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# *Clostridium difficile* in the Long-Term Care Facility: Prevention and Management

**Robin L. P. Jump, MD, PhD**[1,2,*] and **Curtis J. Donskey, MD**[1,2,3]

[1]Geriatric Research Education and Clinical Center, Cleveland Veterans Affairs Medical Center, Cleveland, Ohio

[2]Division of Infectious Diseases and HIV Medicine, Department of Medicine, Case Western, Reserve University, Cleveland, Ohio

[3]Research Service, Cleveland Veterans Affairs Medical Center, Cleveland, Ohio

## Abstract

Residents of long-term care facilities are at high risk for *Clostridium difficile* infection due to frequent antibiotic exposure in a population already rendered vulnerable to infection due to advanced age, multiple comorbid conditions and communal living conditions. Moreover, asymptomatic carriage of toxigenic *C. difficile* and recurrent infections are prevalent in this population. Here, we discuss epidemiology and management of *C. difficile* infection among residents of long-term care facilities. Also, recognizing that both the population and culture differs significantly from that of hospitals, we also address prevention strategies specific to LTCFs.

### Keywords

Long-term care facility; *Clostridium difficile* infection; nursing home; metronidazole; vancomycin; fidaxomycin; fecal microbiota transplant; infection control; ultraviolet radiation; hydrogen peroxide; bleach

## Introduction

*Clostridium difficile* is the most common infectious cause of healthcare-associated diarrhea and rivals methicillin-resistant *Staphylococcus aureus* as the most common bacterial cause of health-care associated infections (1, 2). The Centers for Disease Control and Prevention (CDC) estimates that in the United States, *C. difficile* infections cause 250,000 illnesses and 14,000 deaths annually (3). Associated medical costs impose a burden in excess of $1 billion dollars each year (3). As with most healthcare associated infections (HAIs), strategies to identify, treat and prevent *C. difficile* infection require a multi-pronged effort that

[*]**Corresponding author:** Robin L. P. Jump M.D., Ph.D., Geriatric Research, Education and Clinical Center, 111O(W), Cleveland Veterans Affairs Medical Center, 10701 East Boulevard, Cleveland, Ohio 44106; Telephone: (216)-791-3800 ext. 5628; Fax: (216)-707-5973; robinjump@gmail.com.

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**Human and Animal Rights and Informed Consent**

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encompasses both acute and long-term care facilities. Supported by a comprehensive body of high-quality studies and guidelines that focus on *C. difficile* in hospitals (1, 4–6), there is a growing body of literature addressing the additional challenges faced by long-term care facilities (LTCFs). Here, we discuss prevention and management of *C. difficile* infection in LTCFs, the majority of which are nursing homes.

## Microbiology & Pathogenesis

*C. difficile* is a Gram-positive bacillus that forms spores capable of resisting an array of adverse conditions, including exposure to acidic conditions (pH <1), heat (10 minutes at up 80°C), dehydration, and alcohol-based hand sanitizers (7, 8). In its spore form, *C. difficile* also resists most routine environmental cleaning agents and may last for months on surfaces (9). Both patients and healthcare workers may acquire spores on their hands, unwittingly disseminating spores throughout their environment and leading to unintended ingestion of the spores. Exposure to *C. difficile* spores may go unnoticed by individuals with a healthy gut microbiome as the bacteria pass through the intestine without finding an ecological niche. The phenomenon, termed colonization resistance, is a form of host-defense that protects most individuals from enteric pathogens like *C. difficile* (10). For people with a disrupted gut microbiome, which is most commonly due to a systemic antimicrobial, ingested spores germinate and grow to high concentrations in the intestinal tract with toxin production and spore formation. Similar to infections caused by other *Clostridial* bacteria, the primary means through which *C. difficile* causes disease is through toxins. The toxins, TcdA and TcdB, translocate across epithelial cell membranes cause depolymerization of the cytoskeleton, which leads to cell death. Both toxins are involved in disease pathogenesis.

In 2003, several reports described a dramatic increase in *C. difficile* infection rates associated with increase disease fatality, particularly among older adults (11). This change was caused by the emergence of a new *C. difficile* strain, characterized as toxinotype III, restriction endonuclease group BI, North American pulsed field gel electrophoresis type 1 (NAP1) and ribotype 027 (12, 13). Frequently referred to as epidemic *C. difficile*, the BI/NAP1/027 strain has three distinct features that may help explain both its rapid spread and resulting increase in disease severity. First, it is resistant to fluoroquinolone antibiotics. In 2002, these became the most commonly prescribed antibiotic in the United States, which coincides with the emergence of the epidemic strain (14). At least in the outpatient setting, fluoroquinolone prescriptions among adults and older adults in the US remained essentially unchanged from 2000 to 2010, raising the possibility of persistent selective pressure that favors the epidemic over the non-epidemic strain as one reason for persistent and widespread dissemination (15, 16). Second, compared to most non-epidemic strains, BI/NAP1/027 strains have an 18-base pair deletion in *tcdC*, a gene that is a putative negative regulator of toxin production (17). Some studies have demonstrated that the BI/NAP1/027 strain produces greater concentrations of toxins TcdA and TcdB *in vitro* than other strains (18). However, a recent study found that BI/NAP1/027 strains exhibited robust toxin production, the amounts were not significantly different from those of non-BI/NAP1/027 strains tested (19). Moreover, a recent study involving precise genetic manipulation demonstrated that an aberrant tcdC genotype did not result in increased toxin production (20). Finally, the BI/NAP1/027 strain produces CDT, a binary toxin associated with more

severe diarrhea, higher fatality rates and increased risk of recurrent disease (21, 22). CDTb binds the cell surface and induces translocation, thus permitted CDTa access to cytosolic contents and promotes cell death through cytoskeletal depolymerization, acting upon different molecular targets than TcdA and TcdB (23).

## Epidemiology of *C. difficile* Infection in LTCFs

Since the advent of the BI/NAP1/027 strain, rates of *C. difficile* infection steadily increased, such that by 2009, it was part of nearly 1% of all hospital stays (24). These hospital stays disproportionately involved older adults. In 2009, the rate of *C. difficile* infection-related hospitals stays for adults 65 – 84 years and ≥ 85 years was 4- and 10-fold greater, respectively, than for adults 45 – 64 years (24). Hospitalized patients developing *C. difficile* infection are more likely to be discharged to a LTCF (25–27), yet we know relatively little about the burden of this disease among this vulnerable population.

There is evidence that the BI/NAP1/027 strain may be a common cause of infections in LTCF populations (28–30). In a study of the epidemiology of *C. difficile* in multiple hospitals in the Chicago area, Black *et al*. that 67% of patients with *C. difficile* infection discharged to LTCFs were infected with BI/NAP1/027 strains (27). Among hospitalized patients with *C. difficile* infection, Archbald-Pannone *et al*. reported that LTCF residents were significantly more likely to be infected with BI/NAP1/027 strains than those admitted from home (30). Patients infected with BI/NAP1/027 strains had a higher 6-month mortality and greater inflammation based on fecal lactoferrin testing than those infected with non-epidemic strains (25).

Measuring the burden of *C. difficile* infection in LTCFs requires a standard set of clinical case definitions and surveillance methods that are applicable to that setting (Table 1). While the clinical case definitions are easily applicable across both inpatient and outpatient settings, the current surveillance definitions may be less relevant for estimating the disease burden among LTCFs. Specifically, Mylotte hypothesized that exposure to systemic antibiotics and to *C. difficile* spores often occurs in hospitals with symptom onset in nursing homes shortly after hospital discharge (28). Accordingly, he proposed subdividing the definition for healthcare facility (HCF)-onset, HCF-associated *C. difficile* infection into LTCF-onset, hospital-associated and LTCF-associated (see Table I for details). Using these definitions, Guerrero *et al*. reported that among 40 patients at a single Veterans Affairs Medical Center (VA) with HCF-onset, HCF-associated disease, 34 (85%) met the criteria for LTCF-onset, hospital-associated *C. difficile* infection while 6 (15%) had LTCF-associated disease (29). Taking his sample from 4 community nursing homes, Mylotte *et al*. reported similar outcomes, with 69% of incident *C. difficile* infections developing within 30 days of admission (31). Using a larger sample of eight diverse geographic areas, the CDC reported a nearly identical rate, with 67% of people with nursing home-onset *C. difficile* infections having been discharged from a hospital in the previous 4 weeks (32).

Employing an alternative approach, the CDC's National Healthcare Surveillance Network (NHSN) uses proxy measure to estimate the burden of *C. difficile* infection (33). Their definition, based solely on laboratory data, uses the number of positive *C. difficile* tests per

10,000 resident days, excluding positive tests from the same resident following a previous *C. difficile* positive test within the previous two weeks. Among 30 acute care hospitals in New York State, comparison of *C. difficile* infections detected using the NHSN laboratory-based definition versus those identified using a clinical definition yielded >80% agreement (34). A study at a single VA LTCF found a similar rate of concordance. The NHSN laboratory-based definition detected 76 of 100 *C. difficile* infections identified using a clinical definition (35). The most notable area of discordance was among residents admitted to the LTCF already diagnosed with and on therapy for *C. difficile* infection.

To date, the most comprehensive description of the burden of *C. difficile* infection in LTCFs comes from the Ohio Department of Public Health, which mandated reporting of healthcare-onset *C. difficile* infection. Based on data from 2006, Campbell *et al*. found that the overall rate for initial cases was lower in nursing homes compared to hospitals (1.7 – 2.9 *vs*. 6.4 – 7.9 cases/10,000 patient days, respectively) (36). The absolute number of *C. difficile* infections in nursing homes, however, exceeded those in acute care by more than 50% (11,200 *vs*. 7,000 cases, respectively). Furthermore, using even a very conservative definition of recurrent disease (within 6 months of an initial case), both the number (4,300 *vs*. 1,300 cases, respectively) and proportion (38% *vs*. 23%, respectively) of recurrent cases in nursing homes far exceeded those in hospitals.

LTCF residents include both traditional nursing home residents and patients receiving short-term rehabilitation or post-acute care. Limited data are available on the incidence of *C. difficile* infection among these different resident categories. However, it has been noted that those receiving short-term rehabilitation after hospitalization may be at particularly high risk for infection (24). Laffan *et al*. reported that the incidence of *C. difficile* infection was much higher on rehabilitation and subacute (i.e., ventilator-dependent rehabilitation unit) wards of a LTCF than on a traditional nursing home ward in the same facility (37).

## Risk Factors for *C. difficile* Infection in LTCF Residents

Among the general population, exposure to systemic antibiotics and advanced age are the two primary risk factors for *C. difficile* infection (4, 38). Others, reviewed in greater detail elsewhere, include suppression of gastric acid production, underlying disease severity and low albumin (12, 38–42). Additionally, hospitalization is a risk factor for *C. difficile* infection, which reflects the combination of diminished health and exposure to antibiotics in a location with opportunity to acquire *C. difficile* spores from the environment and from health care workers (32, 43, 44). Not surprisingly, residence in a LTCF is also a risk factor for *C. difficile* infection for similar reasons (32, 45).

Distinct to LTCFs, however, is the proportion of residents colonized with *C. difficile*. Reported rates of asymptomatic colonization among LTCF residents ranges from 5% to 51%, far exceeding the 1 to 3% rate reported among the general population (46–52). In general, studies have found that the prevalence of asymptomatic colonization is higher among LTCF residents than among hospitalized patients. For example, Riggs et al. (44) found that 51% of LTCF residents were asymptomatically colonized with toxigenic *C. difficile*, whereas a subsequent study in the same facility demonstrated that only 11% of

hospitalized patients were asymptomatic carriers of toxigenic strains (53). Asymptomatic carriers shed *C. difficile* spores into their environment (50). Furthermore, they also have spores on their skin, which are easily acquired on the hands of health care workers (50). Given that nearly 80% of LTCF residents require assistance with at least 4 of 5 activities of daily living, the risk for unwitting acquisition and dissemination of spores by health care workers is notable (54). These findings help explain the high incidence (40– 50%) of initial *C. difficile* infections unrelated to recent hospitalizations reported at some LTCFs (55, 56).

## DIAGNOSIS

The diagnosis of *C. difficile* infection requires both clinical symptoms consistent with the diagnosis (diarrhea defined as ≥ 3 unformed stools in < 24 hours) and a positive test for genes that encode for toxins or the toxins themselves (Table 1). Inappropriate testing of individuals with loose stools not meeting criteria for diarrhea or with diarrhea attributable to non-infectious causes (e.g., laxatives, viral gastroenteritis) may result in false-positive diagnoses of *C. difficile* infection if asymptomatic carriage of toxigenic strains is present. For example, there have been several reports of pseudo-outbreaks of *C. difficile* infection when stool specimens were submitted for testing during Norovirus outbreaks (57–59). Given the high prevalence of asymptomatic carriage in LTCFs, education of nurses and physicians on appropriate testing is particularly important in this setting.

Efficient diagnostic testing for *C. difficile* infection is needed to minimize delays in initiation of isolation and treatment for confirmed cases, while also allowing rapid discontinuation of empirical therapy and isolation when testing is negative. However, delays in diagnosis are common in practice. At a large private hospital, the time between symptom onset to sampling and sampling to treatment was 2.24 (range 1 – 17 days) and 3.76 days (range 1–19 days), respectively (60). In a VA hospital and attached LTCF, the average time between placing an order and obtaining a test result from the on-site laboratory was 1.8 days (range 0.2 to 10.6 days), with the time required for collection of stool specimens contributing to much of the delay (61). An intervention focused on expediting stool sample collection and testing and reducing rejection of specimens was effective in significantly reducing the time from test order to diagnosis (50). Notably, in a prior study conducted by the same institution at a time when the affiliated LTCF was separate from the hospital, the average time from onset of diarrhea to diagnosis of *C. difficile* infection was significantly longer in the LTCF than in the hospital (5 versus 2 days, respectively) (25). Because many LTCFs use off-site laboratories, improving the timeliness of diagnostic testing may be a particular challenge in this setting.

Given the delays inherent in use of off-site laboratories, it is often necessary to consider empiric treatment for *C. difficile* infection in LTCF settings. Current practice guidelines recommend empiric treatment only for patients with suspected severe *C. difficile* (3). Empiric treatment of patients with suspected recurrence of infection is also reasonable given the high likelihood of infection in the setting of typical symptoms recurring after discontinuation of therapy. If delays in testing are anticipated in LTCF settings, empiric treatment for residents with high clinical suspicion for *C. difficile* infection but mild to moderate symptoms may be reasonable rather than waiting for test results. In this setting, the

risks of adverse effects of treatment (e.g., adverse drug reactions, promotion of colonization by vancomycin-resistant enterococci) must be balanced against the risks of adverse outcomes due to delays in treatment.

## Management

The treatment of *C. difficile* infection among LTCF residents is the same as treatment in the general adult population. It begins with supportive measures that include replacing fluid and electrolyte losses, avoiding anti-peristaltic agents and, whenever possible, stopping the inciting antibiotic (4, 5). Metronidazole is the first-line agent recommended for non-severe disease while oral vancomycin is recommended for those with severe disease (3). Due to a significant drug-drug interaction resulting in INR elevation, metronidazole should be avoided in patients receiving warfarin or the INR should be closely monitored. Since the emergence of the BI/NAP1/027 strain, there have been increasing reports of metronidazole treatment failure. In a recent systematic review of the evidence, Vardakas *et al*. concluded that oral vancomycin offers some advantages over metronidazole, with fewer treatment failures (22% *vs*. 14%, respectively) and a slight reduction in the risk for recurrent disease (24% *vs*. 27%) (62). For first recurrences, current guidelines recommend treatment with a 2$^{nd}$ course of the agent used for the initial infection; for additional recurrences, a course of tapered and/or pulsed oral vancomycin is recommended (4, 5). Two recent therapeutic advances, fidaxomicin and fecal microbiota transplant (FMT), have increased the array of evidence-based options available for treating *C. difficile* infection, particularly for reducing the risk for recurrent disease and treating patients with multiple recurrences.

In general, ~25% of adults successfully treated for *C. difficile* infection will experience recurrent disease though this may be notably higher among LTCF residents (36, 62). Risk factors associated with recurrent infection include previous recurrences, increasing age and exposure to additional antimicrobials (other than those used to treat *C. difficile* infections) (63– 65). Molecular typing shows that ~50% of recurrent *C. difficile* infections are caused by a new strain (66, 67). These findings suggest that vulnerability to recurrent disease may in part reflect failure to recover colonization resistance. To study this, Abujamel *et, al*. collected serial stool samples from hospitalized patients during and following treatment for *C. difficile* infection and tested if the samples inhibited or supported *C. difficile* growth (68). They found that most patients required 3 weeks following completion of either metronidazole or oral vancomycin for their fecal microbiota to recovery sufficiently to reestablish colonization resistance against *C. difficile*.

Accordingly, to minimize the risk for recurrent disease, an ideal therapy for *C. difficile* infection should favor more rapid restoration of the gut microbiota. This appears to be the advantage that fidaxomicin offers over oral vancomycin for treating initial *C. difficile* infections caused by strains other than BI/NAP1/027 and for first recurrences (69, 70). Fidaxomicin is a novel macrocyclic antibiotic approved by the Food and Drug Administration (FDA) for the treatment of *C. difficile* infection in 2011. Compared to vancomycin, it appears to have little effect upon the major bacterial phylogenetic clusters that comprise a significant portion of human fecal microbiota, including those from Clostridium clusters IV and XIVa and the *Bifidobacteriaceae* family (71). The disadvantage

to fidaxomicin is its substantial cost. A 10-day course costs $2800 dollars, compared with just $250 dollars for oral vancomycin compounded from a 1gm dose of the intravenous formulation. Fidaxomycin may offer some overall cost-benefit by reducing expenses associated with recurrent disease, though this remains controversial (72, 73).

FMT may hold the most promise for treatment of both initial and recurrent disease. First described over 30 years ago, FMT uses feces from a healthy donor to instill and restore a healthy fecal microbiota to patients with active *C. difficile* infection (74, 75). Aesthetic considerations aside, FMT seems to be an effective and safe treatment, curing a majority of recurrent *C. difficile* infections with 1 to 2 treatments (76–78). Even among a brief case series of ambulatory adults 80 years and older, FMT led to symptom resolution in 8 of 10 cases described (79). Studies evaluating the fecal microbiome of people with recurrent *C. difficile* infection reveal an overall lack of microbial diversity (52, 76). Two weeks following FMT, the recipients showed an increase in the diversity of their microbiome, specifically with recovery of species from the Bacteroidetes family and from Clostridium clusters IV and XIVa, and overall patterns indistinguishable from the donor sample (76). A cost-effectiveness analysis that compared treatment of recurrent CDI with metronidazole, oral vancomycin, fidaxomicin and FMT found that FMT was the most cost-effective strategy (80). Interestingly, the same authors report that if FMT is not feasible, oral vancomycin is the preferred alternative.

## Prevention

Efforts to prevent *C. difficile* infection include both reducing patients' vulnerability to infection as well as stringent efforts to prevent exposure to spores through infection control and environmental decontamination.

### Antimicrobial Stewardship

Among the many risk factors for *C. difficile* infection, the most readily modifiable is antibiotic exposure. This is especially important in LTCFs where antibiotics account for 40% of prescriptions (81). An alarming 25 – 75% of those prescriptions are either inappropriate or unnecessary (82, 83). In LTCFs, one of the most common reasons residents receive antimicrobials is for concerns of a urinary tract infection (UTI). Rojanapan *et al*. reported that, compared to remainder of nursing home population, residents in two nursing homes who were prescribed antibiotics for a UTI that did not fulfill the McGeer criteria were 8 times as likely to develop *C. difficile* infection in the 3 months following treatment (84). Reducing antimicrobial use also reduces *C. difficile* infection rates. Through a remarkable effort, the Scottish Government supported the development of a national antimicrobial stewardship plan, with a specific goal to reduce *C. difficile* infections in older adults (85). Between 2008 and 2010, the rates of *C. difficile* infection/1000 bed-days among patients aged ≥ 65 years were more than halved. At a VA LTCF, an infectious disease consult service achieved a 30% reduction in antibiotic use which correlated with a significant decrease in the rate of positive *C. difficile* tests (86, 87). The resources necessary to support these types of intervention are not available to most LTCFs and, as the Scottish program suggests, may require a concerted national effort. Developing effective strategies to

reduce antimicrobial use at the level of LTCFs remains a challenge and area of intense interest (88).

## Infection Control

Current guidelines for prevention of *C. difficile* infections focus on the acute care setting (1). Potential strategies to adapt hospital-based recommendations for preventing *C. difficile* infection to LTCFs are detailed in Table 2. Because patients with *C. difficile* infection are considered the major source for transmission, basic measures to be implemented in all facilities focus on reducing the risk for transmission from symptomatic patients. These basic measures include placement of infected patients in contact precautions, in a private room if available, until diarrhea resolves and disinfection of their rooms and portable equipment after patient discharge, preferably with a sporicidal agent such as sodium hypochlorite (1). If basic measures are unsuccessful in preventing *C. difficile* transmission, adherence to basic practices should be assessed prior to addition of other control strategies. Unfortunately, adherence to basic measures is often suboptimal. If implementation of basic measures has been optimized, several special measures can be considered in addition to basic measures (1). These special measures include placement of patients with suspected *C. difficile* infection preemptively in contact precautions, extending the duration of contact precautions until discharge, and interventions to improve environmental disinfection (e.g., daily disinfection of high-touch surfaces).

Although infection control measures are similar in hospitals and LTCFs, the LTCF setting offers several unique challenges for prevention of pathogen transmission. First, nursing homes are the long-term home of many residents and the need to prevent transmission of *C. difficile* must be balanced with the goal to provide a home-like environment. Second, LTCFs often lack sufficient private rooms to provide single room isolation. Third, many LTCFs have shared bathrooms, rehabilitation facilities, and dining and recreation areas. Fourth, many LTCF residents have dementia or other chronic conditions that compromise their ability to adhere to basic standards of hygiene and to comply with contact precautions. Fifth, the staff in LTCFs may have less training in infection control and less experience with *C. difficile* infection. Sixth, special approaches such as extending the duration of contact precautions may be much less feasible in LTCFs than in hospitals because the length of stay is much longer. Jinno *et al*. found that asymptomatic carriage with shedding of spores was common during the month after treatment of *C. difficile* infection, but noted that a majority of patients with recent infection in a VA facility were cared for in a long-term care setting (89). Finally, as noted previously, many LTCFs do not have on-site laboratory services, and thus may experience significant delays in diagnosis of *C. difficile* infection.

## Vaccination

A systemic antibody response to *C. difficile* toxins provides protection against development of acute diarrhea and against recurrence (90, 91). Based upon these findings, development of an effective vaccine to prevent *C. difficile* infection has been an active area of clinical investigation. One candidate vaccine is now in Phase 3 trials and others are currently under development.

## Conclusion

Age, comorbid illnesses, frequent antibiotic exposure and dependence on health care workers, in the setting of communal living, all serve to increase the risk of LTCF residents becoming colonized or infected with *C. difficile*. While the primary goal for treating *C. difficile* infection is symptom resolution, an important secondary goal is to reduce the risk of recurrent disease by using therapies that promote rapid restoration of a healthy gut microbiota capable of colonization resistance. Vaccines that promote robust antibody production against TcdA and/or Tcd B may be an effective long-term strategy to reduce the burden of *C. difficile* in older adults. Until then, the mainstays of prevention will continue to be reducing unnecessary antibiotic exposure and improving infection control measures.

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**Conflict of Interest**

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## References

1. Dubberke ER MD, MSPH, Carling P MD, Carrico R Ph, DRN, Donskey CJ MD, Loo VG MD, MSc, McDonald LC MD, Maragakis LL MD, MPH, Sandora TJ MD, MPH, Weber DJ MD, MPH, Yokoe DS MD, MPH, Gerding DN MD. Strategies to Prevent *Clostridium difficile* Infections in Acute Care Hospitals: 2014 Update. Infect. Control Hosp. Epidemiol. 2014; 35:628–645. [PubMed: 24799639] * These are the latest infection control-related guidelines published by the Society for Healthcare Epidemiology of America. While not specific for long-term care facilities, the basic principles outlined for hospitals offer general guidance.
2. Magill SS, Edwards JR, Bamberg W, Beldavs ZG, Dumyati G, Kainer MA, Lynfield R, Maloney M, McAllister-Hollod L, Nadle J, Ray SM, Thompson DL, Wilson LE, Fridkin SK. Multistate Point-Prevalence Survey of Health Care-Associated Infections. N. Engl. J. Med. 2014; 370:1198–1208. [PubMed: 24670166]
3. Threat Report 2013 | Antimicrobial Resistance | CDC. available at http://www.cdc.gov/drugresistance/threat-report-2013/index.html** This is a comprehensive and detailed summary of consequences of antimicrobial resistant organisms as well as *C. difficile* for the United States. It summarizes morbidity, mortality and costs. Information is easily accessible and single pages may be extracted to support education of staff, residents and family members.
4. Cohen SH, Gerding DN, Johnson S, Kelly CP, Loo VG, McDonald LC, Pepin J, Wilcox MH. 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. Off. J. Soc. Hosp. Epidemiol. Am. 2010; 31:431–455.* These are the current clinical guidelines published by the Infectious Disease Society of American

and Society for Healthcare Epidemiology of America. An update is in progress with publication projected for Spring, 2015

5. Surawicz CM, Brandt LJ, Binion DG, Ananthakrishnan AN, Curry SR, Gilligan PH, McFarland LV, Mellow M, Zuckerbraun BS. Guidelines for Diagnosis, Treatment, and Prevention of *Clostridium difficile* Infections. Am. J. Gastroenterol. 2013; 108:478–498. [PubMed: 23439232] * Current clinical guidelines published by the American College of Gastroenterology.
6. Bauer MP, Kuijper EJ, Van Dissel JT. European Society of Clinical Microbiology and Infectious Diseases (ESCMID): treatment guidance document for *Clostridium difficile* infection (CDI). Clin. Microbiol. Infect. 2009; 15:1067–1079. [PubMed: 19929973]
7. Rao A, Jump RLP, Pultz NJ, Pultz MJ, Donskey CJ. In Vitro Killing of Nosocomial Pathogens by Acid and Acidified Nitrite. Antimicrob. Agents Chemother. 2006; 50:3901–904. [PubMed: 17065628]
8. Marler LM, Siders JA, Wolters LC, Pettigrew Y, Skitt BL, Allen SD. Comparison of five cultural procedures for isolation of *Clostridium difficile* from stools. J. Clin. Microbiol. 1992; 30:514–516. [PubMed: 1537928]
9. Kim KH, Fekety R, Batts DH, Brown D, Cudmore M, Silva J, Waters D. Isolation of *Clostridium difficile* from the environment and contacts of patients with antibiotic-associated colitis. J. Infect. Dis. 1981; 143:42–50. [PubMed: 7217711]
10. Lawley TD, Walker AW. Intestinal colonization resistance. Immunology. 2013; 138:1–11. [PubMed: 23240815]
11. Zilberberg MD, Shorr AF, Kollef MH. Increase in adult *Clostridium difficile*-related hospitalizations and case-fatality rate, United States, 2000–2005. Emerg. Infect. Dis. 2008; 14:929–931. [PubMed: 18507904]
12. Loo VG, Poirier L, Miller MA, Oughton M, Libman MD, Michaud S, Bourgault A-M, Nguyen T, Frenette C, Kelly M, Vibien A, Brassard P, Fenn S, Dewar K, Hudson TJ, Horn R, René P, Monczak Y, Dascal A. A predominantly clonal multi-institutional outbreak of *Clostridium difficile*-associated diarrhea with high morbidity and mortality. N. Engl. J. Med. 2005; 353:2442–2449. [PubMed: 16322602]
13. McDonald LC, Killgore GE, Thompson A, Owens RC, Kazakova SV, Sambol SP, Johnson S, Gerding DN. An Epidemic, Toxin Gene-Variant Strain of *Clostridium difficile* . N. Engl. J. Med. 2005; 353:2433–2441. [PubMed: 16322603]
14. Linder JA, Huang ES, Steinman MA, Gonzales R, Stafford RS. Fluoroquinolone prescribing in the United States: 1995 to 2002. Am. J. Med. 2005; 118:259–268. [PubMed: 15745724]
15. Lee GC, Reveles KR, Attridge RT, Lawson KA, Mansi IA, Lewis JS, Frei CR. Outpatient antibiotic prescribing in the United States: 2000 to 2010. BMC Med. 2014; 12:96. [PubMed: 24916809]
16. He M, Miyajima F, Roberts P, Ellison L, Pickard DJ, Martin MJ, Connor TR, Harris SR, Fairley D, Bamford KB, D'Arc S, Brazier J, Brown D, Coia JE, Douce G, Gerding D, Kim HJ, Koh TH, Kato H, Senoh M, Louie T, Michell S, Butt E, Peacock SJ, Brown NM, Riley T, Songer G, Wilcox M, Pirmohamed M, Kuijper E, Hawkey P, Wren BW, Dougan G, Parkhill J, Lawley TD. Emergence and global spread of epidemic healthcare-associated *Clostridium difficile* . Nat. Genet. 2013; 45:109–113. [PubMed: 23222960]
17. Jabbari S, Cartman ST, King JR. Mathematical modelling reveals properties of TcdC required for it to be a negative regulator of toxin production in *Clostridium difficile* . J. Math. Biol. 2014
18. Warny M, Pepin J, Fang A, Killgore G, Thompson A, Brazier J, Frost E, McDonald LC. Toxin production by an emerging strain of *Clostridium difficile* associated with outbreaks of severe disease in North America and Europe. Lancet. 2005; 366:1079–1084. [PubMed: 16182895]
19. Merrigan M, Venugopal A, Mallozzi M, Roxas B, Viswanathan VK, Johnson S, Gerding DN, Vedantam G. Human Hypervirulent *Clostridium difficile* Strains Exhibit Increased Sporulation as Well as Robust Toxin Production. J. Bacteriol. 2010; 192:4904–4911. [PubMed: 20675495]
20. Cartman ST, Kelly ML, Heeg D, Heap JT, Minton NP. Precise manipulation of the *Clostridium difficile* chromosome reveals a lack of association between the tcdC genotype and toxin production. Appl. Environ. Microbiol. 2012; 78:4683–4690. [PubMed: 22522680]

21. Bacci S, Mølbak K, Kjeldsen MK, Olsen KEP. Binary toxin and death after *Clostridium difficile* infection. Emerg. Infect. Dis. 2011; 17:976–982. [PubMed: 21749757]
22. Stewart DB, Berg A, Hegarty J. Predicting Recurrence of *C. difficile* Colitis Using Bacterial Virulence Factors: Binary Toxin Is the Key. J. Gastrointest. Surg. 2013; 17:118–125. [PubMed: 23086451]
23. Kaiser E, Kroll C, Ernst K, Schwan C, Popoff M, Fischer G, Buchner J, Aktories K, Barth H. Membrane Translocation of Binary Actin-ADP-Ribosylating Toxins from *Clostridium difficile* and *Clostridium perfringens* Is Facilitated by Cyclophilin A and Hsp90. Infect. Immun. 2011; 79:3913–3921. [PubMed: 21768281]
24. Lucado J, Gould C, Elixhauser A. *Clostridium difficile* Infections (CDI) in Hospital Stays, 2009 - Healthcare Cost and Utilization Project (HCUP) Statistical Briefs - NCBI Bookshelf..
25. McFarland LV, Mulligan ME, Kwok RY, Stamm WE. Nosocomial acquisition of *Clostridium difficile* infection. N. Engl. J. Med. 1989; 320:204–210. [PubMed: 2911306]
26. Dubberke ER. Attributable Outcomes of Endemic *Clostridium difficile*-associated Disease in Nonsurgical Patients. Emerg. Infect. Dis. 2008; 14:1031–1038. [PubMed: 18598621]
27. Black SR MD, MSc, Weaver KN MPH, Jones RC MPH, Ritger KA MD, MPH, Petrella LA BS, Sambol SP BS, Vernon M DrPH, Burton S BS, MPH, Garcia-Houchins S RN, MBA, CIC, Weber SG MD, MSc, Lavin MA RN, MJ, CIC, Gerding D MD, Johnson S MD, Gerber SI MD. *Clostridium difficile* Outbreak Strain BI Is Highly Endemic in Chicago Area Hospitals. Infect. Control Hosp. Epidemiol. 2011; 32:897–902. [PubMed: 21828970]
28. Mylotte JM. Surveillance for *Clostridium difficile*-associated diarrhea in long-term care facilities: what you get is not what you see. Infect. Control Hosp. Epidemiol. Off. J. Soc. Hosp. Epidemiol. Am. 2008; 29:760–763.
29. Guerrero DM, Nerandzic MM, Jury LA, Chang S, Jump RL, Donskey CJ. *Clostridium difficile* Infection in a Department of Veterans Affairs Long-Term Care Facility. Infect. Control Hosp. Epidemiol. 2011; 32:513–515. [PubMed: 21515985]
30. Archbald-Pannone LR, Boone JH, Carman RJ, Lyerly DM, Guerrant RL. *Clostridium difficile* ribotype 027 is most prevalent among inpatients admitted from long-term care facilities. J. Hosp. Infect. 2014
31. Mylotte JM, Russell S, Sackett B, Vallone M, Antalek M. Surveillance for *Clostridium difficile* infection in nursing homes. J. Am. Geriatr. Soc. 2013; 61:122–125. [PubMed: 23253029]
32. Vital Signs: Preventing Clostridium difficile Infections.
33. Laboratory-identified Multidrug-Resistant Organism (MDRO) & *Clostridium difficile* Infection (CDI) Events for Long-term Care Facilities. 2012
34. Gase KA MPH, CIC, Haley VB MS, Xiong K MS, Antwerpen CV RN, BSN, CIC, Stricof RL MPH, CIC. Comparison of 2 *Clostridium difficile* Surveillance Methods: National Healthcare Safety Network's Laboratory-Identified Event Reporting Module versus Clinical Infection Surveillance. Infect. Control Hosp. Epidemiol. 2013; 34:284–290. [PubMed: 23388363]
35. Han A, Jump RLP. Discrepancies between surveillance definition and the clinical incidence of *Clostridium difficile* infection in a VA long-term care facility. Infect Control Hosp Epidemiol in press.
36. Campbell RJ, Giljahn L, Machesky K, Cibulskas-White K, Lane LM, Porter K, Paulson JO, Smith FW, McDonald LC. *Clostridium difficile* infection in Ohio hospitals and nursing homes during 2006. Infect. Control Hosp. Epidemiol. Off. J. Soc. Hosp. Epidemiol. Am. 2009; 30:526–533.
37. Laffan AM, Bellantoni MF, Greenough WB3rd, Zenilman JM. Burden of *Clostridium difficile*-associated diarrhea in a long-term care facility. J. Am. Geriatr. Soc. 2006; 54:1068–1073. [PubMed: 16866677]
38. Loo VG, Bourgault A-M, Poirier L, Lamothe F, Michaud S, Turgeon N, Toye B, Beaudoin A, Frost EH, Gilca R, Brassard P, Dendukuri N, Béliveau C, Oughton M, Brukner I, Dascal A. Host and Pathogen Factors for *Clostridium difficile* Infection and Colonization. N. Engl. J. Med. 2011; 365:1693–1703. [PubMed: 22047560]
39. Jump RL. *Clostridium difficile* infection in older adults. Aging Health. 2013; 9:403–414. [PubMed: 24955106]

40. Dial S, Delaney JAC, Barkun AN, Suissa S. Use of gastric acid-suppressive agents and the risk of community-acquired *Clostridium difficile*-associated disease. JAMA J. Am. Med. Assoc. 2005; 294:2989–2995.
41. Dubberke ER, Reske KA, Yan Y, Olsen MA, McDonald LC, Fraser VJ. *Clostridium difficile*--associated disease in a setting of endemicity: identification of novel risk factors. Clin. Infect. Dis. Off. Publ. Infect. Dis. Soc. Am. 2007; 45:1543–1549.
42. Al-Tureihi FIJ, Hassoun A, Wolf-Klein G, Isenberg H. Albumin, length of stay, and proton pump inhibitors: key factors in *Clostridium difficile*-associated disease in nursing home patients. J. Am. Med. Dir. Assoc. 2005; 6:105–108. [PubMed: 15871884]
43. Eyre DW, Walker AS, Wyllie D, Dingle KE, Griffiths D, Finney J, O'Connor L, Vaughan A, Crook DW, Wilcox MH, Peto TEA. Predictors of first recurrence of *Clostridium difficile* infection: implications for initial management. Clin. Infect. Dis. Off. Publ. Infect. Dis. Soc. Am. 2012; 55(Suppl 2):S77–S87.
44. Guerrero DM, Nerandzic MM, Jury LA, Jinno S, Chang S, Donskey CJ. Acquisition of spores on gloved hands after contact with the skin of patients with *Clostridium difficile* infection and with environmental surfaces in their rooms. Am. J. Infect. Control. 2012; 40:556–558. [PubMed: 21982209]
45. Vesteinsdottir I, Gudlaugsdottir S, Einarsdottir R, Kalaitzakis E, Sigurdardottir O, Bjornsson ES. Risk factors for *Clostridium difficile* toxin-positive diarrhea: a population-based prospective case-control study. Eur. J. Clin. Microbiol. Infect. Dis. 2012; 31:2601–2610. [PubMed: 22441775]
46. Bender B, Laughon B, Gaydos C, Forman M, Bennett R, Greenough WB III, Sears S, Bartlett J. Is *Clostridium difficile* endemic in chronic care facilities? The Lancet. 1986; 328:11–13.
47. Simor AE, Yake SL, Tsimidis K. Infection Due to *Clostridium difficile* Among Elderly Residents of a Long-Term-Care Facility. Clin. Infect. Dis. 1993; 17:672–678. [PubMed: 7903557]
48. Arvand M, Moser V, Schwehn C, Bettge-Weller G, Hensgens MP, Kuijper EJ. High Prevalence of *Clostridium difficile* Colonization among Nursing Home Residents in Hesse, Germany. PLoS ONE. 2012; 7:e30183. [PubMed: 22253917]
49. Marciniak C, Chen D, Stein AC, Semik PE. Prevalence of *Clostridium difficile* Colonization at Admission to Rehabilitation. Arch. Phys. Med. Rehabil. 2006; 87:1086–1090. [PubMed: 16876554]
50. Riggs MM, Sethi AK, Zabarsky TF, Eckstein EC, Jump RLP, Donskey CJ. Asymptomatic Carriers Are a Potential Source for Transmission of Epidemic and Nonepidemic *Clostridium difficile* Strains among Long-Term Care Facility Residents. Clin. Infect. Dis. 2007; 45:992–998. [PubMed: 17879913]
51. Bartlett JG. Antibiotic-Associated Diarrhea. N. Engl. J. Med. 2002; 346:334–339. [PubMed: 11821511]
52. Rea MC, O'Sullivan O, Shanahan F, O'Toole PW, Stanton C, Ross RP, Hill C. *Clostridium difficile* Carriage in Elderly Subjects and Associated Changes in the Intestinal Microbiota. J. Clin. Microbiol. 2011
53. Guerrero DM, Becker JC, Eckstein EC, Kundrapu S, Deshpande A, Sethi AK, Donskey CJ. Asymptomatic carriage of toxigenic *Clostridium difficile* by hospitalized patients. J. Hosp. Infect. 2013; 85:155–158. [PubMed: 23954113]
54. Jones AL, Dwyer LL, Bercovitz AR, Strahan GW. The National Nursing Home Survey: 2004 overview. Vital Health Stat. 2009; 13:1–155.
55. Kim JH, Toy D, Muder RR. Clostridium difficile Infection in a Long-Term Care Facility: Hospital-Associated Illness Compared with Long-Term Care-Associated Illness. Infect. Control Hosp. Epidemiol. 2011; 32:656–660. [PubMed: 21666395]
56. Pawar D MD, Tsay R MPH, MLS, Nelson DS MSN, Elumalai MK MS, Lessa FC MD, McDonald LC MD, Dumyati G MD. Burden of *Clostridium difficile* Infection in Long-Term Care Facilities in Monroe County, New York. Infect. Control Hosp. Epidemiol. 2012; 33:1107–1112. [PubMed: 23041808]
57. Barrett SP, Holmes AH, Newsholme WA, Richards M. Increased detection of *Clostridium difficile* during a norovirus outbreak. J. Hosp. Infect. 2007; 66:394–395. [PubMed: 17669553]

58. Wilcox M, Fawley W. Viral gastroenteritis increases the reports of *Clostridium difficile* infection. J. Hosp. Infect. 2007; 66:395–396. [PubMed: 17662506]
59. Koo HL, Ajami NJ, Jiang Z-D, DuPont HL, Atmar RL, Lewis D, Byers P, Abraham P, Quijano RA, Musher DM, Young EJ. A Nosocomial Outbreak of Norovirus Infection Masquerading as *Clostridium difficile* Infection. Clin. Infect. Dis. 2009; 48:e75–e77. [PubMed: 19245344]
60. Scheurer D. Diagnostic and treatment delays in recurrent *Clostridium difficile*-associated disease. J. Hosp. Med. Off. Publ. Soc. Hosp. Med. 2008; 3:156–159.
61. Kundrapu S, Jury LA, Sitzlar B, Sunkesula VCK, Sethi AK, Donskey CJ. Easily Modified Factors Contribute to Delays in Diagnosis of *Clostridium difficile* Infection: a Cohort Study and Intervention. J. Clin. Microbiol. 2013; 51:2365–2370. [PubMed: 23678072]
62. Vardakas KZ, Polyzos KA, Patouni K, Rafailidis PI, Samonis G, Falagas ME. Treatment failure and recurrence of *Clostridium difficile* infection following treatment with vancomycin or metronidazole: a systematic review of the evidence. Int. J. Antimicrob. Agents. 2012; 40:1–8. [PubMed: 22398198]
63. McFarland LV, Surawicz CM, Rubin M, Fekety R, Elmer GW, Greenberg RN. Recurrent *Clostridium difficile* disease: epidemiology and clinical characteristics. Infect. Control Hosp. Epidemiol. Off. J. Soc. Hosp. Epidemiol. Am. 1999; 20:43–50.
64. Fekety R, McFarland LV, Surawicz CM, Greenberg RN, Elmer GW, Mulligan ME. Recurrent *Clostridium difficile* Diarrhea: Characteristics of and Risk Factors for Patients Enrolled in a Prospective, Randomized, Double-Blinded Trial. Clin. Infect. Dis. 1997; 24:324–333. [PubMed: 9114180]
65. D'Agostino RB, Collins SH, Pencina KM, Kean Y, Gorbach S. Risk Estimation for Recurrent *Clostridium difficile* Infection Based on Clinical Factors. Clin. Infect. Dis. 2014; 58:1386–1393. [PubMed: 24599770]
66. Johnson S, Adelmann A, Clabots CR, Peterson LR, Gerding DN. Recurrences of *Clostridium difficile* Diarrhea Not Caused by the Original Infecting Organism. J. Infect. Dis. 1989; 159:340–343. [PubMed: 2915158]
67. Barbut F, Richard A, Hamadi K, Chomette V, Burghoffer B, Petit J-C. Epidemiology of Recurrences or Reinfections of *Clostridium difficile*-Associated Diarrhea. J. Clin. Microbiol. 2000; 38:2386–2388. [PubMed: 10835010]
68. Abujamel T, Cadnum JL, Jury LA, Sunkesula VCK, Kundrapu S, Jump RL, Stintzi AC, Donskey CJ. Defining the Vulnerable Period for Re-Establishment of Clostridium difficile Colonization after Treatment of *C. difficile* Infection with Oral Vancomycin or Metronidazole. PLoS ONE. 2013; 8:e76269. [PubMed: 24098459]
69. Louie TJ, Miller MA, Mullane KM, Weiss K, Lentnek A, Golan Y, Gorbach S, Sears P, Shue Y-K. Fidaxomicin versus vancomycin for *Clostridium difficile* infection. N. Engl. J. Med. 2011; 364:422–431. [PubMed: 21288078]
70. Cornely OA, Miller MA, Louie TJ, Crook DW, Gorbach SL. Treatment of First Recurrence of *Clostridium difficile* Infection: Fidaxomicin Versus Vancomycin. Clin. Infect. Dis. 2012; 55:S154–S161. [PubMed: 22752865]
71. Tannock GW, Munro K, Taylor C, Lawley B, Young W, Byrne B, Emery J, Louie T. A new macrocyclic antibiotic, fidaxomicin (OPT-80), causes less alteration to the bowel microbiota of *Clostridium difficile*-infected patients than does vancomycin. Microbiology. 2010; 156:3354–3359. [PubMed: 20724385]
72. Bartsch SM, Umscheid CA, Fishman N, Lee BY. Is Fidaxomicin worth the cost? An economic analysis. Clin. Infect. Dis. 2013
73. Stranges PM, Hutton DW, Collins CD. Cost-effectiveness analysis evaluating fidaxomicin versus oral vancomycin for the treatment of *Clostridium difficile* infection in the United States. Value Health J. Int. Soc. Pharmacoeconomics Outcomes Res. 2013; 16:297–304.
74. Bowden TA, Mansberger AR, Lykins LE. Pseudomembraneous enterocolitis: mechanism for restoring floral homeostasis. Am. Surg. 1981; 47:178–183. [PubMed: 7224366]
75. Tvede M, Rask-Madsen J. Bacteriotherapy for chronic relapsing Clostridium difficile diarrhoea in six patients. Lancet. 1989; 1:1156–1160. [PubMed: 2566734]

76. Van Nood E, Vrieze A, Nieuwdorp M, Fuentes S, Zoetendal EG, de Vos WM, Visser CE, Kuijper EJ, Bartelsman JFWM, Tijssen JGP, Speelman P, Dijkgraaf MGW, Keller JJ. Duodenal infusion of donor feces for recurrent *Clostridium difficile* . N. Engl. J. Med. 2013; 368:407–415. [PubMed: 23323867] ** The authors described a randomized, controlled trial demonstrating the benefit of fecal transplant to successfully treat recurrent *C. difficile* infection. The clinical trial uses donor feces from prescreened donors.
77. MacConnachie AA, Fox R, Kennedy DR, Seaton RA. Faecal transplant for recurrent *Clostridium difficile*-associated diarrhoea: a UK case series. QJM Mon. J. Assoc. Physicians. 2009; 102:781–784.
78. Brandt LJ, Aroniadis OC, Mellow M, Kanatzar A, Kelly C, Park T, Stollman N, Rohlke F, Surawicz C. Long-term follow-up of colonoscopic fecal microbiota transplant for recurrent *Clostridium difficile* infection. Am. J. Gastroenterol. 2012; 107:1079–1087. [PubMed: 22450732]
79. Rubin TA, Gessert CE, Aas J. Stool transplantation for older patients with *Clostridium difficile* infection. J. Am. Geriatr. Soc. 2009; 57:2386. [PubMed: 20122011]
80. Konijeti GG, Sauk J, Shrime MG, Gupta M, Ananthakrishnan AN. Cost-effectiveness of Competing Strategies for Management of Recurrent *Clostridium difficile* Infection: A Decision Analysis. Clin. Infect. Dis. 2014; 58:1507–1514. [PubMed: 24692533]
81. Benoit SR, Nsa W, Richards CL, Bratzler DW, Shefer AM, Steele LM, Jernigan JA. Factors Associated with Antimicrobial Use in Nursing Homes: A Multilevel Model. J. Am. Geriatr. Soc. 2008; 56:2039–2044. [PubMed: 19016937]
82. Nicolle LE, Bentley DW, Garibaldi R, Neuhaus EG, Smith PW. Antimicrobial Use in Long-Term-Care Facilities. Infect. Control Hosp. Epidemiol. 2000; 21:537–545. [PubMed: 10968724]
83. Peron EP, Hirsch AA, Jury LA, Jump RLP, Donskey CJ. Another setting for stewardship: high rate of unnecessary antimicrobial use in a veterans affairs long-term care facility. J. Am. Geriatr. Soc. 2013; 61:289–290. [PubMed: 23405923]
84. Rotjanapan P, Dosa D, Thomas KS. Potentially inappropriate treatment of urinary tract infections in two rhode island nursing homes. Arch. Intern. Med. 2011; 171:438–443. [PubMed: 21403040]
85. Nathwani D, Sneddon J, Malcolm W, Wiuff C, Patton A, Hurding S, Eastaway A, Seaton RA, Watson E, Gillies E, Davey P, Bennie M. Scottish Antimicrobial Prescribing Group. Scottish Antimicrobial Prescribing Group (SAPG): development and impact of the Scottish National Antimicrobial Stewardship Programme. Int. J. Antimicrob. Agents. 2011; 38:16–26. [PubMed: 21515030]
86. Jump RLP, Olds DM, Seifi N, Kypriotakis G, Jury LA, Peron EP, Hirsch AA, Drawz PE, Watts B, Bonomo RA, Donskey CJ. Effective Antimicrobial Stewardship in a Long-Term Care Facility through an Infectious Disease Consultation Service: Keeping a LID on Antibiotic Use. Infect. Control Hosp. Epidemiol. Off. J. Soc. Hosp. Epidemiol. Am. 2012; 33:1185–1192.
87. Jump RLP, Olds DM, Jury LA, Sitzlar B, Saade E, Watts B, Bonomo RA, Donskey CJ. Specialty Care Delivery: Bringing Infectious Disease Expertise to the Residents of a Veterans Affairs Long-Term Care Facility. J. Am. Geriatr. Soc. 2013
88. Nicolle LE. Antimicrobial stewardship in long term care facilities: what is effective? Antimicrob. Resist. Infect. Control. 2014; 3:6. [PubMed: 24521205]
89. Jinno S, Kundrapu S, Guerrero DM, Jury LA, Nerandzic MM, Donskey CJ. Potential for transmission of Clostridium difficile by asymptomatic acute care patients and long-term care facility residents with prior *C. difficile* infection. Infect. Control Hosp. Epidemiol. Off. J. Soc. Hosp. Epidemiol. Am. 2012; 33:638–639.
90. Kyne L, Warny M, Qamar A, Kelly CP. Asymptomatic carriage of *Clostridium difficile* and serum levels of IgG antibody against toxin A. N. Engl. J. Med. 2000; 342:390–397. [PubMed: 10666429]
91. Kyne L, Warny M, Qamar A, Kelly CP. Association between antibody response to toxin A and protection against recurrent *Clostridium difficile* diarrhoea. The Lancet. 2001; 357:189–193.
92. McDonald LC, Coignard B, Dubberke E, Song X, Horan T, Kutty PK. Recommendations for surveillance of *Clostridium difficile*-associated disease. Infect. Control Hosp. Epidemiol. Off. J. Soc. Hosp. Epidemiol. Am. 2007; 28:140–145.

93. Zabarsky TF, Sethi AK, Donskey CJ. Sustained reduction in inappropriate treatment of asymptomatic bacteriuria in a long-term care facility through an educational intervention. Am. J. Infect. Control. 2008; 36:476–480. [PubMed: 18786450]

94. Sitzlar B, Deshpande A, Fertelli D, Kundrapu S, Sethi AK, Donskey CJ. An environmental disinfection odyssey: evaluation of sequential interventions to improve disinfection of *Clostridium difficile* isolation rooms. Infect. Control Hosp. Epidemiol. Off. J. Soc. Hosp. Epidemiol. Am. 2013; 34:459–465.

95. Sitzlar B, Jury LA, Kundrapu S, Cadnum JL, Donskey CJ. Effectiveness of an Ultraviolet Radiation Device for Disinfection of Personal Use Items in Rooms of Long-Term Care Facility Residents. Society for Healthcare Epidemiology of America. Dallas, Texas. 2011

96. Sitzlar B, Vajravelu RK, Jury L, Donskey CJ, Jump RLP. Environmental decontamination with ultraviolet radiation to prevent recurrent *Clostridium difficile* infection in 2 roommates in a long-term care Facility. Infect. Control Hosp. Epidemiol. Off. J. Soc. Hosp. Epidemiol. Am. 2012; 33:534–536.

**Table 1**

Surveillance Definitions of *C. difficile* Infection

| Term | Definition | Source |
|---|---|---|
| Clinical Case Definitions | | |
| Non-severe | ≥ 3 unformed or watery stools in ≤ 24 hours and a stool test result positive for toxigenic *C. difficile* OR pseudomembranous colitis on colonoscopic or histopathologic exam | (4) |
| Severe | Leukocytosis with white blood cell count ≥ 15,000 cell/mL and a serum creatinine ≥ 1.5 times the pre-morbid level | (4) |
| Severe, complicated | Hemodynamic instability, ileus or toxic megacolon | (4) |
| Recurrent *C. difficile* infection | A *C. difficile* infection within 8 weeks of a previous infection for which the symptoms resolved | (92) |
| Surveillance Definitions | | |
| HCF-onset, HCF-associated[a] | Symptom onset > 48 hours following admission to healthcare facility | (92) |
| LTCF-onset, hospital-acquired | Symptom onset at a LTCF within 30 days of hospital discharge and no *C. difficile* infection diagnosis in the previous 90 days. | (28) |
| LTCF-associated | Symptom onset more than 30 days after LTCF admission and no *C. difficile* infection diagnosis in the previous 90 days. | (28) |
| Community onset, HCF-associated | Symptom onset in the community or < 48 hours following admission to a healthcare facility, provided symptom onset is < 4 weeks following discharge from a HCF. | (92) |
| Community-associated | Symptom onset in the community or < 48 hours following admission to a healthcare facility, provided symptom onset is > 12 weeks following discharge from a HCF. | (92) |
| Indeterminate | Symptoms onset in the community between 4 – 12 weeks following discharge from a HCF. | (92) |
| Incident Case | *Clostridium difficile*–positive laboratory assay for toxin A and/or B or a toxin-producing organism detected by stool culture or other laboratory means. | (33) |

[a] HCF, healthcare facility; LTCF, long-term care facility

## Table 2

Potential Strategies to Adapt Recommendations to Prevent *Clostridium difficile* Infections in Acute Care Facilities to Long-Term Care Facilities

| **Strategies to prevent *C. difficile* infection in acute care hospitals[a]** | **Barriers to implementation in long-term care facilities** | **Potential adaptation of hospital-based strategies to long-term care facilities[b]** |
|---|---|---|
| **Antimicrobial Stewardship** | | |
| Reduce inappropriate and unnecessary antibiotic use. | Overtreatment of conditions such as asymptomatic bacteriuria is common and may be driven by nursing-initiated testing. | Nursing-focused educational interventions can reduce inappropriate collection and response to "positive" urine studies (93). |
| Establish a formal antimicrobial stewardship program.[c] | Evidence-based strategies for successful antimicrobial stewardship in the long-term care facilities are not well established (88). | Implementation of an Infectious Diseases consult service reduced total antibiotic use and correlated with a decrease in positive *C. difficile* tests (86). |
| **Surveillance and Clinical Response to Suspected *C. difficile* Infections** | | |
| Conduct surveillance | Cases in LTCF often occur soon after hospital discharge resulting in uncertainty regarding the source of acquisition (28). Other causes of diarrhea (e.g., viral gastroenteritis, laxatives and tube feeds) and asymptomatic carriage of *C. difficile* are common. | Have a lower index of suspicion for *C. difficile* infection among residents within ~1 month of a hospital stay (29, 31). Education of nurses and physicians is needed to avoid inappropriate testing that may result in false-positive diagnosis of *C. difficile* infection. |
| Place patients with diarrhea under contact precautions while testing is pending.[c] | May be difficult due to delays in diagnosis related to testing in off-site laboratories. | Consider pre-emptive treatment for severe symptoms, suspected recurrence, or if the suspicion for infection is high and delays in testing are anticipated. |
| Implement a lab-based alert system to provide immediate notification about newly diagnosed cases. | Testing is often performed in an off-site laboratory not directly affiliated with the LTCF. | Follow-up with the laboratory daily to request test results or establish a protocol for immediate notification of results. |
| Prolong the duration of contact precautions after the patient becomes asymptomatic until hospital discharge.[c] | Less feasible due to need to provide a home-like environment; due to long length of stay residents may spend prolonged periods in isolation after symptom resolution, whereas rapid discharge from hospitals is common. | Consider interventions such as resident soap and water hand washing, showering, and enhanced environmental disinfection with a sporicidal disinfectant for 4–6 weeks after discontinuation of treatment |
| People with *C. difficile* infection should be in a single room when possible. | Single rooms often not available and moving residents (and their belongings) may be disruptive. | Contact precautions can be maintained in multiple-bed rooms with education of staff. Consider using temporary isolation rooms. |
| **Preventing Transmission from Environmental Surfaces** | | |
| Ensure cleaning and disinfection of equipment and environment. | Terminal and daily cleaning of nursing home rooms may be difficult due to staffing issues and the length of stay. Cleaning after contact precautions is discontinued often difficult because residents, unlike hospital patients, may not be discharged. | Interventions requiring relatively little time and expense can be effective in improving cleaning (94). |
| Use a sporicidal disinfectant for cleaning and disinfection in rooms of residents with known *C. difficile* infection.[c] | Residents may have many personal items that are not amenable to disinfection with sporicidal products (95). | Use of no-touch technologies (*e.g* ultraviolet radiation, hydrogen peroxide-based technologies) could have a role in the future, but data considered insufficient to draw conclusions (96). |
| Assess the adequacy of room cleaning[c] | Technologies used to monitor cleaning may be expensive and may take excessive time if routine monitoring is conducted. | Consider intermittent assessments, such as 4 randomly selected rooms each month. Share results with staff. |
| **Preventing Transmission by Health Care Workers and Residents** | | |
| Educate providers, therapists, nursing staff, environmental service personnel, and administration. | Staff turnover may limit the collective knowledge about *C. difficile* at the institution. | Mandatory education for all staff annually. More frequent updates as needed for positions with high turn-over (*e.g.*, aides, environmental services) |

| **Strategies to prevent *C. difficile* infection in acute care hospitals**[a] | **Barriers to implementation in long-term care facilities** | **Potential adaptation of hospital-based strategies to long-term care facilities**[b] |
|---|---|---|
| Contact precautions using personal protective equipment (*e.g.*, gloves, gowns) | Staff may have less training and expertise in infection control. | Make personal protective equipment readily available using carts or door hangers. Include signage that illustrates proper use, including removal. |
| Use soap and water as preferred hand hygiene method before exiting the room.[c] | Access to sinks for soap and water hand washing may be limited | Staff may wash hands at the sinks in rooms of affected residents. |
| Measure compliance with hand hygiene and contact precautions.[c] | Finding time and resources to monitor compliance with recommendations is challenging. | Consider intermittent assessments, such as a single 2-hour block/week. Share results with staff. |
| Educate patients and their families | Dementia is common among nursing home residents. | Post signs and posters to instruct families and residents about *C. difficile*. Encourage residents and family members to use soap and water, particularly after dressing, washing and before meals. |

[a] Based, in part, on strategies recommended in (1)

[b] Limited evidence to support strategies to prevent *C. difficile* infection that are specific to long-term care facilities exists. We include references in support of our recommendations when they are available.

[c] Considered special approaches that can be added if *C. difficile* infection rates remain high despite basic practices.