Chapter 42. Targeting Health Care-Associated Infections: Evidence-Based Strategies

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Background

Hospitalization for an acute illness, trauma, chronic care, or other health care conditions is a common occurrence. There were 39.2 million hospital discharges in 2005, with an average length of stay of 4.6 days.[1] Hospitalization brings associated risks, including risk of infection. Nosocomial infections, or hospital-associated infections, are estimated to occur in 5 percent of all acute care hospitalizations, or 2 million cases per year.[2] Hospital-associated infections have been identified as one of the most serious patient safety issues in health care.[3]

Infections that become clinically evident after 48 hours of hospitalization are considered hospital-associated.[2] Risks factors for hospital-associated infections are generally categorized into three areas: iatrogenic, organizational, or patient-related. Iatrogenic risk factors include invasive procedures (e.g., intubation, indwelling vascular lines, urine catheterization) and antibiotic use and prophylaxis. Organizational risk factors include such things as contaminated air-conditioning systems, contaminated water systems, staffing (e.g., nurse-to-patient ratio), and physical layout of the facility (e.g., open beds close together). Examples of patient-related risk factors include severity of illness, immunosuppression, and length of stay.[2]

Nosocomial infections more than double the mortality and morbidity risk for hospitalized patients, resulting in an estimated 20,000 deaths a year.[2] Nosocomial infections increase the costs of hospitalization in addition to increasing morbidity and mortality risk. A meta-analysis of 55 studies examining nosocomial infections and infection control interventions determined that attributable costs are significant; costs associated with bloodstream infections (mean = $38,703) and methicillin-resistant *Staphylococcus aureus* infections (mean = $35,367) are the largest.[3]

Most infections in hospitalized patients are endogenous, meaning they are caused by bacteria that have already colonized the patient's digestive tract prior to infection.[4] The majority (60 percent) of infections in patients hospitalized in an intensive care unit (ICU) setting are caused by bacteria already colonizing the patient on admission (primary endogenous). A lesser amount (23 percent) of infections result from bacteria acquired during the ICU stay, leading to colonization before infection (secondary endogenous). A total of seventeen percent of infections are caused by bacteria introduced from the ICU environment that lead to infection without prior colonization (exogenous). Targeting hospital-associated infections is, therefore, a very important aspect of providing quality health care.

This chapter reviews the evidence-based knowledge on health care-associated infections, highlighting important information for nurses caring for hospitalized patients. The review focuses on hospital-associated pneumonia, urinary tract infection, catheter-related bloodstream infection, sepsis, and antibiotic-resistant infection. An evaluation of the literature, including recent research, and evidence-based practices are presented.

Hospital-Associated Pneumonia

Pneumonia is the second most common hospital-associated infection (after urinary tract infection).[5] In critically ill patients, ventilator-associated pneumonia (VAP) is the most common nosocomial infection. VAP doubles the risk of death, significantly increases ICU length of stay, and adds more than $10,000 to each affected patient's hospital costs.[6]

The current evidence-based recommendations by the Centers for Disease Control and Prevention (CDC) for prevention of nosocomial pneumonia were published in 2004.[5] Although some of the interventions to reduce nosocomial pneumonia are the responsibility of physicians or other health care workers, many of the interventions are the direct responsibility of nurses or can be influenced by nurses. Nursing care can directly contribute to prevention of hospital-associated pneumonia, particularly in patients who are most at risk due to advanced age, postoperative status, or mechanical ventilation. The evidence shows that the most important contributions of nursing care to prevention of hospital-associated pneumonia are in four areas: hand hygiene, respiratory care, patient positioning, and education of staff.

Hand Hygiene

Hand hygiene is an essential component of hospital-associated pneumonia reduction. Evidence-based guidelines have been published for general hand hygiene[7, 8] as well as specific hand hygiene measures related to respiratory care.[6]

Excellent evidence exists that alcohol hand rubs effectively reduce the transmission of potential pathogens from health care workers' hands to patients. For hands that are not visibly soiled, alcohol hand rubs are more effective than hand washing with plain or antimicrobial soap.[8, 9] In the health care setting, the preferred method for cleaning visibly soiled hands is washing with water and antimicrobial soap. Gloves should be worn for handling respiratory secretions or any objects contaminated with respiratory secretions.[5] If soiling from respiratory secretions is anticipated, a gown should also be worn. Hand decontamination and glove changes are required between contacts with different patients, as well as in an encounter with a single patient between contacts with a contaminated body site and the respiratory tract or respiratory equipment.

Respiratory Care

Encouraging patients to do deep-breathing exercises is a common component of nursing care to reduce respiratory complications, particularly in postoperative patients. Most research supports this practice, although some controversy remains regarding the effectiveness of deep-breathing exercises versus incentive spirometry in particular patient populations. Thomas and McIntosh[10] conducted a meta-analysis of literature from 1966 through 1992 that focused on the effects of deep-breathing exercises, incentive spirometry, and intermittent positive pressure breathing on pulmonary complications after upper abdominal surgery. They concluded that both deep-breathing and incentive spirometry were more effective than no treatment, but there was no significant difference between any of the three treatments. More recently, a systematic review of postoperative incentive spirometry studies from 1966 through 2000 concluded that there was not enough evidence to support the use of incentive spirometry to reduce postoperative respiratory complications.[11]

Chumillas and colleagues[12] randomized subjects who had upper abdominal surgery to a breathing exercise program or to no breathing exercise. Postoperative pulmonary complications were reduced in the deep-breathing group (7.5 percent versus 19.5 percent in the control group), and the deep-breathing group had fewer postoperative chest radiograph abnormalities ($P = 0.01$). In a study of 456 abdominal surgery patients, Hall and colleagues[13] found that deep-breathing exercises for low-risk patients, and incentive spirometry plus physiotherapy for high-risk patients, was as effective for prevention of postoperative pulmonary complications as incentive spirometry.

Deep breathing also appears to be effective after coronary artery bypass graft (CABG) surgery. Westerdahl and colleagues[14] randomly assigned subjects for the first 4 postoperative days to hourly deep-breathing exercises during the daytime (n = 48) or to no breathing exercises (n = 42). Compared to the control group, the deep-breathing group had smaller atelectasis on spiral CT scan ($P = 0.045$ at the basal level and $P = 0.01$ at the apical level) and significantly smaller postoperative reduction in lung function (forced vital capacity [FVC], $P = 0.01$; forced expiratory volume [FEV1], $P = 0.01$). In contrast, a randomized study of 56 abdominal surgery patients at high risk for postoperative pulmonary complications demonstrated beneficial results of early postoperative mobilization; however, the study produced no statistically significant difference in outcomes when deep breathing and coughing interventions were added to the early mobilization.[15] Based on current evidence, CDC guidelines encourage deep breathing for all postoperative patients and use of incentive spirometry on postoperative patients who are at high risk for pneumonia.[5]

The earliest CDC guidelines addressing nosocomial pneumonia, published in 1981, placed great emphasis on standardization of practices related to care of respiratory equipment, and this area has been a continued focus in subsequent reports. Recommendations related to procedures for cleaning, sterilizing or disinfecting, and maintaining respiratory equipment now have a strong evidence base, and those recommended procedures are presented in detail in the current CDC report.[5] Compliance with those procedures is primarily the responsibility of respiratory therapy, but it requires the cooperation and support of nurses. Many unresolved issues remain regarding optimal procedures for respiratory tract secretion suctioning, including whether sterile or clean gloves should be used when performing endotracheal suctioning, and whether multiuse closed-system suction catheters or single-use open-system suction catheters are more effective in prevention of pneumonia.

Patient Positioning

Elevation of the head of the bed is believed to reduce the risk of gastroesophageal reflux and aspiration of gastric secretions, and thus to reduce risk of hospital-associated pneumonia. Supine position is an independent risk factor for mortality in mechanically ventilated patients[16, 17] and in all ICU patients.[18] Torres and coworkers[19] conducted a randomized crossover study of the effect of semirecumbent versus supine position in 19 critically ill mechanically ventilated adults. After radiolabeling gastric contents, the researchers found higher radioactive counts in endobronchial aspirates when subjects were in a supine position than when in a semirecumbent position ($P = 0.036$). In a similar design, Orozco-Levi and coworkers[20] introduced radio label through nasogastric tubes in 15 mechanically ventilated subjects and obtained radioactive counts in pharyngeal and endobronchial secretions over a 5-hour period in supine and semirecumbent positions. Bronchial radioactive counts were higher at 5 hours in a supine position compared with baseline ($P < 0.05$) and semirecumbency ($P < 0.01$); importantly, significant reflux occurred by 5 hours even with semirecumbent positioning. These studies support a relationship between head-of-bed position and aspiration of gastric secretions.

Two clinical trials have examined the effect of head-of-bed position on VAP. Prior to the publication of the 2004 CDC guidelines, Drakulovic and coworkers[21] conducted a randomized clinical trial assigning 86 mechanically ventilated ICU subjects to semirecumbent (45 degree) or supine (0 degrees) positions, with position documented once daily. The trial was stopped early because significant findings at an interim analysis showed that the semirecumbent group had lower frequency of clinically suspected pneumonia ($P = 0.003$) and microbiologically confirmed pneumonia ($P = 0.018$) than the supine group. Both supine body position ($P = 0.006$) and enteral nutrition ($P = 0.013$) were identified as independent risk factors for nosocomial pneumonia. A second, larger multicenter trial by van Nieuwenhoven and colleagues[22] was published in 2006. Mechanically ventilated ICU patients were prospectively randomly assigned to a semirecumbent position (45 degrees, n = 109) or standard care (10 degrees, n = 112). Because backrest elevation was continuously electronically monitored during the first week of mechanical ventilation, the researchers were able to document that subjects assigned to 45-degree elevation achieved the target position only 15 percent of the study time, despite intensive efforts to ensure provider compliance. Average elevations (28 degrees in the group assigned to 45-degree elevation, and 10 degrees in the standard-care group) were significantly different between groups ($P < 0.001$), but differences in VAP were not demonstrated.

These two clinical trials of the effect of head-of-bed elevation on VAP differed in several ways that may have affected study outcomes. Important differences existed in the comparison groups, with Draculovic and colleagues assigning subjects to 0 degree elevation, while the subjects assigned to usual care in the van Nieuwenhoven study had an average elevation of 10 degrees. The nosocomial pneumonia rate in the van Nieuwenhoven standard-care group was 6.5 percent, much lower than the 23 percent reported for the Draculovic control group (23 percent). While current evidence and practice guidelines support the elevation of the head of bed to reduce pneumonia risk, additional research is needed to further determine the optimal level for head-of-bed elevation.

Grap and colleagues[23] examined the relationship of backrest elevation to VAP in a descriptive study of 66 subjects over a total of 276 patient days. Backrest elevation was continuously monitored. Mean backrest elevation for the entire study period was 21.7 degrees, but backrest elevations were less than 30 degrees 72 percent of the time, and less than 10 degrees 39 percent of the time. In a statistical model predicting pneumonia risk on study day 4, 81 percent of the variability ($F = 7.31$, $P = 0.003$) was accounted for by the pneumonia score on study day 1, severity of illness, and percentage of time spent at less than 30 degrees in the first 24 hours. Thus, early initiation of elevated backrest may influence outcomes in patients who are at highest risk.

Elevation of the head of the bed for patients at risk is a simple and inexpensive intervention that has the potential to decrease nosocomial pneumonia. Adverse effects of elevating the head of the bed have not been demonstrated in patients who do not have a medical contraindication. However, most evidence suggests that this intervention is not widely used. The effectiveness of turning or lateral rotation remains an unresolved issue. Additional research is needed to identify optimal or sufficient head-of-bed elevation to prevent nosocomial pneumonia, to determine the effects of turning, and to address barriers to implementation of optimal patient positioning.

The Institute for Healthcare Improvement (IHI) outlines a ventilator bundle, or care strategies, to target VAP. A "bundle" is a group of interventions that when implemented together, produce better outcomes than when implemented individually.[24] The ventilator bundle incorporates evidence-based interventions aimed at reducing VAP incidence, including head-of-bed elevation greater than 20 degrees, assessment of the need for continued mechanical ventilation, and prophylaxis for stress ulcer disease and deep vein thrombosis.[25]

Additional VAP Prevention Measures

Additional measures for VAP prevention include preventing orophyarngeal colonization through oral care and effective endotracheal tube maintenance. Guidelines for VAP prevention recommend maintaining endotracheal tube cuff pressures above 20 cm H20 to ensure minimal leakage.[26] Continuous aspiration of subglottic secretions has also been advocated for preventing microaspiration. A meta-analysis assessing the impact of continuous aspiration of subglottic secretions in five randomized clinical trials found a 50-percent reduction in VAP and a delayed onset in the development of VAP by 6.8 days,[27] yet further research on the use and cost-effectiveness is needed.

Implementation of oral care protocols can be an effective mechanism to target removal of dental plaque and minimize colonization and aspiration of biofilm. Several studies have demonstrated benefits of tooth brushing and oral suctioning.[28–31] Research assessing the impact of chlorhexidine gluconate (CHG) for oral care hygiene has demonstrated beneficial impact with tooth brushing,[31, 32] however additional research is indicated.[33]

Staff Education and Compliance

The CDC urges education of staff and involvement of health care workers at all levels in implementing interventions to prevent hospital-associated pneumonia, and nurses are an essential component of these preventive efforts. The potential for compliance programs to positively affect nosocomial infections was demonstrated by Won and colleagues[34] in their study of hand hygiene. Following an intensive hand hygiene compliance program in a neonatal ICU, which increased hand hygiene compliance from 43 percent to 80 percent, a significant decrease in all nosocomial infections ($P = 0.003$) was documented. The effect was even more apparent for nosocomial respiratory infection ($P = 0.002$), with a significant correlation between hand washing compliance and nosocomial respiratory infections ($r = –0.385$; $P = 0.014$).

Education aimed at reducing the occurrence of VAP using a self-study module on risk factors and practice modifications demonstrated beneficial results in another study.[35] The education program, directed toward respiratory care practitioners and ICU nurses, was developed by a multidisciplinary task force. Fact sheets and posters reinforcing the study module information were distributed in an urban teaching hospital. Following implementation of the education intervention, the rate of VAP decreased from 12.6 per 1,000 ventilator days to 5.7 per 1,000 ventilator days, a decrease of 57.6 percent ($P < 0.001$).

In addition to promoting best practices for the care of ventilator patients, nurses should advocate for physician practices that reduce the risk of hospital-associated pneumonia. The use of noninvasive modalities whenever possible (for example, positive pressure ventilation by face mask to reduce endotracheal intubation) and removal of invasive devises when they are no longer necessary are important considerations. The IHI bundle focuses on daily assessment of the need for mechanical ventilation as one mechanism for removing invasive devices when indicated. Nurses can also help to educate all hospital personnel about procedures to prevent pneumonia that are appropriate to the worker's level of responsibility. Table 1 outlines evidence-based guidelines for hospital-associated pneumonia prevention and management, including nursing-based care.

Urinary Tract Infections

The use of indwelling urinary catheters is common in the hospital setting. Urinary tract infection (UTI) is the most common hospital-associated infection, and a major associated cause is indwelling urinary catheters.[36] UTIs account for about 40 percent of hospital-associated infections, and an estimated 80 percent are associated with urinary catheters.[37] Almost 1 million episodes of nosocomial UTI occur each year in the United States,[38] and the most important risk factor is the presence of an indwelling urinary catheter.[39] Biofilm formation by uropathogens on the urinary catheter have been implicated as the underlying cause of catheter-associated UTI.[40] Adverse consequences of a catheter-associated UTI include local and systemic morbidity, secondary bloodstream infection, increased costs, and mortality.[41] In the hospital setting, the ICU has the highest prevalence of nosocomial UTIs with an estimated rate of 8–21 percent.[39] Guidelines for the prevention of catheter-associated UTIs issued by the CDC outline several recommendations, including appropriate use of indwelling catheters, education of personnel on proper catheter insertion using aseptic technique and sterile equipment, and maintenance to ensure closed sterile drainage (see Table 2).[42]

Due to increased risk of infection associated with urinary catheters, a number of practices have been evaluated in an attempt to reduce the incidence of urinary catheter-related infections.[38] These include alternative approaches to use of urinary catheters and antimicrobial urinary catheters.

Alternative Approaches to Urinary Catheterization

A Cochrane systematic review has investigated the advantages and disadvantages of alternative approaches to indwelling catheters for short-term bladder drainage in adults.[37] Of 17 randomized clinical trials, 14 compared indwelling urethral catheterization with suprapubic catheterization, and 3 trials compared indwelling urethral catheterization with intermittent catheterization. Patients managed with an indwelling urinary catheter had higher incidences of bacteriuria (relative risk [RR] = 2.60, 95% confidence interval [CI] = 2.12–3.18), more frequent recatheterizations (RR = 4.12, 95% CI = 2.94–7.56), and more reports of patient discomfort (RR = 2.98, 95% CI = 2.31–3.85). Of the trials assessing indwelling urethral catheters with intermittent catheterization, fewer cases of bacteriuria were found in patients receiving intermittent catheterization (RR = 2.90, 95% CI = 1.44–5.84). The results of the systematic review indicate that suprapubic catheters have advantages over indwelling urinary catheters in terms of incidence of bacteriuria, recatheterization, and patient reports of discomfort. Intermittent catheterization was also associated with a lower risk of bacteriuria compared to indwelling urinary catheters, but supported with limited evidence. However, suprapubic catheterization typically involves percutaneous placement of a urinary catheter directly into the bladder, a technique that is considered minor surgery;[38] therefore, the practical application of this alternative measure is questionable. A previous review of studies assessing the efficacy of suprapubic catheters with standard noncoated catheters also substantiated lower rates of bacteriuria for suprapubic catheters, but highlighted that mechanical complications—including catheter dislodgement, obstruction, and failed introduction—can occur. The review could not substantiate the overall benefit of routine suprapubic catheterization.[38]

Antimicrobial Catheters

A variety of specialized urethral catheters have been designed to reduce the risk of catheter-associated UTI. These include antiseptic-impregnated catheters and catheters coated with silver alloy or nitrofurazone.[36, 41] A Cochrane systematic review has examined 18 clinical trials to assess the different types of urethral catheters for the management of short-term catheter use in hospitalized patients.[36] Silver oxide catheters were not associated with a statistically significant reduction in bacteriuria, but the confidence intervals were wide (RR = 0.89, 95 percent CI = 0.68–1.15). Silver alloy catheters were found to significantly reduce the incidence of bacteriuria (RR = 0.36, 95 percent CI = 0.24–0.52). The results of the review indicated advantages from silver alloy catheters, including an economic benefit compared to standard catheter use. A previous review of four clinical trials studies assessing silver alloy catheters also substantiated a significant reduction in the development of catheter-associated bacteriuria.[38]

Another systematic review of antimicrobial urinary catheters in the prevention of catheter-associated UTI in hospitalized patients analyzed 12 clinical trials of nitrofurazone-coated or silver alloy-coated urinary catheters. Both nitrofurazone-coated and silver alloy-coated catheters reduced the development of bacteriuria in comparison with latex or silicone control catheters.[41] However data on comparative efficacy is lacking as no trial directly compared nitrofurazone-coated and silver alloy-coated catheters. While evidence exists to support the use of antimicrobial urinary catheters in preventing bacteriuria in hospitalized patients during short-term catheterization, estimates on cost-effectiveness have not been established.[41] Additional strategies for preventing catheter-associated UTI—including hand-held bladder scanners, computerized order/entry system prompts, and education on appropriate use of indwelling urinary catheter—have also proved beneficial.[43]

Table 2 outlines evidence-based strategies for UTI prevention. Nursing-related care aspects include thorough assessment to determine need for indwelling catheter use, aseptic insertion technique, indwelling catheter care to minimize infection risk, and astute monitoring of patients with urinary catheters for signs of UTI. All of these are important measures to decrease the risk of catheter-associated UTI.

Catheter-Related Bloodstream Infection

Central venous catheters (CVCs) are frequently used in hospitalized patients and they carry associated risks, the most common being bloodstream infection (BSI). According to the CDC, up to 250,000 hospital-associated catheter-related bloodstream infections (CR-BSIs) occur annually in U.S. hospitals, with approximately 80,000 of these occurring in ICUs.[44] CVCs of all types are the most frequent cause of nosocomial BSIs.[45]

A CR-BSI is defined as the presence of bacteremia in a patient with an intravascular catheter with at least one positive blood culture and clinical signs of infections (i.e., fever, chills, and/or hypotension), with no apparent source for the BSI except the catheter. Specific criteria for CR-BSI include either a positive culture with the same organism isolated from the catheter and peripheral blood, simultaneous blood cultures with a $\geq$ 5:1 ratio of catheter versus peripheral culture, or a differential period of catheter culture versus peripheral blood culture positivity of >

2 hours.[46] A BSI is considered to be associated with a central line if the line was in place during the 48-hour period before development of the BSI.[46] Although CVSs account for only a small percentage of all intravenous lines, they cause most CR-BSIs.[47] The most common mechanism of CVC-BSI is migration of the organism from the insertion site along the surface of the catheter and colonization of its distal part.[48] CR-BSIs can also occur from contamination of the catheter hub or infusate administered through the device.[45]

Several practices have been evaluated in an attempt to reduce the incidence of CVC-BSI. These include the use of antimicrobial catheters, antimicrobial-impregnated dressings, and interventions related to catheter insertion and maintenance.

Antimicrobial Catheters and Dressings

Catheters impregnated or coated with antimicrobials or antiseptics have been shown to decrease the risk of CVC-BSI. Multiple randomized controlled trials and several meta-analyses have demonstrated that catheters coated on the external surface with chlorhexidine/silver sulfadiazine or minocycline/rifampin reduce the risk for CVC-BSI compared with standard noncoated catheters.[49–52] Chlorhexidine-impregnated dressings have also been found to reduce the rate of CVC colonization.[48] While evidence for the efficacy of CVC catheters coated with antibacterial or antiseptic agents exists, limited information exists related to their cost-effectiveness. Current CDC recommendations include use of CVC catheters coated with antibacterial or antiseptic agents for high-risk patients or situations in which CR-BSI rates are high despite careful attention to guidelines.[52]

Catheter Insertion and Maintenance Interventions To Reduce CVC-BSI

CVC-BSIs often result from contamination of the catheter during insertion.[52] Maximum sterile barrier precautions during insertion are indicated to reduce the incidence of CVC-BSI. Effective barrier precautions include the use of sterile gloves, long-sleeved gowns, full-size drape, masks, and head covers by all personnel involved in the central line insertion procedure.[52]

In addition to maximal barrier precautions during insertions, the 2002 CDC guidelines for the prevention of CVC infections outline other evidence-based practices, including the following:[53]

1. Use of a 2-percent chlorhexidine preparation as the preferred skin antiseptic prior to insertion
2. Education and training of staff who insert and maintain intravenous lines
3. No routine replacement of central lines at scheduled intervals

Additional measures advocated for best practices for CVC care include hand hygiene by washing hands with conventional antiseptic-containing soap and water or with waterless alcohol-based gels or foam before and after palpating insertion sites; and before and after insertion, replacing, accessing, or dressing a CVC.[53] Avoidance of antibiotic ointment at insertion sites, which can promote fungal infections and antibiotic resistance, and restricted use of stopcocks on any tubing other than pressure tubing to minimize contamination are also recommended.[53] Either sterile gauze or transparent, semipermeable dressings can be used, as research has demonstrated similar risks of CVC-BSI.[53] Gauze dressings should be replaced every 2 days and transparent dressings every 7 days or when the dressing becomes damp, loose, or soiled.[53, 54]

The IHI has also published a central line bundle to reduce CVC-BSI.[55] The components of the central line bundle include hand hygiene to prevent contamination of central lines, maximal barrier precautions and CHG antisepsis for central line insertion, optimal catheter site selection with the subclavian vein as the preferred site for nontunneled catheters, and daily review of line necessity with removal of unnecessary lines.[55]

Educational measures related to CVC insertion and maintenance have proven effective in several studies.[56–58] Focused aspects of education included proper insertion and maintenance, a catheter insertion cart, a checklist to ensure adherence to evidence-based guidelines, and empowering nurses to stop the catheter insertion procedure if a violation of guidelines is observed. Table 3 outlines evidence-based strategies for CVC-BSI prevention. Nursing-related care aspects include maximal barrier precaustings during CVC insertion; maintenance of central line site to minimize infection risk; prevention of contamination of CVC ports during blood sampling, infusion of intravenous fluids, or medication administration; maintenance of sterile technique for dressing changes; intravenous tubing changes based on protocol guidelines; and astute monitoring of patients with central lines for signs of infection.

Sepsis

Sepsis, or clinical manifestation of the systemic response to infection, represents a significant condition that results in increased mortality for hospitalized patients. The incidence of sepsis is increasing, with more than 750,000 cases occurring in the United States each year.[59] Severe sepsis, which occurs when sepsis progresses to involve acute organ dysfunction, results in more than 200,000 annual fatalities, and the number of cases are projected to increase.[59] Epidemiological studies indicate that between 11 percent and 27 percent of ICU admissions have severe sepsis, with mortality rates ranging from 20 percent to more than 50 percent.[59–62] As infections can progress to sepsis, heightened monitoring of hospitalized patients for signs of sepsis are indicated for any patient with a suspected or confirmed infection. Focal areas pertinent to sepsis include monitoring, treatment, and prevention.

Monitoring for Sepsis Risk

Many risk factors exist for the development and progression of sepsis, including advanced age, compromised immune system response, chronic illness, broad spectrum antibiotic use, and exposure to infection risk associated with surgical and invasive procedures.[63] The severity of sepsis varies widely. Some patients experience a controlled inflammatory response to systemic infection.[64] However, the majority of patients with sepsis develop organ dysfunction (severe sepsis) with hypotension and a resultant state of decreased tissue perfusion. In addition to inflammation, severe sepsis is associated with activation of coagulation and impairment of fibrinolysis, which further impairs perfusion. The development of organ system failure can occur in the initial stages of severe sepsis, but the duration and progression of organ failure are influential in predicting survival.[65] Septic shock is the most severe form of sepsis: hypotension is resistive to fluid resuscitation, a condition which is often associated with high mortality rates.[64] Identified risk factors for increased mortality in sepsis include the microbiological etiology of sepsis; the site of the infection, with increased mortality associated with intra-abdominal or lower respiratory tract infections; presence of underlying disease; presence of shock; need for vasopressors; multiple organ failure; and neutropenia.[66] Many factors contribute to multiple organ dysfunction syndrome in sepsis, including inadequate tissue/organ perfusion, cellular injury, ischemia, and diffuse endothelial cell injury.[63] The progression of sepsis can be deterred by early recognition and treatment, including early goal-directed therapy focusing on establishing adequate perfusion and targeted measures for sepsis treatment.[24, 67]

Treatment of Sepsis

The Surviving Sepsis Campaign evidence-based guidelines for the treatment of sepsis were released in 2004 and have been promoted to improve outcomes for patients with severe sepsis.[24, 68] The guidelines outline recommendations for targeting treatment of patients at risk of developing severe sepsis and septic shock. The guideline recommendations are aimed at providing resuscitation for sepsis-induced hypoperfusion and enhancing perfusion, antibiotic administration to combat infection, cultures to identify the source of infection, mechanical ventilation to optimize oxygenation, and source control to contain the infection. Additional treatment practices include glycemic control, steroid administration for adrenal insufficiency, prophylaxis measures for deep vein thrombosis and stress ulcer prevention, renal replacement therapies, administration of recombinant human activated protein C (rhAPC), blood product administration, sedation and analgesia, and consideration for limitation of support in critically ill patients.[68] These evidence-based guidelines are outlined in Table 4.

Bundles are also established for recognition and treatment of severe sepsis. The severe sepsis bundles are categorized into 6- and 24-hour bundles. The 6-hour bundle outlines the following interventions, which should be implemented immediately and within the first 6 hours of identification of severe sepsis:

1. Measure serum lactate.
2. Obtain blood cultures prior to antibiotics.
3. Administer broad-spectrum antibiotics within 3 hours from time of presentation in the emergency room and 1 hour for nonemergency room ICU admissions.
4. For hypotension and/or lactate > 4 mmol/L,
   a. Administer an initial minimum of 20 ml/kg of crystalloid (or colloid equivalent).
   b. Administer vasopressor for hypotension not responding to initial fluid resuscitation to maintain mean arterial pressure $\geq$ 65 mm Hg.
5. With persistent hypotension despite fluid resuscitation and/or lactate > 4 mmol/L,
   a. Achieve a central venous pressure (CVP) $\geq$ 8 mm Hg.
   b. Achieve a central venous oxygen saturation ($S_{CV}O_2$) of $\geq$ 70 percent.

The 24-hour bundle outlines the following interventions, which should be implemented immediately and within the first 24 hours of identification of severe sepsis:

1. Administer low-dose steroids for septic shock based on a standardized ICU policy.
2. Administer drotrecogin alfa (activated) based on a standardized ICU policy.
3. Maintain glucose control $\geq$ lower limit of normal, but < 150 mg/dL.
4. Maintain inspiratory plateau pressures < 30 mm H_20 for mechanically ventilated patients.

Implementation of the Surviving Sepsis Campaign guidelines, including the sepsis bundles, can favorably influence the course of sepsis. Additional focused approaches to the management of sepsis include early rapid-resuscitation shock protocols,[69] comprehensive interdisciplinary sepsis treatment protocols,[70] and algorithm-based or goal-directed care.[71]

Prevention of Sepsis

Nursing-related implications for early detection and treatment of sepsis include assessing patients for signs of infection, obtaining cultures for suspected infection, providing medical treatments for sepsis, and infection-prevention measures.[72] Awareness of the risk factors, clinical signs and symptoms, pathophysiology, and updates in the management of sepsis can enhance the nursing care for patients with severe sepsis and promote best practices for sepsis care in the ICU. Infection-prevention measures for sepsis include general infection control practices, hand-washing principles, and measures to prevent nosocomial infections (oral care and proper positioning to prevent nosocomial pneumonia, care of invasive catheters, skin care, wound care, identifying patients at risk for infection, prioritizing cultures for patients with suspected infection, and providing astute clinical assessment for early detection of sepsis).[73] Table 5 outlines general infection-prevention measures, highlighting nursing care considerations. A Cochrane systematic review is currently underway to assess the impact of the use of preoperative bathing or showering with skin antiseptics in reducing surgical-site infections.[74] Keeping up to date with evidence-based and research practices aimed at preventing health care-associated infections is an additional essential aspect of nursing care.

Antibiotic-Resistant Infections

Both the CDC and the World Health Organization have identified antibiotic resistance as an important public health concern.[75] The emergence of antimicrobial resistance in hospitals has been attributed to antibiotic use patterns as well as the capability of bacterial strains to develop resistance mechanisms through genetic alterations.[76] It is estimated that up to 50 percent of antibiotic use in hospitals is inappropriate.[77] According to the CDC, more than 70 percent of the bacteria that cause hospital-associated infections are resistant to at least one of the drugs most commonly used to treat them.[78]

When compared to infections caused by susceptible bacteria, infections caused by multidrug-resistant bacteria are associated with higher incidences of mortality, morbidity, and increased hospital length of stay.[77] Hospitalized patients who contract an infection with an antibiotic-resistant organism also have more costly management and therapies, and encounter more medical complications, than patients who do not acquire an infection or become infected with sensitive organisms.[79–80]

Data from many sources, including the CDC, indicate that antibiotic resistance to all the commonly used drug classes is increasing.[79] For example, between 1998 and 2003, the following increases in resistant organisms have occurred in critically ill patients: 11 percent increase in methicillin-resistant *Staphylococcus aureus* (MRSA); 12 percent increase in vancomycin-resistant *enterococci* (VRE); 47 percent increase in 3rd generation cephalosporin-resistant *Kliebsiella pneumoniae*; and a 20 percent increase in 3rd generation cephalosporin-resistant *Pseudomonas aeruginosa*.[81] An additional nosocomial infection that has been linked to antibiotic use in the hospital setting is *Clostridium difficile* (*C. difficile*). Although *C. difficile* is not an antibiotic-resistant infection, increased incidences in hospitalized settings have heightened awarenes.[82]

Because of the widespread increases in resistant organisms with the concomitant difficulties associated with treatment and complications, addressing the issue of resistant organisms has become one of the CDC's major concerns. Several main areas of focus for the prevention of antibiotic-resistant infections include control of antibiotic use, determining the right antibiotic, and control of patient-to-patient spread.

Control of Antibiotic Use

Antibiotics are effective in treating infections because they kill or inhibit the growth of susceptible bacteria; however, they are not effective against viral infections. In an ever-increasing number of instances, one of more of the bacteria causing the infection are able to survive. Those bacteria are then able to multiply and begin to proliferate a new strain of bacteria that have developed the inherent ability to survive in the presence of the antibiotics that are designed to eradicate them. The more exposure bacteria have to various antibiotics, the more likely it is that resistant organisms develop.

According to the CDC, the biggest contribution to the development and continuing increase in resistant organisms is the overuse of antibiotics. Therefore, decreasing inappropriate antibiotic administration is the best way to control resistance. In 1995, the CDC[83] launched a national campaign to reduce antimicrobial resistance. The two major goals of this campaign are (1) to reduce inappropriate antibiotic use, and (2) to reduce the spread of resistance to antibiotics. Following are the three major CDC recommendations for supporting and achieving these goals:

- Prescribe antibiotic therapy only when it is likely to be beneficial.
- Use an agent that targets the likely pathogens.
- Order the antibiotic for the appropriate dose and duration.

Determining the Right Antibiotic

To effectively reduce antimicrobial resistance, prescribing health care providers must keep themselves informed about the most common infectious organisms present in the patient populations that they treat. For example, both VAP and hospital-associated pneumonia due to MRSA are becoming more common, and treatment strategies have emerged. Data compiled by an expert panel of the American Thoracic Society[26] support the following recommendations:

1. Apply early, appropriate, broad-spectrum antibiotic therapy at adequate doses; avoid excessive antibiotics through appropriate antibiotic deescalation.
2. Empiric regimens should include agents from a different antibiotic class than the patient has recently received.
3. Combination therapy should be used judiciously.
4. Linezolid may be an appropriate alternative to vancomycin.
5. Shorten antibiotic duration to the minimum effective period, and use short-course therapy whenever possible.
6. Use local microbiologic data to adapt treatment recommendations to the clinical setting.

Research has demonstrated the benefit of focused interventions aimed at improving antibiotic prescribing practices for hospital patients. A Cochrane systematic review of 66 studies revealed that interventions to improve antibiotic prescribing, dosing, timing of first dose, and duration of treatment are successful in reducing antimicrobial resistance.[77] Specific interventions included distribution of educational materials; reminders provided verbally, on paper, or by computer; formulary restrictions; therapeutic substitutions; automatic stop orders; antibiotic policy change strategies, including cycling, rotation, and crossover studies; computerized order entry; and Web-based antimicrobial approval systems.[77, 84] Other strategies, such as selective decontamination of the digestive tract and use of CHG for daily bathing of hospitalized patients, have demonstrated efficacy in single-site controlled trials, but require further study.[4, 85]

Control Patient-to-Patient Spread

Controlling the patient-to-patient spread of bacteria is one of the least expensive, most basic, and effective means for controlling the spread of resistant organisms. Both MRSA and VRE, two of the most troublesome resistant organisms, are spread primarily from person-to-person contact. In hospitalized patients, this includes transmission by the hands of a health care provider caring for an infected patient. Diligent hand washing is therefore of the utmost importance, and nurses can have a major influence. Both MRSA and VRE can also survive on equipment and surfaces, such as floors, sinks, and blood pressure cuffs.

Specific CDC recommendations to prevent the spread of antimicrobial-resistant infections in hospitalized patients are outlined in Table 6. Focused measures include monitoring antimicrobial resistance of both community and nosocomial isolates on a regular basis, monitoring use of antimicrobials, increasing clinical staff awareness, and use of the CDC's guidelines for isolation precautions in hospitals.[76, 78] Preventative nursing care measures are essential in minimizing infection risk for hospitalized patients. Table 5 outlines additional essentials of infection-prevention measures for reducing the risk of health care associated infection among hospitalized patients.

Evidence-Based Practice Implications

Implementation of evidence-based practices, such as those that follow, can have a significant impact on lowering the incidence of health care-associated infections:

- Preventing health care-associated infections is an important component of ensuring a safe health care environment for hospitalized patients.
- Hand hygiene is an essential aspect of hospital-associated infection-reduction strategies.
- Nursing care measures can directly contribute to prevention of central line infections, urinary tract infections, sepsis, and antibiotic-resistant infections.
- Nursing care can directly contribute to prevention of hospital-associated pneumonia, particularly in patients who are most at risk related to advanced age, postoperative status, or mechanical ventilation. The evidence shows that the most important contributions of nursing care to prevention of hospital-associated pneumonia are in four areas: hand hygiene, respiratory care, patient positioning, and education of staff.
- Nursing-related care aimed at preventing urinary tract infections includes thorough assessment to determine need for indwelling catheter use, aseptic insertion technique, indwelling catheter care to minimize infection risk, and astute monitoring of patients with urinary catheters for signs of infection.
- Nursing-related measures to reduce the incidence of central line-associated infections include ensuring maximal barrier precautions during line insertion, maintenance of the central line site to minimize infection risk, prevention of contamination of central line ports during blood sampling, and maintenance of sterile techniques for dressing changes.

- Infection-prevention measures for sepsis include general infection control practices, hand-washing principles, and measures to prevent nosocomial infections (oral care and proper positioning to prevent nosocomial pneumonia, care of invasive catheters, skin care, wound care, identifying patients at risk for infection, prioritizing cultures for patients with suspected infection, and providing astute clinical assessment for early detection of sepsis).
- The main areas of focus for the prevention of antibiotic-resistant infections include control of antibiotic use, determining the right antibiotic, and control of patient-to-patient spread.
- Controlling patient-to-patient spread of infection with hand hygiene and general infection control practices are the most effective means for controlling the spread of resistant organisms.
- Keeping up to date with evidence-based and research practices aimed at preventing health care-associated infections is an essential aspect of nursing care.

Research Implications

Given the gaps in the current evidence base, additional research is needed in the following areas:

1. Continuous aspiration of subglottic secretions for VAP prevention
2. Semirecumbent position for VAP prevention
3. Silver alloy-coated catheters to prevent hospital-associated UTI
4. Suprapubic catheters to prevent hospital-associated UTI
5. Strategies to ensure use of full barrier precautions (gowns and gloves, dedicated equipment, dedicated personnel) during central line insertion
6. Tunneling short-term CVCs to decrease central line infections
7. Antibiotic limitations on hospital-associated infections due to antibiotic-resistant organisms
8. Strategies to promote appropriate antibiotic administration in hospitals, including the use of informatics technology (e.g., computer-assisted decision support) to assist in point-of-care prescribing and patient-outcome monitoring
9. Source control measures such as chlorhexidine gluconate for bathing, oral care protocols, and selective decontamination of the digestive tract
10. Strategies to improve hand-washing compliance (education/behavior change, sink technology and placement) to reduce hospital-associated infections

Conclusion

A number of factors can lead to the development of health care-associated infections in the hospital setting, including increasing patient acuity levels, chronically ill and acutely ill patients who harbor antibiotic-resistant bacteria, and frequent use of broad-spectrum antibiotics. Health care-associated infections can significantly impact patient outcomes, including morbidity and mortality rates, length of hospital stay, and costs of care. Therefore, focusing on health care-associated infections is an important aspect of providing quality health care.

A targeted approach to infection in hospitalized settings includes prevention measures, early recognition and treatment of infection, appropriate use of antimicrobials, and measures to prevent the transmission of infection among hospitalized patients. This chapter has reviewed the evidence-based knowledge on health care-associated infections—including hospital-associated pneumonia, urinary tract infection, catheter-related bloodstream infection, sepsis, and antibiotic-resistant infections—highlighting important information for nurses caring for hospitalized patients. Nurses can play a key role in the prevention, identification, and management of infections in hospitalized patients through the use of evidence-based measures to ensure a safe health care environment for hospitalized patients.

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Table 1. Evidence-Based Guidelines for Prevention and Management of Hospital-Associated Pneumonia

- Hand hygiene as an essential component of hospital-associated pneumonia reduction.
- Respiratory care with encouragement of deep-breathing exercises.
- Head-of-bed elevation to between 30 and 45 degrees.
- Daily assessment of readiness for extubation.
- Control of oral-tracheal secretions and oral care to minimize colonization and aspiration of biofilm.
- Staff education about the significance of nosocomial pneumonias in patients and how interventions can reduce VAP.
  - Consider forming a multidisciplinary team (nurses, physicians, respiratory therapist, clinical pharmacist) or a unit group of staff to address VAP practice changes.
  - Develop communication strategies to alert and remind staff of the importance of VAP interventions.

Sources: Adapted from Institute for Healthcare Improvement. *Getting Started Kit: Prevent Ventilator Associated Pneumonia*, 2006, http://www.ihi.org/NR/rdonlyres/A448DDB1-E2A4-4D13-8F02-16417EC52990/0/VAPHowtoGuideFINAL.pdf (accessed March 11, 2006); and the American Association of Critical Care Nurses practice alert: Ventilator-Associated Pneumonia, http://www.aacn.org (accessed March 5, 2006).

Table 2. Evidence-Based Strategies for Urinary Tract Infection Prevention

- Indwelling urinary catheters should be inserted using aseptic technique and sterile equipment.
- Only hospital personnel who know the correct technique of aseptic insertion and maintenance of the catheter should handle catheters.
- Hospital personnel should be provided with periodic in-service training stressing the correct techniques and potential complications of urinary catheterization.
- Indwelling urinary catheters should be inserted only when necessary and left in place only for as long as necessary.
- Other methods of urinary drainage such as condom catheter drainage, suprapubic catheterization, and intermittent urethral catheterization should be considered as alternatives to indwelling urethral catheterization.
- Hand washing should be done immediately before and after any manipulation of the indwelling urinary catheter site or apparatus.
- Indwelling catheters should be properly secured after insertion to prevent movement and urethral traction.
- A sterile, continuously closed drainage system should be maintained.
- The catheter and drainage tube should not be disconnected unless the catheter must be irrigated, and irrigation should be used only for suspected obstruction.
- If breaks in aseptic technique, disconnection, or leakage occur, the collecting system should be replaced using aseptic technique after disinfecting the catheter-tubing junction.
- Specimen collections should be obtained from the distal end of the catheter, preferably from the sampling port after cleansing with a disinfectant and then the urine specimen aspirated with a sterile needle and syringe.
- Consider the use of antimicrobial catheters for indwelling urinary catheters.

Source: Adapted from Wong ES, *Guideline for Prevention of Catheter-Associated Urinary Tract Infections.* http://www.cdc.gov/ncidod/dhqp/gl_catheter_assoc.html.

Table 3. Evidence-Based Strategies for Central Line Infection Prevention

- Education and training should be provided for staff who insert and maintain intravenous lines.
- Maximal sterile barriers should be used during catheter insertion (cap, mask, sterile gown and gloves, and a large sterile drape).
- A 2% chlorhexidine preparation is the preferred skin antiseptic, to be applied prior to insertion.
- Antiseptic- or antibiotic-impregnated catheters should be reserved for very high-risk patients or situations in which catheter-related BSI rates are high despite careful attention to these recommendations.
- Replace peripheral intravenous sites in the adult patient population at least every 96 hours but no more frequently than every 72 hours. Peripheral venous catheters in children should be left in until the intravenous therapy is completed, unless complications such as phlebitis or infiltration occur.
- Replace intravenous tubing at least every 96 hours but no more frequently than every 72 hours.
- Replace intravenous catheters as soon as possible when adherence to aseptic technique during catheter insertion cannot be ensured (i.e., prehospital, code situation).
- Central lines should not routinely be replaced at scheduled intervals.
- Consider use of a central line insertion checklist to ensure all processes related to central line insertion are executed for each line placement.
- Consider use of a central line insertion cart to avoid the difficulty of finding necessary equipment to institute maximal barrier precautions.
- Replace central line dressings whenever damp, loose, or soiled or at a frequency of every 2 days for gauze dressings and every 7 days for transparent dressings.
- Avoid use of antibiotic ointment at insertion sites because it can promote fungal infections and antibiotic resistance.
- Include daily review of line necessity.
- Assess competency of staff who insert and care for intravascular catheters.

Sources: Adapted from: O'Grady NP, et al., *Guidelines for the Prevention of Intravascular Catheter-Related Infections*, Centers for Disease Control and Prevention, MMWR Recomm Rep 2002;51(RR-10):1–29; Institute for Healthcare Improvement, *Getting Started Kit: Prevent Central Line Infections*, 2006, available at: http://www.ihi.org/NR/rdonlyres/BF4CC102-C564-4436-AC3A-0C57B1202872/0/CentralLinesHowtoGuideFINAL720.pdf (accessed March 11, 2006); and American Association of Critical Care Nurses practice alert: *Preventing Catheter-Related Bloodstream Infections*, www.aacn.org (accessed March 5, 2006).

Table 4. Evidence-Based Guidelines for Sepsis

The Surviving Sepsis Campaign guidelines outline evidence-based recommendations for targeting treatment of patients at risk of developing severe sepsis and septic shock.

The following grading system was used to classify the treatment recommendations:

A. Supported by at least two level I investigations (large, randomized trials with confident results)
B. Supported by one level I investigation
C. Supported by level II investigations only (small, randomized trials with uncertain results)
D. Supported by at least one level III investigation (nonrandomized study)
E. Supported by level IV (nonrandomized, historical controls, and expert opinion) or level V evidence (case series, uncontrolled studies, and expert opinion)

a. Initial resuscitation for sepsis-induced hypoperfusion—grade B
   - Fluid resuscitation to a central venous pressure of 8–12 mmHg
   - Early goal-directed therapy

- Transfusion of packed red blood cells to achieve a hematocrit of ≥ 30 percent
- Administration of inotropic infusion (e.g., dobutamine)

b. Diagnosis
- Obtain cultures: at least two blood cultures with one drawn percutaneously and one drawn through each vascular access device; cultures of other sites such as urine, wounds, respiratory secretions should be obtained *before* antibiotic therapy is initiated—grade D
- Diagnostic studies (e.g., ultrasound, imaging studies)—grade E

c. Antibiotic therapy
- Empirical antibiotics—grade E

d. Source control
- Removal of potentially infected device, drainage of abscess, debridement of infected necrotic tissue—grade E

e. Enhance perfusion
- Fluid therapy—grade C
- Vaspressors—grade E
- Inotropic therapy—grade E

f. Steroids
- For patients with relative adrenal insufficiency—grade C

g. Recombinant human activated protein C (rhAPC)—grade B
- For patients with sepsis-induced multiple organ failure with no absolute contraindication related to bleeding risk

h. Blood product administration
- To target hemoglobin of 7.0 to 9.0 g/dL—grade B

i. Mechanical ventilation
- Lung protective ventilation for acute lung injury/acute respiratory distress syndrome—grade B

j. Sedation, analgesia, and neuromuscular blockade
- To provide comfort yet avoid prolonged sedation—grade B

k. Glucose control
- To maintain blood glucose <150 mg/dL—grade D

l. Renal replacement
- For acute renal failure—grade B

m. Prophylaxis measures
- Deep vein thrombosis—grade A
- Stress ulcer—grade A

n. Consideration for limitation of support
- Discuss end-of-life care for critically ill patients—grade E
- Promote family communication to discuss use of life-sustaining therapies—grade E

Source: Adapted from Dellinger et al. Surviving Sepsis Campaign guidelines for management of severe sepsis and septic shock. Crit Care Med 2004;32:858-72.

Table 5. General Infection-Prevention Measures

- Standard precautions apply to the care of all patients.
- Contact precautions apply to patients with a known or suspected infection with pathogens that can be transmitted by direct or indirect contact.
- Droplet precautions apply to patients with a known or suspected infection with pathogens that can be transmitted by infectious droplets.
- Airborne precautions apply to patients known or suspected to be infected with epidemiologically important pathogens that can be transmitted by the airborne route.

Categories of Infection-Prevention Measures

- Hand washing: after touching blood, body fluids, secretions, excretions, and contaminated items, whether or not gloves are worn; after gloves are removed, between patient contacts, between tasks and procedures
- Gloves: when touching blood, body fluids, secretions, excretions, and contaminated items; before touching mucous membranes and nonintact skin; between tasks and procedures; after contact with potentially contaminated material
- Mask, eye protection, face shield: to protect mucous membranes of the eyes, nose, and mouth during procedures and patient-care activities with the potential to generate splashes or sprays of blood, body fluids, secretions, and excretions
- Gown: to protect skin and prevent soiling of clothing during procedures and patient-care activities with the potential to generate splashes or sprays of blood, body fluids, secretions, or excretions
- Patient care equipment: appropriate handling of used patient-care equipment soiled with blood, body fluids, secretions, and excretions to prevent skin and mucous membrane exposures, contamination of clothing, and transfer of microorganisms to other patients and environments; to ensure that reusable equipment is not used until it has been cleaned and reprocessed appropriately; to ensure that single-use items are discarded properly
- Environmental control: to ensure adherence with procedures for the routine care, cleaning, and disinfection of environmental surfaces, beds, bedrails, bedside equipment, and other frequently touched surfaces
- Linen: procedures for handling, transporting, and processing used linen soiled with blood, body fluids, secretions, and excretions to prevent skin and mucous membrane exposures and contamination of clothing; to avoid spread of microorganisms to other patients and environments
- Patient placement: placement of patients with the potential to contaminate the environment in a private room

Source: Adapted from CDC, *Standard Precautions.* http://www.cdc.gov/ncidod/dhqp/gl_isolation_standard.html. Accessed February 21, 2006

Table 6. Measures To Prevent Antimicrobial Resistance in Hospitalized Patients

- Establish systems for monitoring bacterial resistance and antibiotic use.
- Place limitations on antibiotic use.
- Establish systems for monitoring both process and outcome measures for infected patients, such as appropriate use of universal precautions, compliance with hand washing, length of hospital stay, or complication rates.
- Adopt the recommendations of the CDC's guidelines for isolation precautions in hospitals to prevent colonization and/or spread of resistant microorganisms.
- Place infected patients in private rooms or only with other infected patients.
- Hospital staff should wear gloves and gowns whenever they enter the room of an infected patient, even if there is no direct patient contact, because these organisms can extensively contaminate the environment.
- Patient-care items should be single-patient use whenever possible.
- Use a notification system so that staff are aware of the detection of cases where antimicrobial-resistant infections such as MRSA and VRE have been detected.
- Ensure that clinical staff are knowledgeable about hospital policies regarding antimicrobial-resistant infections such as MRSA and VRE colonizing in or infecting patients.

Source: Adapted from Centers for Disease Control, *Antimicrobial Resistence in Healthcare Settings,* 2005. http://www.cdc.gov/ncidod/dhqp/ar.html. Accessed February 20, 2006.