Reminder Systems to Reduce the Duration of Indwelling Urinary Catheters: A Narrative Review

Tom J. Blodgett

Urinary tract infection is among the most common diseases in hospitalized patients, accounting for more than 40% of nosocomial infections (Edwards et al., 2008; Tambyah, Knasinski, & Maki, 2002). Indwelling urinary catheters are responsible for approximately 80% of nosocomial urinary tract infections in the acute care setting, and many of these devices are used for inappropriate reasons (Gokula, Hickner, & Smith, 2004; Jamulitrat & Panmanee, 2007). Saint and colleagues (2000) estimated that approximately 20% of hospitalized adults have a urinary catheter placed during their hospitalization. Moreover, almost 30% of physicians are unaware that their patients are catheterized (Saint et al., 2000), which leads to longer catheter use and a higher risk for catheter-associated urinary tract infection (CAUTI).

The duration of catheter use is the most significant predictor of CAUTI (Al-Asmary, Al-Helali, Abdel-Fattah, Al-Jabban, & Al-Bamri, 2004; Beaujean et al., 1997; Danchaivijitr, Drirapatra, Cherd rungsi, Jintanothaitavorn, & Srihapol, 2005; Kunin, 2006). The incidence of CAUTI increases 3% to 10% per day of catheterization (Saint, Lipsky, & Goold, 2002). The risk for developing complications, such as delirium, falls, pyelonephritis, immobility, and urosepsis, also increases with the duration of catheter use (Kunin, 2006; Martin, Mannino, Eaton, & Moss, 2003; Saint et al., 2002). Reducing the duration of catheter use is essential to reducing the incidence, morbidity, and mortality of CAUTI (Wald & Kramer, 2007).

Furthermore, urinary tract infections (UTIs) are expensive. CAUTIs cost an estimated $589 per case (Tambyah et al., 2002),

Catheter-associated urinary tract infection (CAUTI) is a common and costly problem for hospitalized patients. Policymakers have taken notice of the importance of these infections, and changes to the prospective payment rules of Medicare, Medicaid, and many additional third-party payers have been implemented to hold hospitals accountable for the delivery of poor quality health care services. As key members of the health care team, nurses must be prepared to utilize evidence-based practices to prevent CAUTI in hospitalized patients. This article describes several variable-technology interventions to remind clinicians to remove unnecessary urinary catheters and proposes potential roles for nursing informatics in the prevention of CAUTI in hospitalized adults.

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Key Words: Indwelling urinary catheter, urinary tract infection, pathogenesis, reminder systems, catheter-associated urinary tract infection (CAUTI).

Objectives

1. Explain how catheter use is a significant predictor of catheter-associated urinary tract infection (CAUTI).
2. Describe the etiology and diagnosis of a CAUTI.
3. Discuss how physical and virtual reminders for catheter removal play a role in the prevention and treatment of CAUTI.
4. List the implications for nursing and health informatics.

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Note: Objectives and CNE Evaluation Form appear on page 379.
while urinary tract-related bacteremia costs an additional $2,800 per episode (Saint, Veenstra, & Lipsky, 2000). The total annual cost of treating a CAUTI is approximately $424 million (Foxman, 2002). Due to the high incidence and cost of CAUTI, the Centers for Medicare and Medicaid Services (CMS) no longer pays for the treatment of patients who contract CAUTI in hospitals (CMS, 2007). This rule change is intended to make hospitals financially accountable for failing to prevent 10 specific hospital-acquired conditions, including CAUTI (see Table 1). Many private insurers, such as Aetna, Anthem, and United Healthcare Systems, have followed this example (Wald & Kramer, 2007).

While the relationship between indwelling urinary catheters and UTIs has been known for decades, advances in understanding how to prevent these infections have only recently been made. Interventions, such as reminder systems and nurse-driven protocols for catheter removal, have effectively reduced CAUTI incidence (Huang et al., 2004; Topal et al., 2005). The purposes of this article are to describe the pathogenesis, diagnostic methods, and treatment of CAUTI; synthesize the available literature about indwelling urinary catheter removal reminders systems; and identify potential roles for nursing informatics in the prevention of CAUTI.

Table 1. Hospital-Acquired Conditions No Longer Covered by Medicare, Medicaid, and Many Private Insurers

- Foreign Object Retained after Surgery
- Air Embolism
- Blood Incompatibility
- Stage III and IV Pressure Ulcers
- Falls and Trauma
  - Fractures
  - Dislocations
  - Intracranial Injuries
  - Crushing Injuries
  - Burns
  - Electric Shock
- Manifestations of Poor Glycemic Control
  - Diabetic Ketoacidosis
  - Nonketotic Hyperosmolar Coma
  - Hypoglycemic Coma
  - Secondary Diabetes with Ketoacidosis
  - Secondary Diabetes with Hyperosmolarity
- Catheter-Associated Urinary Tract Infection
- Vascular Catheter-Associated Infection
- Surgical Site Infection Following:
  - Coronary Artery Bypass Graft – Mediastinitis
  - Bariatric Surgery
    - Laparoscopic Gastric Bypass
    - Gastroenterostomy
    - Laparoscopic Gastric Restrictive Surgery
  - Orthopedic Procedures
    - Spine
    - Neck
    - Shoulder
    - Elbow
- Deep Vein Thrombosis and Pulmonary Embolism
  - Total Knee Replacement
  - Hip Replacement

Overview of Catheter-Associated Urinary Tract Infection

Pathogenesis

Both bacteriuria and evidence of a host immune response must be present to qualify as CAUTI. Environmental bacteria from the patient’s perineum and introitus use the extraluminal surface of the urinary catheter to bypass the urinary sphincters and gain access to the urinary tract (Daifuku & Stamm, 1984; Johnson et al., 2005; Mathur, Sabbuba, Suller, Stickler, & Feneley, 2005). These bacteria are generally coliform species (such as *Escherichia coli*), enterococcus species, and *Proteus mirabilis* (Trautner & Darouiche, 2004).

Ascension to the urinary tract requires the formation of complex bacterial communities on the catheter surface, known as biofilms (Jacobsen, Stickler, Mobley, & Shirliff, 2008; Matsukawa, Kunishima, Takahashi, Takeyama, & Tsukamoto, 2005; Saint & Chenoweth, 2003). These structures are made of a thick glycoproteinoaceous substance secreted by the bacteria that have colonized the catheter surface. They protect these uropathogens from the host immune response, antimicrobial agents, and aspiration during specimen collection (Ferrierees, Hancock, & Klemm, 2007; Stickler, 2002; Trautner & Darouiche, 2004; Warren, 2001). Furthermore, many virulence properties of bacteria are upregulated in the biofilm environment to enhance their survival, including the exchange of plasmids that encode for antimicrobial resistance and capsule formation (Johnson, 2003; Lunden, Autio, Markkula, Hellstrom, & Korkeala, 2003; Orskov, 1978; Whitfield & Roberts, 1999). Although little is known about biofilm development on urinary catheters over time, the duration of catheter use may be germane to the extent of biofilm growth, which provides an expanding reservoir for uropathogens.
The host immune response to bacteriuria consists of the innate, cellular, and humoral branches of the immune system. This response begins when Toll-like receptor 4 (TLR4) on the bladder epithelial cells recognizes lipopolysaccharide of various uropathogens, such as E. coli, which triggers a cascade of reactions in the cell that leads to the recruitment of neutrophils to the bladder (Bergsten, Wullt, Schembri, Leijonhufvud, & Svanborg, 2007; Frendeus et al., 2001; Klemm, Roos, Ulett, Svanborg, & Schembri, 2006; Wullt et al., 2001).

The urinary tract mucosa is protected by B-lymphocytes, which generate antigen-specific memory B-lymphocytes and plasma cells when activated by a pathogen in the urinary tract. Memory B-lymphocytes “remember” the antigen they encountered upon activation, which facilitates a rapid antigen-specific immune response if that antigen is encountered again. Plasma cells produce antigen-specific immunoglobulin A (IgA), which coats the uropathogen and enhances the cytotoxic and phagocytic activities of other immune cells, such as T-lymphocytes, as well as prevents the adhesion of E. coli to bladder epithelial cells (Kantele, Mottonen, Ala-Kaila, & Arvilommi, 2003; Thumbikat, Waltenbaugh, Schaeffer, & Klumpf, 2006). Thumbikat and colleagues (2006) also found that patients with a UTI had developed an antigen-specific T lymphocyte response to the uropathogen. In the hospital setting, several medications and comorbid conditions, such as glucocorticoids and diabetes mellitus, can blunt this complex immune response, placing hospitalized patients at higher risk for infectious diseases, such as CAUTI.

**Diagnosis**

Clinicians may find several diagnostic approaches for CAUTI useful. These include quantitative urine culture, urinalysis (leukocyte esterase and nitrite), microscopy, and Gram’s stain. Each of these has distinct advantages and disadvantages. However, the presence of an indwelling urinary catheter may affect the diagnostic accuracy of these tests.

**Quantitative urine culture.** Using sterile technique, the nurse collects a sample of at least 5 mL of urine from the sampling port of the urinary catheter. This sample is sent in a sterile container to the microbiology laboratory for analysis within 2 hours of collection. The microbiology staff will dip a calibrated “loop” into the urine sample and spread the urine across a specific culture plate that permits the growth of E. coli. This inoculated plate will be placed in a 37-degree Celsius incubator for up to 48 hours. The microbiology staff will examine the plates at specific intervals, and any growth of bacteria on the plates will be considered “significant.”

The threshold used to establish “significant” bacteriuria depends upon the size of the loop the staff member uses. For example, a UTI that is not caused by an indwelling urinary catheter is diagnosed using a bacterial concentration threshold of 10⁵ colony-forming units per mL of urine (10⁵ cfu/mL), which would require a specific loop size. However, many researchers advocate for the use of a much lower diagnostic threshold for CAUTI, 10⁴ cfu/mL, because the concentration of uropathogens can increase by 100-fold within 24 to 48 hours in the presence of an indwelling urinary catheter (Platt, Folk, Murdoch, & Rosner, 1982; Tambyah et al., 2002). A lower diagnostic threshold could help identify more patients with CAUTI, but it would also increase the likelihood that patients without “true” CAUTI will receive unnecessary treatment.

**Leukocyte esterase and nitrite tests.** These tests are standard components of the routine urinalysis and are commonly performed to diagnose a UTI. The sample is collected using sterile technique since environmental contaminants may affect the diagnostic accuracy of these tests. Because bacteria require up to 4 hours to reduce nitrate to nitrite, urinary catheters should be clamped for 4 hours prior to collecting a urine specimen for urinalysis (McPherson, Ben-Ezra, & Zhao, 2006). Furthermore, bacteria continue to produce nitrite outside the body, so specimens must be analyzed within 2 hours of being collected or refrigerated until an analysis can be performed. A medical technologist can test these samples in the laboratory, or a nurse can test them at the point of care. While the diagnostic accuracy of these tests is generally low for patients with urinary catheters (Van Nostrand, Junkins, & Bartholdi, 2000), they may have some utility as screening tests or to “rule-out” CAUTI. More research is needed to understand the validity of these tests in specific hospital populations, such as the elderly and critically ill.

**Microscopy and Gram’s stain.** Urine microscopy is one of the most commonly used methods to detect pyuria and bacteriuria, and Gram’s stain is commonly used to rapidly classify potential uropathogens (Pezzlo, 1988). Because micromorganisms multiply rapidly in the urine, these specimens must be collected from the catheter using aseptic technique and transported to the laboratory without delay.

Although these tests are inexpensive and have acceptable sensitivity and specificity for UTIs in certain populations (Wiwanitkit, Udomsantisuk, & Boonchalermvichian, 2005), urine microscopy and Gram’s stain require technical expertise, and may be subject to interpretation bias. Furthermore, the diagnostic accuracy of these tests has not been studied in hospitalized patients with urinary catheters.

**Prevention and Treatment of CAUTI**

Several interventions to pre-
vent and treat CAUTI have been tested in hospitalized patients (see Table 2). However, the effectiveness of many of these interventions varies between studies. Catheter removal reminder systems are the most consistently effective interventions, although too few studies have been conducted to make specific recommendations about which system to implement. In general, these reminder systems are divided into two categories: physical reminders and virtual reminders.

### Physical Reminders

Several studies have shown that interventions based on face-to-face, paper-based, or educational reminders to remove urinary catheters can significantly reduce catheter duration and rates of CAUTI (Apisarnthanarak et al., 2007; Crouzet et al., 2007; Fakih et al., 2008; Goetz, Kedzuf, Wagener, & Muder, 1999; Gokula, Smith, & Hickner, 2007; Huang et al., 2004; Loeb et al., 2008; Reilly et al., 2008). In these studies, physical reminder systems were tested to inform physicians that their patient had an indwelling urinary catheter and to seek an order to discontinue this device (see Table 3).

The face-to-face reminder is a simple and inexpensive intervention that can be implemented as part of routine nurse-physician communication. This reminder system involves staff nurses discussing directly with the physician the need to discontinue an urinary catheter after a specified period of time, usually 3 to 4 days (Apisarnthanarak et al., 2007; Crouzet et al., 2007; Fakih et al., 2008; Huang et al., 2004). Face-to-face reminders were shown to reduce the duration of catheterization, inappropriate catheter use, and rate of CAUTI. Furthermore, length of hospital stay, cost of antibiotic therapy, and the overall cost of hospitalization was decreased with the use of this reminder system.

Paper-based reminders are also simple and inexpensive interventions, but may require more resources for implementation than face-to-face reminders. This reminder system uses stickers, preprinted “stop-orders,” and nurse-driven protocols to encourage clinicians to insert catheters only when necessary and remove them quickly (Gokula et al., 2004; Loeb et al., 2008; Reilly et al., 2008; Saint, Kaufman, Thompson, Rogers, & Chenoweth, 2005). Paper-based reminders decreased overall catheter utilization and inappropriate catheter utilization in all studies. Loeb and colleagues (2008) tested pre-written “stop orders,” which nurses used to determine the necessity of urinary catheters and discontinue

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<th>Table 2. Preventive and Therapeutic Interventions for CAUTI</th>
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<tr>
<td><strong>Preventive</strong></td>
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<tr>
<td>- Avoid catheter insertion unless absolutely necessary:</td>
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<td>- Critical monitoring of urine output.</td>
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<td>- Prolonged surgical cases and post-genitourinary surgery.</td>
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<td>- Urinary incontinence with open sacral pressure ulcer.</td>
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<td>- Acute urinary retention.</td>
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<td>- Palliative care at request of patient or family.</td>
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<td>- Immediate and rapid bladder decompression with abdominal trauma.</td>
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<td>- Remove catheter as soon as possible after insertion:</td>
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<tr>
<td>- Physical reminder system (face-to-face, chart-based, educational, interdisciplinary rounds).</td>
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<tr>
<td>- Virtual reminder system tied to computerized order entry or initiation of “Urinary Catheterization” nursing intervention.</td>
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<td>- Always use a catheter size appropriate for the age and weight of the patient.</td>
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<td>- Use catheters coated with silver-hydrogel or nitrofurantoin to prevent biofilm growth.</td>
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<td>- Use meticulous sterile technique with catheter insertion.</td>
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<td>- Prevent catheter dislodgement by stabilizing or securing it to the abdomen or inner thigh.</td>
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<td>- Maintain urinary drainage bag slightly below the level of the bladder and keep drainage tubing coiled to avoid falling below the level of the bag.</td>
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<td>- Cleanse urethral meatus, perineum, and proximal catheter tubing at least once daily with soap and water (more frequent cleaning and use of antiseptic solutions do not provide additional protection).</td>
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<td>- Do not disconnect catheter drainage system.</td>
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<td>- Wash hands and wear gloves when touching catheter tubing.</td>
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<td>- Avoid contamination of catheter drainage spigot, and disinfect after emptying of the drainage bag, which should be done at least every 8 hours.</td>
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<td>- Use a separate, labeled graduated container to collect urine for each patient.</td>
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<td>- Disinfect the sampling port before and after urine sampling.</td>
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<td>- Avoid clamping urinary drainage tubing during patient transport.</td>
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<td>- Use portable bladder ultrasound (such as bladder scan) to evaluate urinary retention.</td>
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<td>- Use intermittent catheterization to manage urinary retention with regular bladder emptying according to an established schedule.</td>
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<td>- Increase oral or intravenous fluid intake.</td>
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<td>- Remove catheter as soon as possible to eliminate reservoir for infection:</td>
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<td>- Physical reminder system.</td>
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<tr>
<td>- Virtual reminder system.</td>
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<tr>
<td>- Treat symptomatic CAUTI (fever, leukocytosis) with appropriate antimicrobials, as prescribed.</td>
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<tr>
<td>- Increase oral or intravenous fluid intake.</td>
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<tr>
<td>- Monitor clinical response to CAUTI treatment and change care plan as needed.</td>
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<tr>
<td>Apisarnthanarak et al. (2007)</td>
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<td>Crouzet et al. (2007)</td>
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<td>Fakih et al. (2006)</td>
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<td>Goetz et al. (1999)</td>
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<th>Results</th>
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<tr>
<td>Huang et al. (2004)</td>
<td>The nurse reminded the physician daily to remove urinary catheters in place for more than 5 days.</td>
<td>Pretest-posttest quality improvement program</td>
<td>N = 6,297 ICU patients consecutively admitted to a 1,310-bed Taiwanese hospital (surgical, neuro-surgical, CV surgical, medical, coronary) Mean age 65 years old 28% female</td>
<td>Catheter duration decreased by 2.4 days (p &lt; 0.001). CAUTI rate decreased by 3.2 per 1,000 catheter-days (p = 0.009). Linear relationship between duration of catheterization and CAUTI rate (p = 0.01). 69% decreased cost of antibiotics (p = 0.004).</td>
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<td>Loeb et al. (2008)</td>
<td>Prewritten &quot;stop orders&quot; in the catheterized patients chart were used to guide nurse’s independent decision-making about catheter necessity; unnecessary catheters were removed by nurse Follow-up by research nurse</td>
<td>Randomized controlled trial</td>
<td>N = 692 hospitalized patients admitted to Canadian hospital with urinary catheters inserted for at least 48 hours Mean age 79 years old 62% female</td>
<td>Overall catheter duration decreased by 1.34 days (p &lt; 0.001). Unnecessary catheter duration decreased by 1.69 days (p &lt; 0.001). No significant decrease in rates of CAUTI (p = 0.71).</td>
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<td>Reilly et al. (2008)</td>
<td>Daily “catheter-necessity” checklists. Criteria-based catheter use guidelines Decision-making algorithm</td>
<td>Single-group pretest-posttest</td>
<td>N = 206 patients consecutively admitted to a 22-bed medical-surgical ICU</td>
<td>Catheter duration decreased by 1.74 days (p = 0.38). 33% decreased CAUTI rates (p-value not provided).</td>
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**Virtual Reminders**

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<td>Corria et al. (2003)</td>
<td>Automated reminder triggered by computerized physician order for urinary catheter (MD forced to select indication and whether to renew or discontinue catheter order)</td>
<td>Prospective quasi-experimental study with comparison group</td>
<td>N = 742 patients consecutively admitted to medicine and cardiology services in a VA hospital Demographic information about the sample was not provided</td>
<td>No difference in rates of catheter use (p = 0.15). Documentation of catheter order was more common in the treatment group (p &lt; 0.001). Mean duration of catheterization was reduced by 3 days in the treatment group (p = 0.03). No difference in CAUTI rates (p = 0.71).</td>
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those that were unnecessary, on rates of CAUTI in hospitalized patients. Their intervention failed to reduce CAUTI rates, although the authors proposed that methodological flaws might have affected specimen collection, catheter removal patterns in the control group, and sampling of patients receiving antimicrobial medications.

Educational reminder systems require more resources than either face-to-face or paper-based reminders, but have been shown to significantly reduce overall and inappropriate catheter use, CAUTI rates, and cost (Fakhli et al., 2008; Goetz et al., 1999; Gokula et al., 2007). Furthermore, other types of physical reminder systems have required an educational component to ensure consistent implementation, which suggests that education about CAUTI is essential regardless of the type of reminder system implemented. This type of reminder system uses multidisciplinary rounds, feedback to staff nurses in the form of quarterly CAUTI reports, and multidisciplinary classroom lectures to inform staff about inappropriate catheter use and encourage early catheter removal.

**Virtual Reminders**

Health informatics systems can provide clinicians, researchers, and regulatory agencies with rich datasets for quality measurement, assurance, and improvement. They can also be used to remind nurses and physicians to remove unnecessary urinary catheters (Comia, Amory, Fraser, Saint, & Lipsky, 2003; Saint et al., 2005; Topal et al., 2005). “Virtual” reminders include automatic stop orders tied to computerized catheter orders and the use of reminders sent on alphanumeric pagers (see Table 3).

Although these virtual reminder systems can require substantial investments of time, personnel, and finances, they offer some important advantages over the less-expensive physical reminder systems. For example, since virtual reminders can be linked to existing computerized physician order entry (CPOE) and nursing documentation systems, documentation of catheter utilization and adherence to virtual reminders can be easily monitored. For example, Comia and colleagues (2003) found that documentation of catheter orders was significantly more common among patients on units with CPOE than on units without CPOE (92% vs. 29%, p < 0.001). Virtual reminders have also been shown to increase compliance with contact isolation of patients infected with antibiotic-resistant organisms (Kho et al., 2008). Virtual reminder systems decrease duration of catheterization, rates of CAUTI, and cost.

**Combined Reminders**

Physical reminder systems and virtual reminder systems have been implemented together (Saint et al., 2005; Topal et al., 2005). This approach has led to decreased rates of CAUTI, decreased duration of catheterization, decreased inappropriate use of urinary catheters, and

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<td>Saint et al. (2005)</td>
<td>Simple chart reminder in physician notes, in which physicians were asked to either (a) discontinue the catheter or (b) continue the catheter and select the catheter indication</td>
<td>Pretest-posttest with comparison group</td>
<td>N = 5,678 patients consecutively admitted to medical-surgical units in a teaching hospital Catheter use was different between the intervention and comparison groups at pretest (p &lt; 0.001)</td>
<td>Catheter use was decreased in the treatment group post-intervention (p &lt; 0.001). Re-catheterization rates were not significantly different between groups (p = 0.410). Estimated cost savings of approximately $50,832 per year.</td>
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<td>Topal et al. (2005)</td>
<td>Computerized reminders to physicians triggered by computerized physician orders for catheter insertion Nurse-driven protocol to independently remove unnecessary urinary catheters Portable bladder ultrasound machines available to assess need for re-catheterization</td>
<td>Prospective cohort</td>
<td>N = 303 Mean age 70 years old 59% female No difference in antimicrobial use between groups</td>
<td>Device use decreased between study phases (p &lt; 0.001). CAUTI rate decreased between study phases (p &lt; 0.001). The most common reason for catheter use was urinary output monitoring.</td>
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decreased cost. For example, Saint and colleagues (2005) used simple paper-based reminders in patients’ charts to encourage physicians to specify the reason for catheterization and to remove unnecessary catheters. Because compliance with this paper-based reminder was low, investigators implemented a virtual reminder using the hospital’s alphanumeric paging system to remind physicians to complete the paper-based reminder form.

Health informatics systems can strengthen physical reminders through case-finding strategies. For example, Apisarnthanarak and colleagues (2007) tested the use of a daily face-to-face reminder in which physicians from the research team met with treating physicians to request the removal of unnecessary urinary catheters from patients who have been catheterized for 3 days or longer. Members of the research team browsed computerized physician orders to identify patients with urinary catheters.

**Implications for Health Informatics And Nursing Practice**

Physical, virtual, and combined reminder systems are effective interventions that can be implemented at the individual and institutional levels. A recent review by Cornia and Lipsky (2008), as well as an evidence-based practice protocol jointly developed by The Society for Healthcare Epidemiology of American (SHEA) and the Infectious Disease Society of America (IDSA) (Lo et al., 2008), advocates for the use of reminder systems as an important intervention to prevent CAUTI in hospitalized patients. Many of these interventions, particularly face-to-face, paper-based, and alphanumerical paging systems, can be implemented with few resources and with minimal training.

As hospitals increase the adoption of health informatics systems and these systems continue to evolve, virtual reminder systems may become more common. Although virtual reminders have been met with some ambivalence in the health care community (Saleem et al., 2005), there is growing evidence that these types of reminders may improve adherence to evidence-based guidelines related to CAUTI prevention, as well as the prevention of other infectious diseases and chronic conditions (Dexheimer, Talbot, Sanders, Rosebloom, & Aronsky, 2008; Kho et al., 2008).

Health care informaticists can implement virtual reminders in a variety of ways to impact catheter use and incidence of CAUTI. First, automated reminders can be attached to computerized physician orders for catheterization, which will prompt physicians to remove urinary catheters that are no longer necessary. Automated reminders can also be added to computerized nursing documentation. For example, when a urinary catheter documentation parameter is added to the patient’s care plan, the nurse would receive a catheter removal reminder on the third or fourth day of catheterization. Health informatics systems can also be used to prompt physical reminders. If nurses or physicians ignore these automated virtual reminders, a message can automatically be sent to their supervisor or to the hospital infection control team. Finally, quality managers can use health informatics systems to monitor adherence to computerized reminders and provide feedback to staff about their performance.

Virtual and physical reminder systems are effective interventions to reduce CAUTI in hospitals. With increasing sociopolitical and financial pressure to prevent these nosocomial infections, urologic nurses and nursing informaticists must work together to plan, implement, and evaluate reminder systems that can be incorporated into their existing institutional design.

**References**


