessment and communication of resident status to prescribers can help ensure that antibiotics are prescribed only when necessary.

Incidence of *Clostridium difficile* infection

Rates of CDI are increasing in both acute care hospitals and long-term care facilities.

This increase may be due to:

- Strains of *C. difficile* bacteria that cause more severe disease (epidemic NAP1 strain)
- Inadequate infection prevention and control practices in healthcare facilities
- Overuse and misuse of antibiotics

Figures 1 and 2 (below) show the increasing rates of *C. difficile* infection in hospitalized patients from 1998 to 2011 and the rates of *C. difficile* by gender and age for 2011.

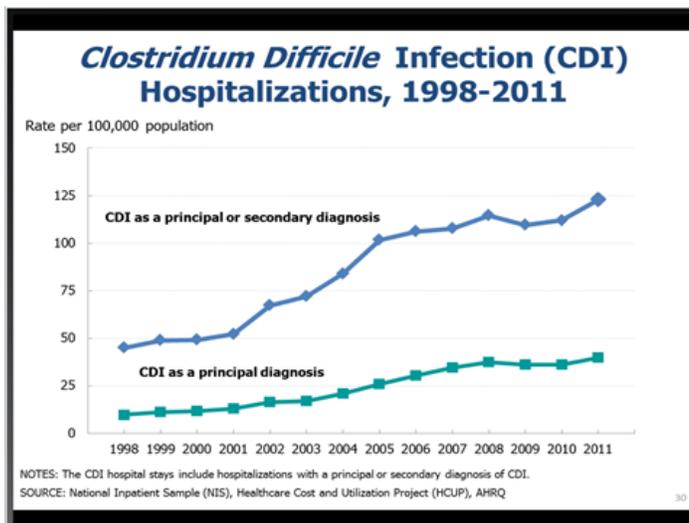


Figure 1. *C. difficile* as a Discharge Diagnosis, 1998-2011.

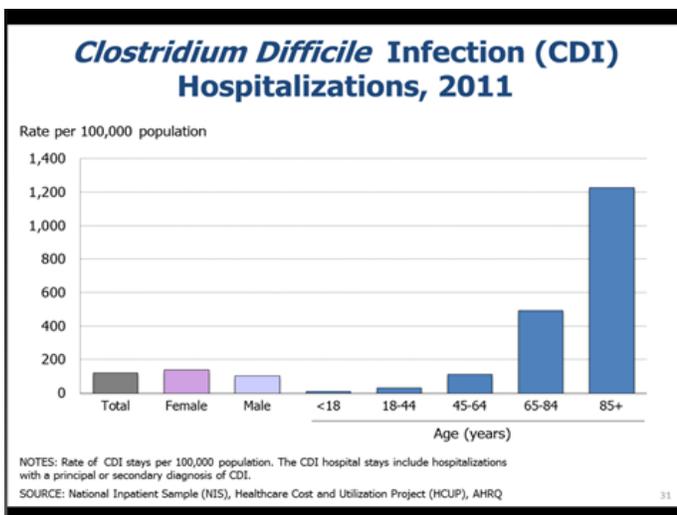


Figure 2: National Rates of *C. difficile* Hospitalizations as Principal or Secondary Diagnosis by Gender and Age, 2011.

Diagnosis of CDI

To determine if a resident has CDI, you must consider both clinical symptoms and lab test results. Be familiar with your facility's stool testing policy for *C. difficile*. The stool to be tested must be loose and watery (takes the shape of the stool collection container). See the Bristol Stool Chart below - stool to be tested should be type 5 - 7.

Who Should be Tested for CDI?

- Test only symptomatic residents for CDI
 - Residents with ≥ 3 unformed stools per 24 hours
 - See Bristol Stool Chart
- Do not perform tests-of-cure on any patients post-treatment
- Retest for CDI only if CDI symptoms continue after 10 days of treatment or resolve and then come back
- Do not repeat testing during the same episode of diarrhea for a resident with confirmed CDI

| Bristol Stool Chart | |
|--|--|
| Type 1  Separate hard lumps, like nuts (hard to pass) | Type 2  Sausage-shaped but lumpy |
| Type 3  Like a sausage but with cracks on its surface | Type 4  Like a sausage or snake, smooth and soft |
| Type 5  Soft blobs with clear-cut edges (passed easily) | Type 6  Fluffy pieces with ragged edges, a mushy stool |
| Type 7  Watery, no solid pieces. Entirely Liquid | Reproduced by kind permission of Dr KW Heaton, Reader in Medicine at the University of Bristol |

How to obtain stool specimens

- Fresh stool is required from resident with suspected CDI
 - Only unformed stools should be collected
- Collect specimen in clean, watertight container
- Stool specimen must be refrigerated immediately after collection.
 - Store at 2 - 8 degrees Celsius
 - *C. difficile* toxin is very unstable and degrades at room temperature in as short as two hours.
- Submit fresh stool to the lab for *C. difficile* testing as soon as possible

- Do not place stool specimens in refrigerator where food is stored.
- False-negative results occur when specimens are not kept refrigerated until testing can be done.
- Submit one specimen per resident; do not perform repeat testing

Diagnostic laboratory tests for *C. difficile*

Common tests for *C. difficile* are summarized in the table below; PCR and an EIA combination of GDH and toxin detection are the most frequently used.

| Laboratory Test | Substance detected | Time required | Sensitivity | Specificity |
|-------------------------------|---|---------------|-------------|-------------|
| Toxin culture (gold standard) | Toxigenic <i>C. difficile</i> | 3-5 days | >95% | 80-90% |
| EIA toxin A or A/B | Toxin A or A/B | Hours | 75-80% | 97-98% |
| RT-PCR | Toxigenic <i>C. difficile</i> | Hours | >98% | 80-99% |
| Cytotoxin | Toxin B | 1-3 days | 95% | 90-95% |
| EIA GDH and toxin A/B | <i>C. difficile</i> and <i>C. difficile</i> toxin | Hours | 95 - 100% | 97 - 98% |
| EIA GDH | <i>C. difficile</i> | Hours | 95 - 100% | 70 - 80% |

Source: Bartlett JG. Detection of *Clostridium difficile* Infection. ICHE 2010; 31(S1):S35-S37.

Sensitivity of a test indicates the probability that if the person has the disease, the test will be positive.

Specificity is the probability that if a person does not have the disease, the test will be negative.

Treatment of CDI

Treatment of CDI involves a number of strategies.

Stop the antibiotic!

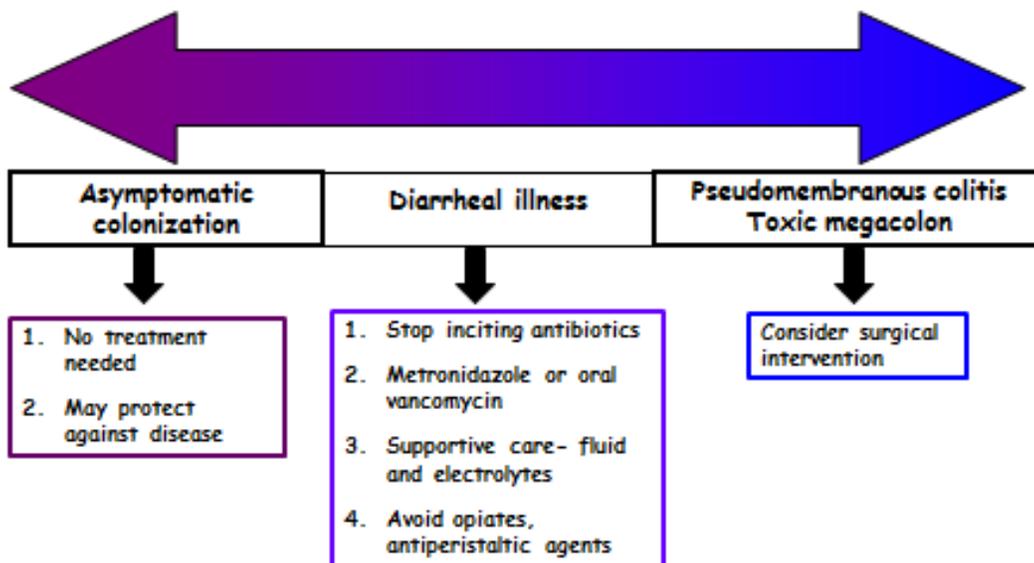
As soon as CDI is diagnosed, any noncritical antibiotic therapy should be discontinued. After discontinuation of the antibiotic, the normal bowel flora can begin to return (this can take as long as 4-6 weeks). Symptoms resolve in 15-20% of people after discontinuing the "offending" antibiotic.

Medication

As unusual as it seems, CDI is usually treated with an antibiotic such as metronidazole (oral or intravenous) or oral vancomycin. Intravenous vancomycin is ineffective as it does not penetrate into the gastrointestinal system. Metronidazole is generally preferred for most cases of mild to moderate disease; vancomycin may be preferred for severe infection. A new drug, fidaxomicin, has been shown to perform as well as vancomycin for the treatment of mild to moderately severe CDI, and may be associated with fewer recurrent episodes. Consultation with an infectious disease physician may be indicated when determining the most appropriate medication for the treatment of CDI.

Persons with asymptomatic colonization should not be treated with antibiotics. Routine screening for asymptomatic colonization should not be performed and prophylactic treatment for CDI is not recommended, even in outbreak situations.

Treating *C. difficile*



Rehydration

Watery diarrhea caused by CDI can lead to dehydration. Provide as many clear liquids as possible such as water, non-caffeinated tea, broth, or electrolyte rich liquids. Keep in mind any other conditions that may require fluid restrictions (like congestive heart failure).

Other treatment considerations

- Fecal Microbiota Transplantation (FMT)
 - FMT is being studied as a treatment to restore normal bowel flora with the use of intestinal microorganisms from a healthy donor; particularly as an option in patients with multiple episodes of CDI recurrence.
 - FMT can be delivered via enema, colonoscopy, or via the nasogastric route.
- Avoid anti-diarrheals (anti-peristaltics)
 - Diarrhea is nature's way of purging toxins and "bad" bacteria from the intestine. Anti-diarrheals will slow this process.
- Probiotics
 - Probiotics such as *Lactobacillus*, *Saccharomyces*, or *Bifidobacterium* can be found in dietary supplements. These may replace bacteria normally found in the large bowel but there is no conclusive evidence that these are effective.

Monitor resident for status changes

CDI can result in serious intestinal conditions such as ileus (bowel obstruction) that need immediate evaluation by a physician. Symptoms of bowel obstruction can include:

- Cramping abdominal pain that comes and goes
- Abdominal distention
- Dramatic decrease in bowel movements (e.g. from 10/day to 0/day)
- Diminished or absence of bowel sounds

Notify the resident's physician immediately if these signs or symptoms develop.

Recurrent CDI

Residents can have recurrent CDI due to relapse or reinfection. Recurrence of CDI symptoms occurs in 6-35% of patients.

- Retest for CDI only if CDI symptoms continue after 10 days of treatment or resolve and then come back
- Do not repeat testing during the same episode of diarrhea for a resident with confirmed CDI

Infection Prevention and Control

Keys to Successfully Preventing CDI:

- Prevent acquisition of *C difficile* bacteria
 - Always use good infection prevention and control practices, including good hand hygiene (see below)
- Prevent development of CDI
 - Antimicrobial stewardship (see page 21)

Infection Prevention and Control (See also Appendices 1-5)

Good infection prevention and control practices are essential to preventing the spread of *C difficile* bacteria.

Infection prevention and control practices include:

Implementation of CDI surveillance

- Surveillance programs are an important measure used to detect and prevent outbreaks of *C. difficile* within healthcare facilities. A surveillance program should incorporate:
 - Early and accurate recognition of CDI residents
 - Standardized definitions:
 - Healthcare Facility-Onset (HO): specimen collected >3 days after admission to the facility (on or after day 4)
 - Community-Onset Healthcare Facility-Associated (CO-HCFA): infection in a patient discharged from the facility ≤4 weeks prior to specimen collection date
 - Community-Onset (CO): specimen collected ≤3 days after admission to the facility (days 1,2, or 3 of admission)

Hand hygiene

- Perform excellent hand hygiene when caring for all residents
- Clean hands with antibacterial soap and water for 15 - 20 seconds before and after entering rooms of, and caring for residents with CDI; rubbing and friction will remove the *C. difficile* spores.
- Alcohol-based hand rubs can be used when soap and water are not available, however are not recommended during *C. difficile* outbreaks. Alcohol-based products, chlorhexidine, iodophors, and other antiseptic agents have poor activity against *C. difficile* spores.

- Always perform hand-hygiene before donning gloves and/or gowns and after taking them off.



Standard Precautions for the care of **all residents, all of the time**

- Wear gloves, gown, mask or eye protection if you anticipate you may have any contact with body fluids (direct contact, spraying or splashing) while performing care to the resident

Contact Precautions for the care of residents with CDI symptoms

- Always wear gloves and a gown to provide care to the resident
- Dedicate equipment to individual residents who have CDI whenever possible (e.g., commodes, blood pressure cuffs, and stethoscopes)
 - Clean and disinfect all shared equipment immediately after use and before use with any other resident.

Isolation Precautions

- Private room, if possible
 - Room two CDI positive residents together if a private room is not available.
- Remove residents from Contact and Isolation Precautions when their watery diarrhea has resolved for 48-72 hours
- For residents that are continent or the diarrhea can be contained with incontinence products, and who can follow instructions and perform appropriate hand hygiene, consider letting residents enter common areas and participate in social activities.

Environmental cleaning and disinfecting

- *C difficile* spores can survive for months on environmental surfaces. Follow your facility's cleaning and disinfection policies and procedures.
- Cleaning must be done before disinfection.
 - Cleaning removes all food, dirt, organic matter and allows the disinfection product to be effective against microorganisms.
 - Be sure you know what areas/items are your responsibility to clean and disinfect.
- Routine daily cleaning and disinfection of resident rooms should include ALL touchable vertical and horizontal surfaces; these surfaces include, but are not limited to, the following items:
 - Bedrails, furniture (e.g., bedside and over-the-bed tables, bedside commodes, cabinet fronts including handles, visitor chairs, countertops)
 - Bathrooms (e.g., sink, floor, tub/shower and fixtures, toilet seat and flush handle, soap dispenser, paper towel dispenser)
 - Frequently touched surfaces (e.g., light switches, door knobs, call bell, monitor cables, computer keyboards, TV remotes, telephone, IV poles, infusion pumps, sharps container)
- Terminally clean and disinfect the room of a resident with CDI after discharge - regardless of how long ago they had diarrhea. Make sure to include bed frame, mattress, pillows, and curtains.

Cleaning and disinfection products for CDI

- Use an EPA-registered, hospital-grade disinfectant for routine disinfection in CDI rooms.
 - A bleach-containing or other sporicidal disinfectant is recommended.
 - Be familiar with the manufacturer recommendations and follow these instructions for diluting and applying the product; leave the product on the surface/item for the recommended amount of time.

Antibiotic Stewardship

Antibiotic use disrupts the normal bowel flora; using antibiotics only when clinically indicated is one of the most important keys to preventing CDI.

Antibiotic use in LTCFs is high, accounting for about 40% of all prescription medications in LTCFs. Up to 25 - 75% of LTCF residents receive at least one systemic antibiotic each year, and as many as 75% of these are not clinically indicated. Some reasons antibiotics are prescribed unnecessarily include inability of LTCF residents to communicate their symptoms to healthcare personnel, not obtaining cultures to determine if antibiotics are needed, treating colonization and not just infection, and pressuring prescribers for antibiotics.

Antimicrobial stewardship is a multidisciplinary approach that includes strategies to prevent antimicrobial misuse so that the benefits of antimicrobials outweigh the risks.

Principles of antimicrobial stewardship in long-term care include:

- Using antibiotics only when they are needed
- Assisting residents in managing symptoms of non-bacterial infections
- Using evidence-based guidelines regarding indication for treatment, antibiotic selection, and duration of antibiotic therapy

Ingredients for a successful antimicrobial stewardship program:

- Education for nurses and providers
 - Evidence-based guidelines for clinical assessment, testing for and treating infections
- Accurate assessment of resident changes in condition
 - Thorough, accurate and timely assessment of a resident's change in condition leads to correct symptom recognition
- Accurate, timely communication of resident signs/symptoms and laboratory results to key healthcare personnel
 - Communication of resident changes in condition to appropriate staff leads to correct action being taken
- Documentation of resident changes in condition, including signs and symptoms of a possible infection
 - Documentation of resident assessment findings leads to correct follow-up
- Participation of all care providers within the LTCF

Post-test

1. Describe characteristics of the *Clostridium difficile* bacterium.
2. Describe at least one important factor associated with the development of CDI in long-term care residents.
3. State the difference between colonization and infection with *Clostridium difficile* bacteria.
4. Describe at least three ways that you can prevent the transmission of *Clostridium difficile* bacteria in long-term care facilities.

Appendices

Algorithms for Prevention and Management of *Clostridium difficile* Infections in Long-term Care Facilities

A1: Early Recognition and Testing

A2: Contact Precautions

A3: Room Placement

A4: Environmental Cleaning and Disinfection

Appendix 5: Social and Activity Precautions

Definitions and commonly used acronyms

ADL: activities of daily living

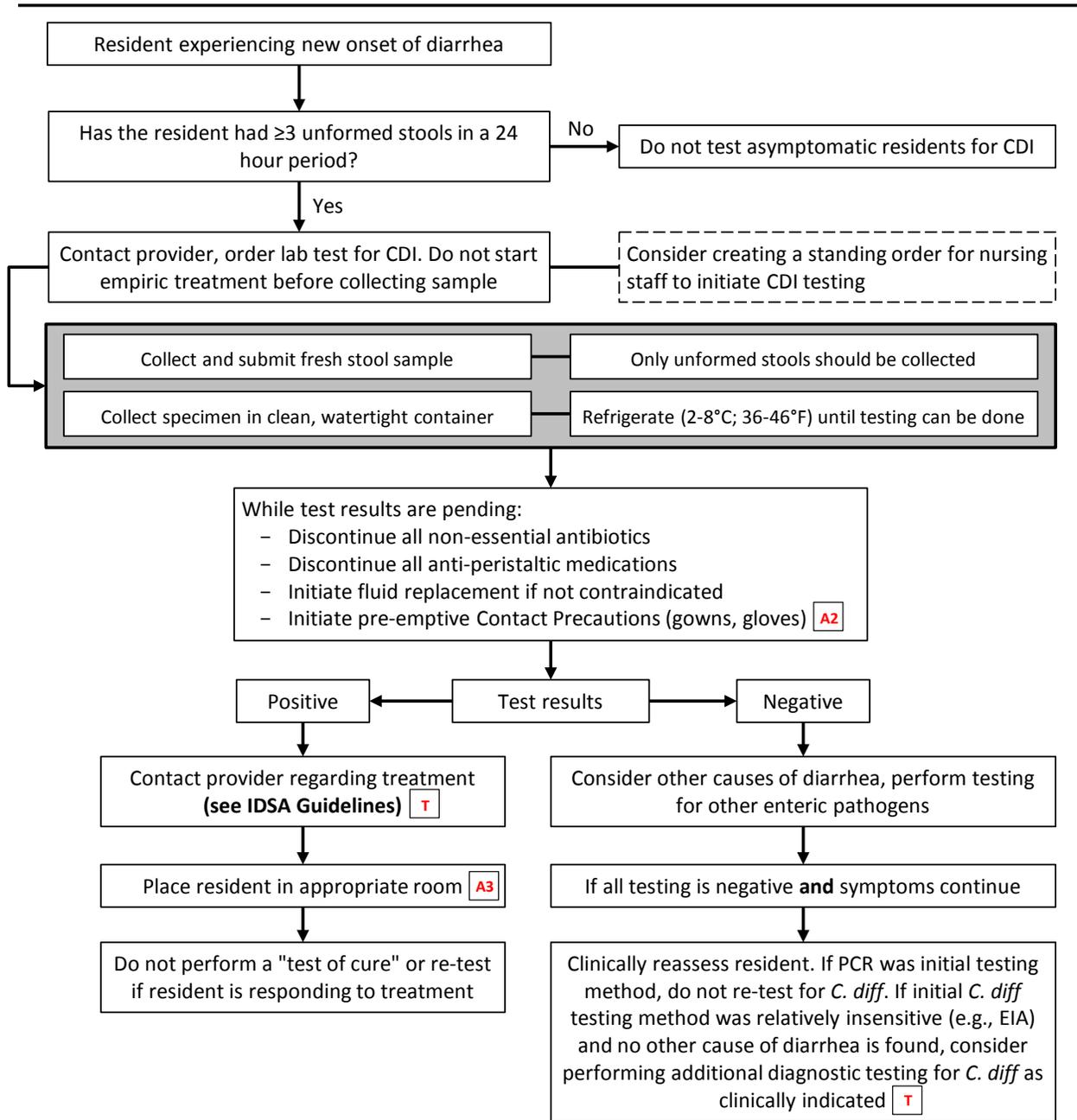
CDI: *Clostridium difficile* infection

HH: hand hygiene

PPE: personal protective equipment

PPIs: proton pump inhibitors

A1. Early Recognition and Testing



Action Items:

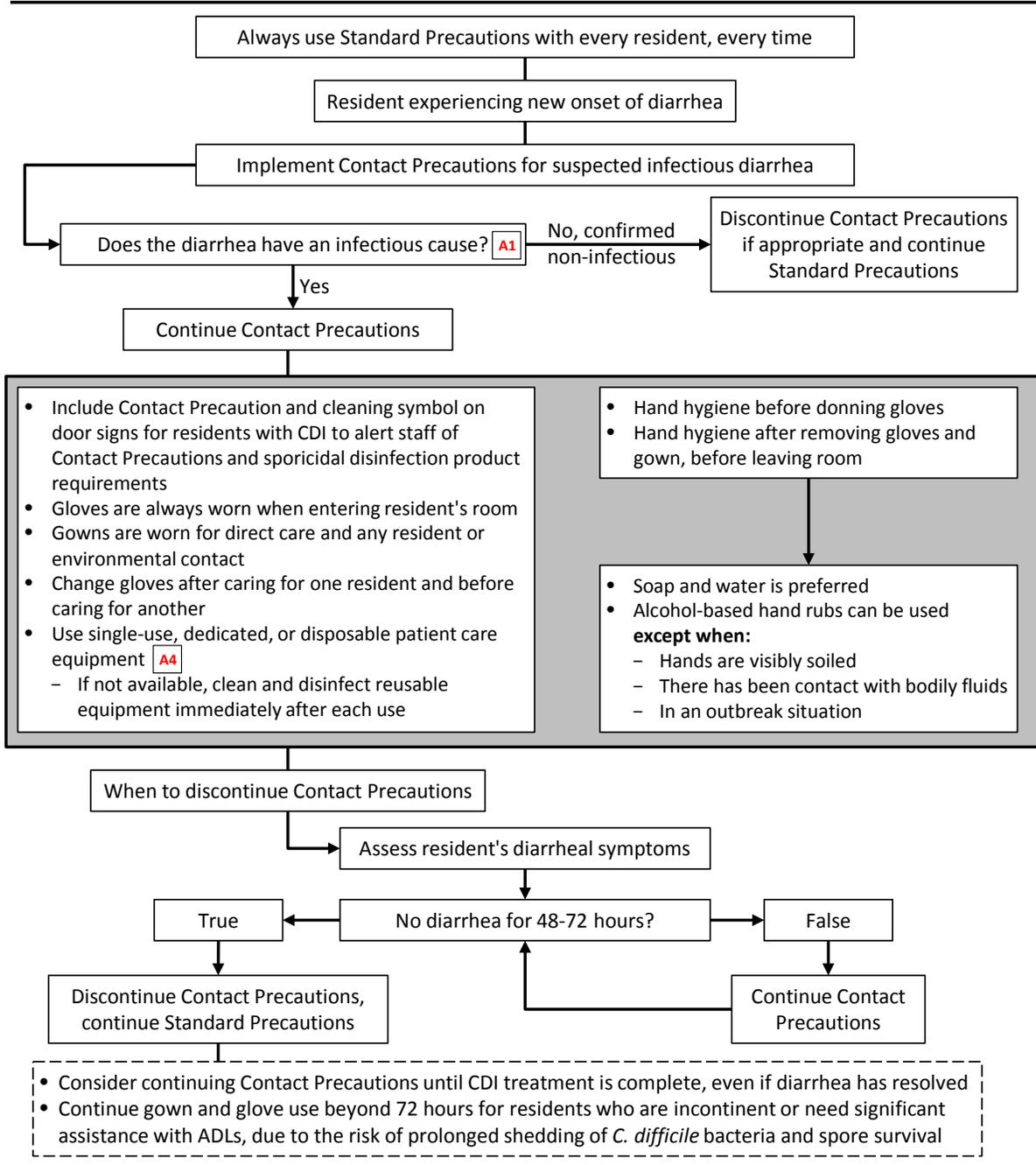
- Train staff to recognize CDI symptoms and to submit only unformed stools for CDI testing
- Establish policy with lab to reject formed and repeat stools for CDI testing
- Know what diagnostic testing method is used by your laboratory

Other considerations:

- Contact Precautions
- Room placement
- Social and activity precautions
- Environmental cleaning and disinfection



A2. Contact Precautions



Action Items:

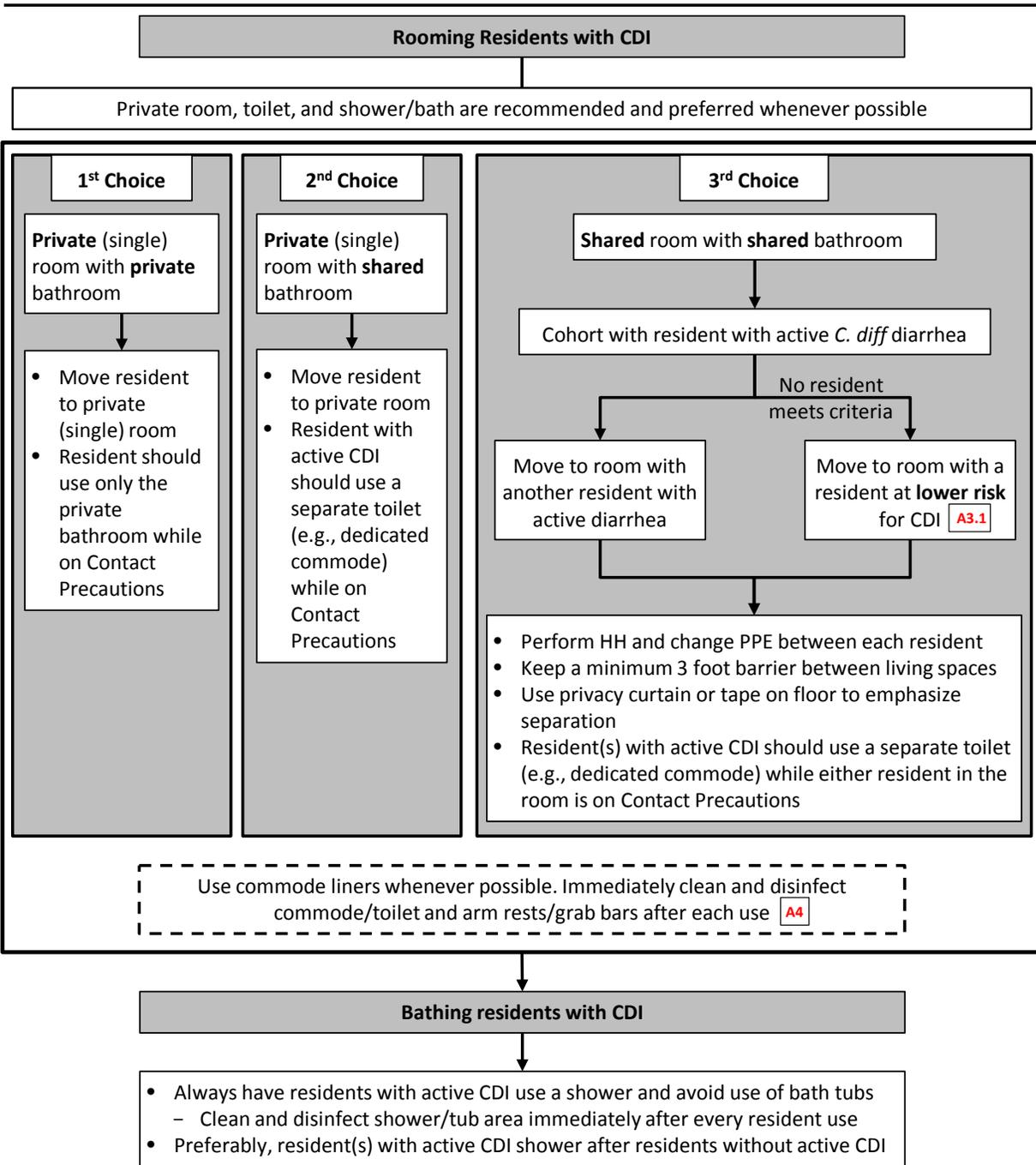
Provide gowns, gloves, and alcohol-based hand rubs outside resident's room
 Assure laundry bin, trash can, and alcohol-based hand rubs are readily accessible inside resident's room

Other Considerations:

Early recognition and testing
 Room placement
 Social and activity precautions
 Environmental cleaning and disinfection



A3. Room Placement



Other Considerations:

- Early recognition and testing
- Contact Precautions
- Social and activity precautions
- Environmental cleaning and disinfection



A3.1 Identifying Lower Risk Roommates

Primary considerations

Not currently taking antibiotics (1st choice)

or has not taken antibiotics in previous 4 weeks (2nd choice)

or has not taken antibiotics in previous 12 weeks (3rd choice)

No history of prior CDI (1st choice)

or has no CDI in previous 4 weeks (2nd choice)

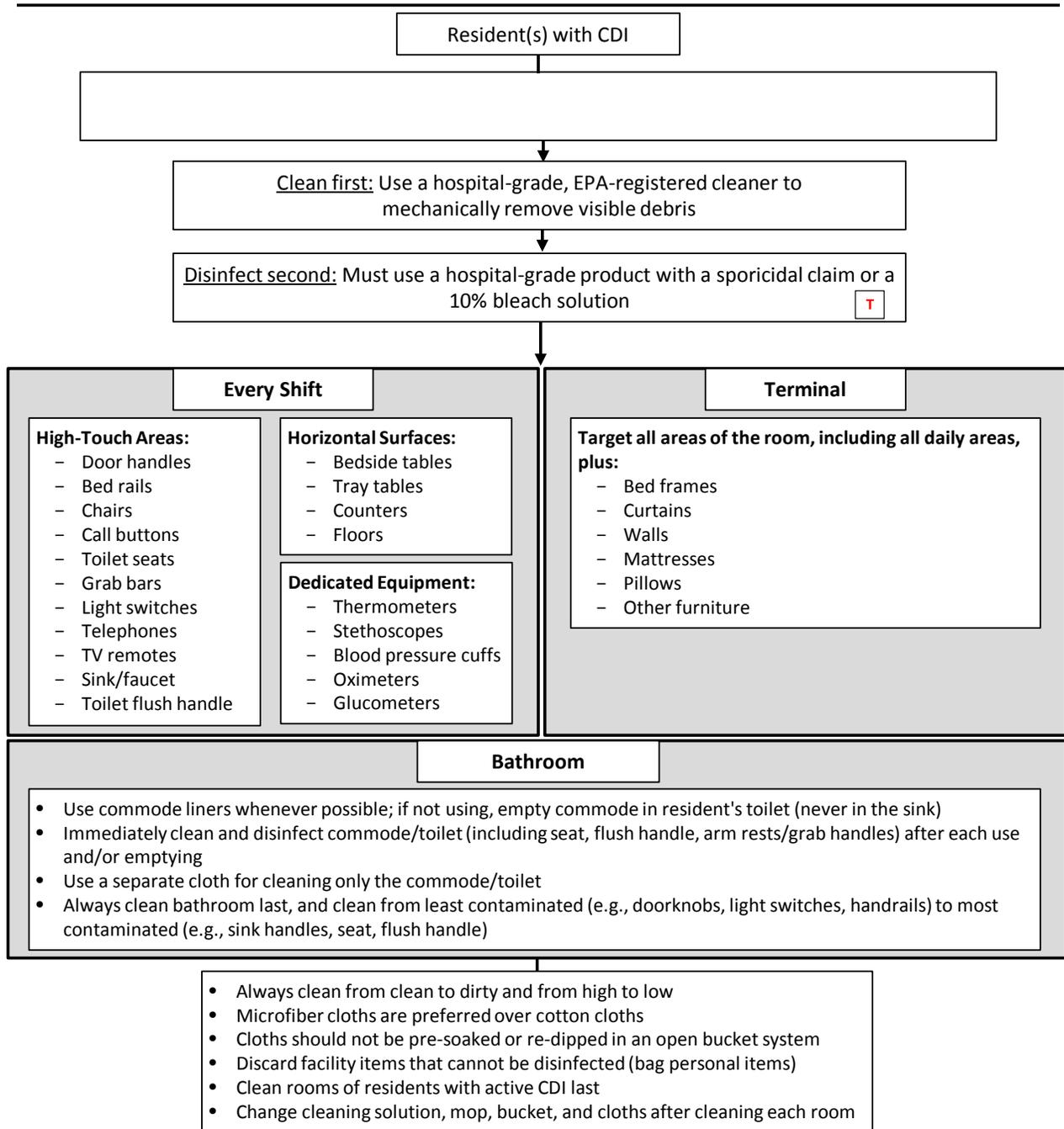
or has no CDI in previous 12 weeks (3rd choice)

Secondary considerations

- Not currently on proton pump inhibitors (PPIs)
- No GI/bowel condition comorbidities (diverticular disease, inflammatory bowel disease, Crohn's, peptic ulcer disease)
- No PEG/PEJ tube (no tube feeds)
- Not severely immunocompromised (cancer, chemotherapy, or solid organ transplant)
- Not bedbound/heavily dependent on healthcare workers for ADLs



A4. Environmental Cleaning and Disinfection

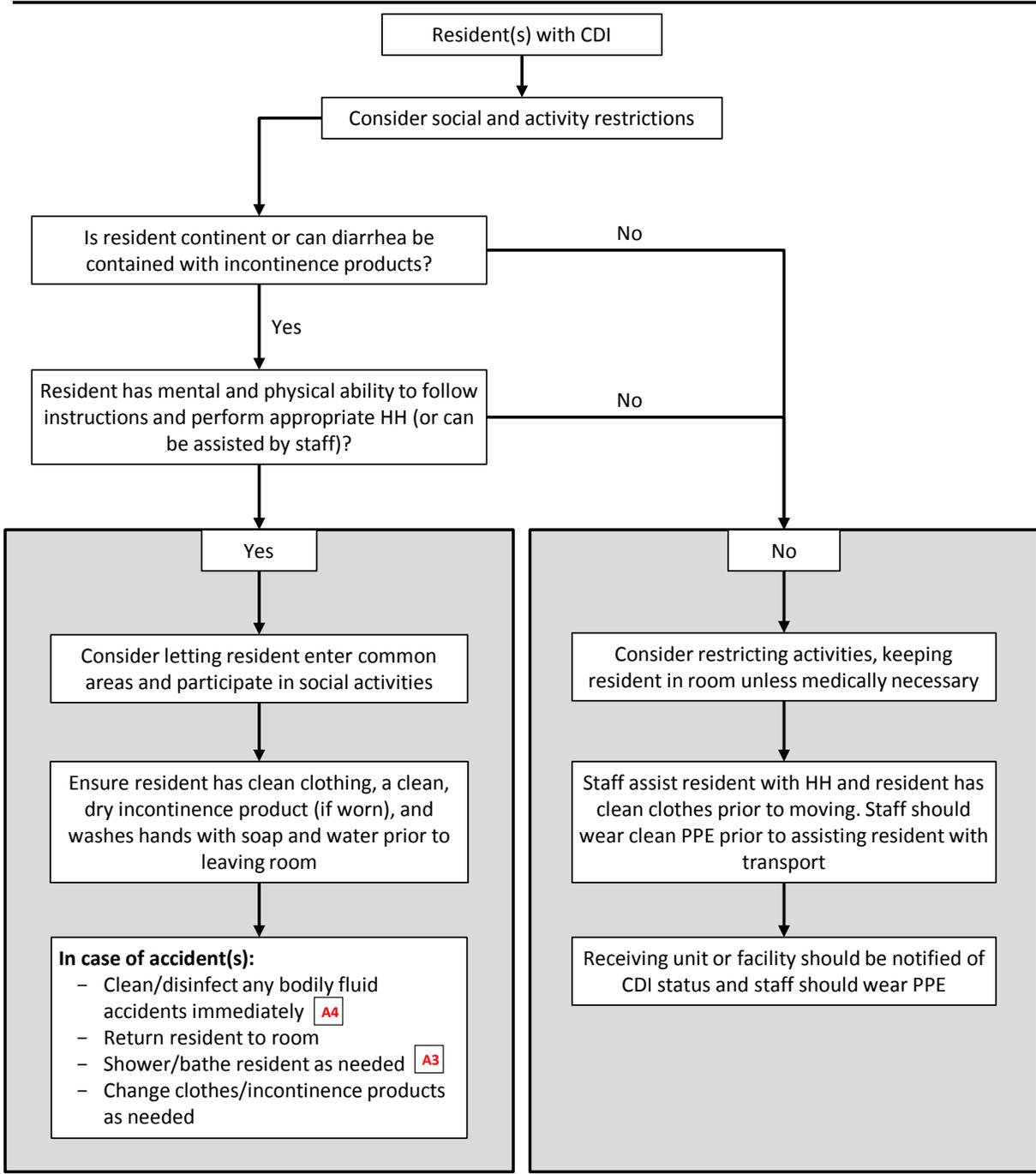


Action Items:

- Train Environmental Service staff on importance of cleaning and disinfection and the transmission of disease
- Establish responsibility for different elements of environmental cleaning and disinfection
- Provide Environmental Service staff with high-touch cards for reference
- Include cleaning symbol on door signs for residents with CDI to alert Environmental Services staff of rooms requiring sporicidal disinfection products



A5. Social and Activity Precautions



Action Items:

Ensure a facility transfer form exists for transferring residents between facilities

Other Considerations:

- Early recognition and testing
- Room placement
- Environmental cleaning and disinfection

- A** Please see additional algorithm
- T** Please see toolkit for more information



Glossary

Cytotoxicity - The quality of being toxic to cells. Examples of toxic agents are chemical substances or an immune cell.

Diarrhea¹² - At least six watery stools over 36 hours, three unformed stools in 24 hours for 2 days, or eight unformed stools over 48 hours.

Enterotoxin - A toxin produced by enterobacteria that acts on the intestinal mucosa to cause diarrhea.

Fecal incontinence - Inability to prevent the discharge of feces.

Ileus - Mechanical, dynamic, or adynamic obstruction of the bowel; may be accompanied by severe colicky pain, abdominal distention, vomiting, absence of passage of stool, and often fever and dehydration.

Normal bowel flora - A population of organisms that inhabit the bowel that under normal conditions do not cause infection.

Probiotics - Dietary supplements containing potentially beneficial bacteria or yeast that are intended to assist the body's naturally occurring flora within the digestive tract. Common probiotics include *Lactobacillus*, *Sacchayromyces*, or *Bifidobacterium*.

Pseudomembraneous colitis (PMC) - A form of gastroenteritis caused by the body's inflammatory response to the *C. difficile* toxins. It causes yellowish plaques, called pseudomembranes, to form on the inner lining of the colon. These plaques prevent the regular absorption of nutrients through the intestine and cause watery diarrhea. This inflammation of the intestine can be very painful.

Sepsis - The presence of various pus-forming and other pathogenic organisms or their toxins in the blood or tissues.

Spores - In biology, a spore is a reproductive structure that is adapted for dispersion and surviving for extended periods of time in unfavorable conditions. Spores form part of the life cycles of many plants, algae, fungi and some protozoans. The term spore may also refer to the dormant stage of some bacteria, like *Clostridium difficile*.

Toxic megacolon - An acute non-obstructive dilation of the colon, often seen in advanced ulcerative colitis or as a result of a *C. difficile* infection.

Toxigenic - Producing toxins

Virulence - The disease evoking power of a pathogen

References

1. Simor AE, Bradley SF, Strausbaugh LJ, et al. *Clostridium difficile* in long-term-care facilities for the elderly. *Infect Control Hosp Epidemiol.* 2002;23:696-703.
2. Laffan AM, Bellantoni MF, Greenough WB, et al. Burden of *Clostridium difficile*-associated diarrhea in a long-term care facility. *J Am Geriatr Soc.* 2006;54:1068-1073.
3. Ozawa TT, Valadez T. *Clostridium difficile* infection associated with levofloxacin treatment. *Tenn Med.* 2002;95:113-5.
4. Tan ET, Robertson CA, Brynildsen S, et al. *Clostridium difficile*-associated disease in New Jersey hospitals, 2000-2004. *Emerg Infect Dis.* 2007;13:498-500.
5. McDonald LC, Owings M, Jernigan DB. *Clostridium difficile* infection in patients discharged from US short-stay hospitals, 1996-2003. *Emerg Infect Dis.* 2006;12:409-415.
6. Dallal RM, Harbrecht BG, Boujoukas AJ, et al. Fulminant *Clostridium difficile*: An underappreciated and increasing cause of death and complications. *Ann Surg.* 2002; 235: 363-372.
7. Gerding DN, Johnson S, Peterson LR, et al. *Clostridium difficile*-associated diarrhea and colitis. *Infect Control Hosp Epidemiol.* 1995;16:459-477.
8. Shim JK, Johnson S, Samore MH, et al. Primary symptomless colonisation by *Clostridium difficile* and decreased risk of subsequent diarrhoea. *Lancet* 1998;351:633-6.
9. Palmore TN, Sohn S, Malak SF, et al. Risk factors for acquisition of *Clostridium difficile*-associated diarrhea among outpatients at a cancer hospital. *Infect Control Hosp Epidemiol.* 2005;26:680-684.
10. Johnson S, Homann SR, Bettin KM, et al. Treatment of asymptomatic *Clostridium difficile* carriers (fecal excretors) with vancomycin or metronidazole. A randomized, placebo-controlled trial. *Ann Intern Med* 1992; 117:297-302.
11. Centers for Disease Control and Prevention. Boyce JM, Pittet D. Guideline for Hand Hygiene in Health-Care Settings: Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. *Morb Mortal Wkly Rep.* 2002; 51(RR16): 1-44.
12. 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;88:137-140.
13. Rutala WA. "Best" practices for disinfection of non-critical surfaces and equipment. Talk presented at: Association for Professionals in Infection Control and Epidemiology conference; May 2, 2014; Peewaukee, WI.

Other resources

Crawford T, Huesgen E, Danzinger L. Fidaxomicin: A novel antibiotic for the treatment of *Clostridium difficile* infection. *Am J Health-Syst Pharm* 2012; 69:933-943.

Simor A. Diagnosis, management, and prevention of *Clostridium difficile* infections in long-term care facilities: A review. *Am J Gastroenterol*. 2010; 58:1556-1564.

Cohen SH, Gerding DN, Johnson S, et al. Clinical practice guidelines for *Clostridium difficile* infection in adults: 2010 update by the Society for Healthcare Epidemiology of America (SHEA) and the Infectious Diseases Society of America (IDSA). *Infect Control Hosp Epidemiol*. 2010; 31(5):431-455.

Dubberke ER, Gerding DN. Rationale for hand hygiene recommendations for caring for a patient with *Clostridium difficile* infection. A compendium of strategies to prevent health-care associated infections in acute care hospitals. Fall 2011 update. Available at <http://www.shea-online.org/Portals/0/CDI%20hand%20hygiene%20Update.pdf>.

Beniot SR, Wato N, Richards CL, et al. Factors associated with antimicrobial use in nursing homes: a multi-level model. *Am J Gastroenterol*. 2008;56:2039-2044.

Association for Professionals in Infection Control and Epidemiology. Guide to Preventing *Clostridium difficile* Infections. 2013. Available at http://apic.org/Resource_/EliminationGuideForm/59397fc6-3f90-43d1-9325-e8be75d86888/File/2013CDiffFinal.pdf

Khanna S, Pardi DS. *Clostridium difficile* infection: new insights into management. *Mayo Clin Proc*. 2012;87(11):1106-1117.