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Infection in Acute Care: Evidence for Practice

Preventing and treating the three most common infections in this setting.

ABSTRACT: Infection may be either a cause for admission to an acute care hospital or health care associated, a complication of receiving care for another illness in the acute care environment. In recent years, there has been significant research investigating risk factors for infection in the hospital setting, best practices for diagnosis and treatment, and ways to prevent many health care–associated infections. Multidrug-resistant organisms are a consequence of antibiotic overuse, poor environmental hygiene, and our increasing ability to keep chronically ill patients alive longer through invasive intensive care support. This article reviews the evidence on infection in acute care settings, with a focus on community- and hospital-acquired pneumonia, surgical site infections, and *Clostridioides difficile* infection. Recommendations for integrating this evidence into nursing practice are offered.

Keywords: *Clostridioides difficile*, community-acquired pneumonia, health care–associated infection, hospital-acquired pneumonia, multidrug-resistant organisms, surgical site infection, ventilator-associated pneumonia

Infections have afflicted humans since the beginning of recorded history, often with devastating outcomes. An infection may be a cause for admission to an acute care hospital, as in cases of community-acquired pneumonia (CAP). An infection may also be health care associated, a complication of receiving care for another illness in a health care environment, as in cases of hospital-acquired pneumonia (HAP). While medical advances have brought lifesaving treatment for many diseases, such advances have also increased the risk of health care–associated infections (HAIs). The Centers for Disease Control and Prevention (CDC) defines an HAI as an infection diagnosed after admission that wasn't suspected or present at the time of admission.[1] The CDC also publishes specific diagnostic surveillance definitions used to collect data on HAIs via the National Healthcare Safety Network.[2]

This article reviews the evidence for the three most commonly encountered infections in the acute care hospital environment: pneumonia (community acquired and hospital acquired, with the latter including ventilator-associated pneumonia [VAP]), surgical site infection, and gastrointestinal (GI) tract infection with *Clostridioides difficile* (previously known as *Clostridium difficile*[3]). It also offers recommendations for prevention and control. Readers should keep in mind that evidence and recommendations may not apply to special populations such as severely immunocompromised patients, pregnant women, or children.

THE SCOPE OF THE PROBLEM

A CDC survey of HAI prevalence in 2015 among more than 12,000 inpatients found that 3.2% had some type of HAI.[4] Compared with results from a

Nurses don isolation precautions garb before entering the room of a patient with a multidrug-resistant infection. Photo courtesy of Vancouver Coastal Health.

prior CDC survey in 2011, this represented a 16% reduction in overall risk of HAI and reflected decreases in the rates of surgical site and urinary tract infections; but the rates of HAP and *C. difficile* remained unchanged.[4] The most common infections identified in the 2015 survey were pneumonia (25.8%); GI tract infection (21.3%), predominantly with *C. difficile*; and surgical site infections (16.2%). Nearly 24% of all infections were device related, including central line–associated bloodstream infections, catheter-associated urinary tract infections, and VAP. Fortunately, national efforts to strengthen infection prevention programs in hospitals are having positive effects, and the incidence of many types of HAIs has been decreasing steadily in recent years.[5] That said, hospitalized patients are often at increased risk for developing infection; this includes patients with immune system deficiencies or who are on immunosuppressive agents, patients with invasive devices, and patients with diabetes, among others.

Multidrug-resistant organisms (MDROs). The development of numerous antibiotic agents during the last century resulted in drastic reductions in mortality rates from infection.[6] But with the widespread use of these drugs, pathogens of every type have become increasingly resistant to their effects, and MDROs have become prevalent. MDROs can be found in almost every care setting, but they proliferate in acute care settings. Factors that predispose acutely ill patients to acquire MDROs include contact with multiple providers, environmental colonization with MDROs, greater antibiotic exposure, immunosuppression, the use of indwelling devices, the use of mechanical ventilation, hyperlipidemia, history of surgery, older age, and greater susceptibility associated with whatever malady led to acute care admission.[7-10] (For more on the role of antibiotics, see *Antibiotic Overuse: A Dangerous Trend*.[11-17])

It is within this complex context that nurses must provide care to patients with infections, whether community acquired or health care associated.

PNEUMONIA

Together with influenza, pneumonia remains the eighth leading cause of death in the United States.[18] Despite advances in antibiotic and antiviral therapies, mortality is higher in older populations.[19]

CAP was recently identified as the sixth leading diagnosis at hospital admission.[20] Risk factors include older age; smoking; environmental exposure to toxins (such as certain gases, dust, metals); malnutrition;

poor oral health; chronic lung disease; functional impairment; history of CAP within the past two years; and treatment with certain drugs, including immunosuppressive agents, oral steroids, and gastric acid–suppressing agents.[21] Presentation can vary greatly. Some people have moderate symptoms of fever, cough, phlegm, and malaise that gradually worsen over time. Others may present with severe dyspnea and hypoxemia, requiring endotracheal intubation and mechanical ventilation. Diagnosis is usually based on clinical symptoms and chest radiography findings, although chest radiography has been found to have low diagnostic sensitivity compared with chest computed tomography (CT).[22] Some experts have called for greater use of CT scans in diagnosing CAP.[22] For more, see *CDC Clinical Definitions for Pneumonia in Adults*[23] and *Community-Acquired Pneumonia: Clinical Severity Scoring Systems*.[19, 24-30] (It's important to remember that surveillance definitions such as the CDC's differ somewhat from clinical diagnostic criteria.)

Identification of specific pathogens often isn't possible because of the difficulty of obtaining adequate specimens, although newer microbiological testing methods show promise. Thus treatment is often based on the likely pathogens and on the presenting level of severity. Most "textbook" lists of pathogens causing CAP begin with *Streptococcus pneumoniae* and include *Chlamydophila*, *Haemophilus influenzae*, *Legionella* species, *Moraxella catarrhalis*, *Mycoplasma pneumoniae*, *Staphylococcus aureus*, and group A streptococci.[19] One recent study analyzed data for more than 2,200 patients for whom there was radiographic evidence of pneumonia and at least one specimen available for both bacterial and viral testing.[31] It's worth noting that both human rhinovirus and influenza were detected more often than *S. pneumoniae*; the researchers suggested that improved "influenza-vaccine uptake and effectiveness" might decrease the incidence of CAP.[31]

Treatment. Prompt antibiotic therapy in any infectious process improves outcomes. Regimens for CAP vary, depending on the likely pathogen and the level of illness severity. Current guidelines for patients with CAP hospitalized in a non-ICU setting call for either a β-lactam and macrolide combination or a respiratory fluoroquinolone.[30] In a randomized crossover trial, Postma and colleagues found β-lactam monotherapy to be "noninferior" to the two aforementioned strategies,[32] but this is insufficient evidence to recommend a practice change. And in a study of patients sick enough to be admitted to an ICU, Pereira and colleagues confirmed that combination β-lactam with macrolide therapy resulted in lower in-hospital and six-month mortality rates.[33]

In patients hospitalized with CAP in an ICU setting, the most recent guidelines jointly issued by the Infectious Diseases Society of America (IDSA) and the American Thoracic Society (ATS) recommend more aggressive therapy.[30] In general, treatment with a β-lactam antibiotic plus either azithromycin (Zithromax and others) or a respiratory fluoroquinolone is advised. In cases of community-acquired methicillin-resistant *S. aureus* (MRSA), vancomycin (Vancocin) or linezolid (Zyvox) should also be added. If *Pseudomonas aeruginosa* is suspected, treatment with an antipneumococcal, antipseudomonal β-lactam plus other drugs in various combinations is advised.

Patients with CAP should receive antibiotic therapy for at least five days, continuing until the patient has been afebrile for at least 48 hours and has no more than one CAP-associated sign of instability (such as continued need for oxygen therapy or an elevated white blood cell count).[30] These discontinu-

Community-Acquired Pneumonia: Clinical Severity Scoring Systems

For patients who present to an ED or urgent care center with community-acquired pneumonia (CAP), determining the need for admission and the level of care should be guided by one of the following clinical severity scoring systems:

- Confusion, urea, respiratory rate, blood pressure, and age ≥ 65 years (CURB-65) severity score[24, 25]
- Pneumonia Severity Index[26]
- Systolic blood pressure, multilobar chest involvement, albumin level, respiratory rate, tachycardia, confusion, oxygenation, and arterial pH (SMART-COP) score[27, 28]
- The 2007 minor criteria jointly issued by the Infectious Diseases Society of America (IDSA) and American Thoracic Society (ATS)[29, 30]

All of these have been validated for predicting CAP severity, outcome, and need for intensive therapy. Use of a clinical severity scoring system is strongly recommended, based on level I evidence, in the IDSA–ATS's CAP guidelines.[19, 30] These scoring systems can be quickly calculated online by using a medical calculator application such as www.mdcalc.com.

ation criteria were recently validated in a study by Uranga and colleagues.[34]

In cases of severe CAP and treatment failure, there is some evidence to support the use of adjunctive therapy with corticosteroids.[35, 36] But this therapy remains controversial and further research is needed.[19]

HAP refers to pneumonia that develops during hospitalization. (An older term, health care–associated pneumonia, referred to pneumonia that developed in people who, though not hospitalized, had significant health care contact, such as by receiving dialysis or residing in nursing homes. This term has been removed from the most recent IDSA–ATS guidelines.) Additional risk factors for HAP include being hospitalized for more than 48 hours and being a surgical patient.[37] Although VAP also usually develops during hospitalization, it is discussed separately in the literature and in this article.

Treatment. The most significant difference between CAP and HAP is the greater risk hospitalized patients have for the development of MDRO pneumonia.[38, 39] Thus, treatment recommendations vary somewhat from those for CAP, and are based on a patient's risk of mortality and MDROs; they are similar to those for VAP, described below. The IDSA–ATS guidelines for HAP strongly recommend antibiotic therapy for seven days in duration, despite a "very low quality" of evidence.[39] Shorter courses of therapy for HAP have been studied, but there is insufficient evidence with regard to nonventilated patients in particular to support a change in practice.[40]

Clinical surveys indicate that as many as 5% to 15% of patients on ventilators develop pneumonia.

VAP. The CDC defines VAP as a pneumonia that develops when the patient has been on mechanical ventilation for more than two days.[23] Additional risk factors for VAP include having suffered major trauma or brain injury.[37] Overall, VAP rates have been decreasing.[41] This may be owing to a heightened focus on preventive practices such as daily "sedation vacations," endotracheal tubes with subglottic secretion drainage ports, elevating the head of the bed, early mobility, oral care with chlorhexidine, and more aggressive extubation.[42] Nonetheless, clinical surveys indicate that as many as 5% to 15% of patients on ventilators develop pneumonia.[42, 43]

CDC Clinical Definitions for Pneumonia in Adults[23]

Imaging.
Two or more chest X-rays with at least one of the following:
- New or progressive infiltrates
- Consolidation
- Cavitation

Clinical signs and symptoms.
At least one of the following:
- Fever above 38°C (100.4°F) with no other cause
- Leukopenia (WBC, 4,000/mm^3 or less) or leukocytosis (WBC, 12,000/mm^3 or more)
- Altered mental status with no other cause (in adults, age 70 years or older)

And at least two of the following:
- New onset of purulent sputum, or change in sputum quality, or increased secretions, or increased suctioning requirements
- New or worsening cough, or dyspnea, or tachypnea
- Rales or bronchial breath sounds
- Worsening gas exchange, increased oxygen needs, or increased ventilator demands

CDC = Centers for Disease Control and Prevention; WBC = white blood cell.

For diagnostic purposes, noninvasive sampling with semiquantitative cultures is recommended (such as endotracheal suction tube specimens), rather than more invasive methods (such as mini-bronchoalveolar lavage or bronchoscopic specimens).[39] The use of clinical scoring systems such as the Clinical Pulmonary Infection Score is not recommended.

Treatment. Many institutions use procalcitonin and C-reactive protein levels to discern the need for antibiotic therapy in cases of suspected infection. But because of insufficient evidence, the current IDSA–ATS guidelines for treating HAP and VAP do not recommend their routine use when considering whether to begin antibiotic therapy.[39] This may change (at least for the sickest patients), as a recent meta-analysis of procalcitonin use in guiding antibiotic treatment decisions showed a lower 30-day mortality rate (21.1% versus 23.7%) and a one-day decrease in antibiotic use in the group whose treatment was guided by procalcitonin levels compared with controls.[44] Because high procalcitonin levels may also be found in inflammatory processes such as severe trauma, surgery, cardiogenic shock, and autoimmune disease caution must be used in their interpretation.

Treatment for VAP should begin with aggressive empiric antibiotic therapy as soon as VAP is suspected. It should be based on local antibiogram data regarding the prevalence of MDROs in the clinical area and on guideline recommendations.

Precise regimens for VAP vary, depending on the likely pathogen and the level of illness severity. At minimum, treatment should include broad-spectrum antibiotics that target *S. aureus*, *P. aeruginosa*, and other gram-negative bacteria.[39] In areas with greater than 10% prevalence of multidrug-resistant *P. aeruginosa*, an anti-MRSA agent is also recommended, at least until definitive culture results are obtained. Once such results are in, this broad-spectrum regimen should be scaled back to a more targeted regimen, in order to lower the risk of development of MDROs in both the patient and the clinical environment. The IDSA–ATS guidelines for VAP strongly recommend antibiotic therapy of seven days in duration, based on moderate-quality evidence.[39]

Prevention and treatment. In summary, evidence-based recommendations for managing hospitalized patients at risk for or who have CAP, HAP, or VAP include the following.[19, 30, 39, 42, 45]

Treatment.

- Begin empiric antibiotic therapy quickly, ideally within three hours of initial symptoms.
- In patients with CAP, use a validated severity scoring method to gauge level of illness and risk of worsening.
- Use short durations of antibiotic therapy if symptoms resolve (CAP, five days; VAP or HAP, seven days).
- Choose antibiotics for HAP or VAP based on local data per hospital antibiogram.

Prevention.

- Keep the head of the patient's bed elevated at 30° or more to prevent aspiration.
- Use endotracheal tubes with subglottic suction.
- Encourage early ambulation.
- Aggressively manage electrolytes and fluid balance and hypoxemia.
- General infection prevention strategies, such as proper handwashing and encouraging at-risk populations to get the influenza vaccine, are also important.

SURGICAL SITE INFECTIONS

Surgical site infections (SSIs) account for nearly 20% of all HAIs and are associated with significantly longer hospital stays and an increased risk of death.[46] Overall, approximately 2% to 5% of patients undergoing surgery are affected.[46] But the rate for patients undergoing specific surgeries and facing associated risk factors can vary widely. For example, in a recent study by Sanger and colleagues of 851 patients undergoing abdominal surgeries, 19.6% developed SSIs while recovering in the hospital.[47] It's estimated that up to 60% of SSIs are preventable.[48]

Risk factors may be patient or procedure related, with patient-related factors classified as modifiable or nonmodifiable.[46, 48] Modifiable risk factors include alcohol use, smoking, glycemic control (in people with diabetes), obesity, preoperative hypoalbuminemia, and use of immunosuppressive medications. Nonmodifiable factors include age, history of radiotherapy, and

Antibiotic Overuse: A Dangerous Trend

The overuse of antibiotics continues to be rampant. At the 2018 Infectious Diseases Society of America national conference, Linder and colleagues reported on their analysis of more than 500,000 outpatient antibiotic prescriptions; they found that 46% of antibiotic prescriptions were provided without an infection-related diagnosis and 20% were provided without an in-person visit.[11] In the inpatient environment, a retrospective analysis of data from 552 participating acute care hospitals between 2006 and 2012 showed that 55% of patients received at least one dose of antibiotics; the overall usage rate was 755 days of therapy per 1,000 patient-days.[12] During the study period, the use of broad-spectrum agents (such as carbapenem) increased significantly, likely due to concerns about the rising prevalence of infections caused by gram-negative multidrug-resistant organisms (MDROs). According to the Centers for Disease Control and Prevention, "There is no doubt that overprescribing and misprescribing [antibiotics] is contributing to the growing challenges posed by *Clostridium difficile* and antibiotic-resistant organisms."[13] This dangerous trend is not limited to the United States. An analysis of data collected in 76 countries between 2000 and 2015 found that antibiotic consumption increased 65%, as measured in defined daily doses.[14]

In the United States, it's estimated that about 23,000 people die annually from antibiotic-resistant infections.[15] Treatment costs for antibiotic-resistant infections stand at about $2.2 billion annually.[16] Moreover, besides contributing to the increasing prevalence of MDROs, antibiotic use can have other negative consequences. One study of nearly 1,500 inpatients given antibiotic treatment found that 20% experienced at least one antibiotic-associated adverse drug event.[17] The most common such events included gastrointestinal, renal, and hematologic aberrancies. The researchers concluded that better stewardship of antibiotics was vital to patient safety.

recent skin or soft tissue infection. Clinical evidence of SSI may include fever; an elevated white blood cell count; edema, erythema, or excessive pain at the surgical site; wound dehiscence; foul odor; and purulent drainage at the surgical site. It can be initially difficult to distinguish normal postoperative surgical wound appearance from an infected surgical site. Frequent, serial examinations of the site, preferably by the same person, can be helpful. There is evidence supporting daily clinical wound assessment as a significant early predictor of SSI.[47]

Prevention and treatment. Strategies to prevent SSIs are well documented and supported by several evidence-based professional guidelines.[46, 48, 49] These strategies include smoking cessation, glucose control, not shaving the surgical site (clipping only if necessary), and maintaining perioperative normothermia. Antibiotic prophylaxis is recommended only when indicated; when so indicated, it should be administered within one hour of incision with an appropriate agent (within two hours for vancomycin or fluoroquinolones), and should be discontinued within 24 hours of surgery.[46, 48, 50]

Further recommendations include preoperative bathing with chlorhexidine, perioperative administration of supplemental oxygen for patients undergoing general anesthesia, and consideration of the use of antibiotic sutures for wound closure.[46, 49] Although preoperative chlorhexidine bathing is recommended, optimal timing and number of applications remain unclear. Postoperatively, early showering (12 hours after surgery) has not been shown to increase SSI rates.[46] The use of wound vacuum therapy is increasingly common in treating SSIs and is recommended for certain wounds.[46, 49] But both topical wound antibiotic treatment and the use of silver-containing dressings have shown mixed results in the literature, and neither is routinely recommended by current guidelines.[46, 49]

Once an SSI is diagnosed, treatment recommendations include opening the wound to allow drainage.[51] This involves removing staples or sutures and possible incision and drainage at the site if indicated. Depending on the site and severity of infection, IV or oral antimicrobial treatment may be ordered for some patients, particularly if the patient is immunocompromised or physically weak owing to age or comorbidities.[51]

In all surgical patients, postoperative monitoring for necrotizing fasciitis is crucial. Patients most at risk are those who have diabetes, are immunocompromised, or have suffered traumatic wounds.[52] Clinical findings suggestive of necrotizing fasciitis include excessive pain or tenderness (disproportionate to what is usual for a given surgery), fever, soft-tissue edema, and skin bullae or necrosis. Imaging may show gas in the tissues (suggestive of group A streptococcal infection), although the absence of gas doesn't rule out necrotizing fasciitis. If necrotizing fasciitis is suspected, immediate consultation with a surgeon experienced with this infection is warranted, as open surgical inspection and biopsy are the most definitive means of diagnosing and treating the infection.

GI INFECTION: *C. DIFFICILE*

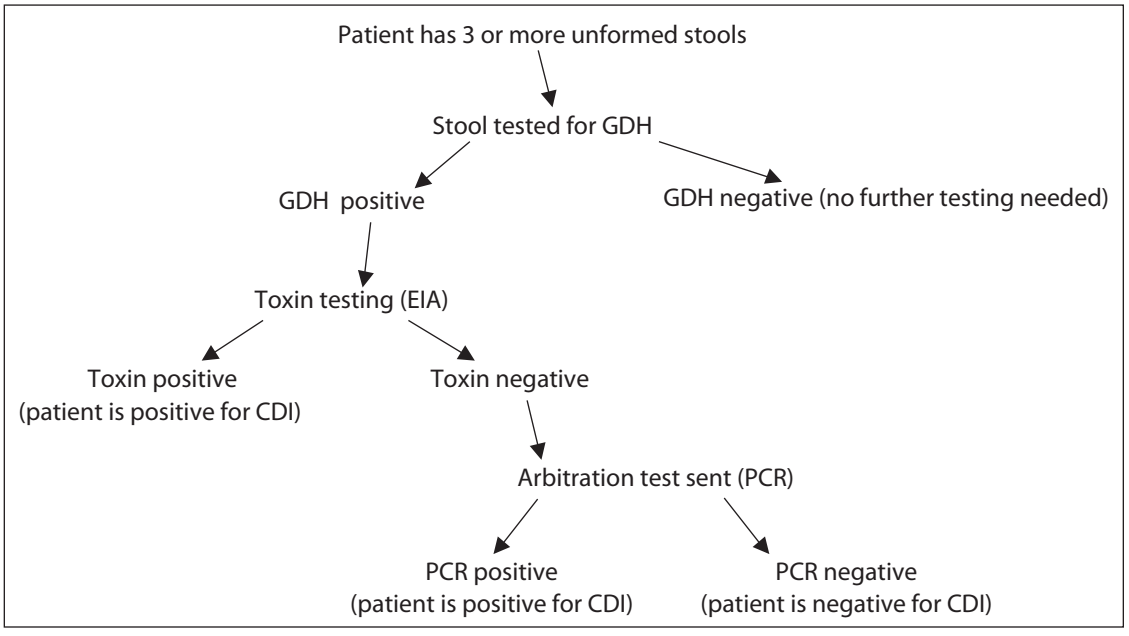
Incidence rates of *C. difficile* infection (CDI) have steadily and dramatically risen during the past 20 years in both community and inpatient populations. One surveillance study showed a near doubling of such rates in hospitalized adults between 2001 and 2010, from 4.5 to 8.2 cases per 1,000 patient discharges.[53] Although estimates vary, CDIs reportedly account for 15.5% to 21.3% of HAIs[3, 4] and cause from 14,000 to 29,000 deaths annually.[54, 55] Multiple recurrences of CDI are common in both inpatient and community settings.[54, 56]

It can be initially difficult to distinguish normal postoperative surgical wound appearance from an infected surgical site.

The top three risk factors for CDI are antibiotic use, exposure to the organism, and serious comorbidities; other factors include GI surgery or manipulation (such as colonoscopy), immunocompromise, longer lengths of stay, older age, and proton pump inhibitor use.[54, 57, 58] Risk factors for recurrence include chronic kidney disease; female sex; nursing home residency; and the use of antibiotics, proton pump inhibitors, or corticosteroids within 90 days of CDI diagnosis.[54]

Diagnosis of CDI should involve use of a multistep testing algorithm. The current guidelines, jointly issued by the IDSA and the Society for Healthcare Epidemiology of America (SHEA), recommend testing patients who have three or more unformed stools in 24 hours with no laxative use.[59] Screening proceeds by following a testing algorithm, often first testing for glutamate dehydrogenase, which is an enzyme produced by all strains of *C. difficile*. This test has a high negative predictive value[60]; thus, if the result is negative, no further testing is needed. If the result is positive, this should be confirmed with either a toxin test or a nucleic acid amplification test, such as the polymerase chain reaction

Figure 1. Sample Algorithm for Diagnosis of *Clostridioides difficile* Infection[59]



CDI = *Clostridioides difficile* infection; EIA = enzyme immunoassay; GDH = glutamate dehydrogenase; PCR = polymerase chain reaction.

test.[59] For an evidence-based testing algorithm, see Figure 1.[59]

Prevention and treatment. As soon as CDI is suspected, it is appropriate to institute contact precautions and conduct room disinfection with a sporicidal cleaning product, according to the IDSA–SHEA guidelines.[59] For routine use, either soap and water or alcohol-based hand rubs or sanitizers are acceptable for hand hygiene. During outbreaks or in hyperendemic settings, staff should use soap and running water with vigorous rubbing to remove any spores present, although the quality of supporting evidence is low. Once a patient is discharged or if contact precautions are discontinued, terminal cleaning of the room and equipment are recommended. Adjunctive disinfection methods such as with ultraviolet light may be helpful. Contact precautions may be discontinued once the patient has at least 48 hours without diarrhea, but institutions with higher rates of CDI should continue using contact precautions until the patient is discharged.

Treatment of CDI previously consisted of oral or IV metronidazole (Flagyl); newer data support the use of oral vancomycin or fidaxomicin (Dificid) instead.[59] Severe infection should be treated with oral vancomycin. If ileus is present or if absorption is questionable owing to poor gut function, the recommended treatment is vancomycin per rectum along with IV metronidazole.

A recent large study of patients with CDI who were treated with either vancomycin or metronidazole found no difference in risk of recurrence between the groups; but in cases of severe CDI, the risk of 30-day mortality was significantly lower among those who received vancomycin.[56] The IDSA–SHEA guidelines recommend treating recurrences aggressively with one of three options: a prolonged "taper and pulse" course of vancomycin; a 10-day course of fidaxomicin; or, if metronidazole was used initially, a 10-day course of vancomycin.[59]

NURSING IMPLICATIONS

Given the profound effects that HAIs can have on patient outcomes and health care costs, it's clear that infection prevention and control measures are paramount. Good antibiotic stewardship has been associated with decreased incidences of and colonization by many MDROs, including gram-negative bacteria and MRSA, as well as a lower incidence of CDI,[61] and should be routine practice in every setting. Nurses in clinical practice can contribute to HAI prevention and control in the following ways.

- *Promote good antibiotic stewardship*. Encourage daily medical team review of the need for any antibiotics the patient is receiving and discuss the potential for deescalation to the most narrow-spectrum agent that would be effective.
- *Practice and preach good hygiene and contact precautions*. Wash hands before and after each patient or environmental contact. Maintain strict contact precautions for those patients who are infected or colonized with MDROs or *C. difficile*. Keep long hair contained. Adhere to the evidence-based

practice recommendations described above, and continue learning about infection prevention.

- *Promote a clean patient environment*. Encourage leadership to consider the use of adjunctive environmental cleaning methods such as ultraviolet light.
- *Recognize and report early symptoms* of infection to the medical team.
- *Support the patient's nutritional status* with enteral nutrition as soon as feasible.

Improving patient outcomes and decreasing infection rates require a multidisciplinary approach with strong leadership support, impeccable nursing assessment and care, and adherence to evidence-based guidelines for medical treatment. ▼

For 56 additional continuing nursing education activities on the topic of preventing hospital-acquired infections, go to www.nursingcenter.com/ce.

Douglas Houghton is the director of Advanced Practice Providers at Jackson Memorial Hospital, Miami, FL. Contact author: dhoughton@jhsmiami.org. *The author and planners have disclosed no potential conflicts of interest, financial or otherwise.*

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