Reducing unnecessary urinary catheter use and other strategies to prevent catheter-associated urinary tract infection: an integrative review

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ABSTRACT
Background Catheter-associated urinary tract infections (CAUTI) are costly, common and often preventable by reducing unnecessary urinary catheter (UC) use.
Methods To summarise interventions to reduce UC use and CAUTIs, we updated a prior systematic review (through October 2012), and a meta-analysis regarding interventions prompting UC removal by reminders or stop orders. A narrative review summarises other CAUTI prevention strategies including aseptic insertion, catheter maintenance, antimicrobial UCs, and bladder bundle implementation.
Results 30 studies were identified and summarised with interventions to prompt removal of UCs, with potential for inclusion in the meta-analyses. By meta-analysis (11 studies), the rate of CAUTI (episodes per 1000 catheter-days) was reduced by 53% (rate ratio 0.47; 95% CI 0.30 to 0.64; p<0.001) using a reminder or stop order, with five studies also including interventions to decrease initial UC placement. The pooled (nine studies) standardised mean difference (SMD) in catheterisation duration (days) was −1.06 overall (p=0.065) including a statistically significant decrease in stop-order studies (SMD −0.37; p<0.001) but not in reminder studies (SMD, −1.54; p=0.071). No significant harm from catheter removal strategies is supported. Limited research is available regarding the impact of UC insertion and maintenance technique. A recent randomised controlled trial indicates antimicrobial catheters provide no significant benefit in preventing symptomatic CAUTIs.
Conclusions UC reminders and stop orders appear to reduce CAUTI rates and should be used to improve patient safety. Several evidence-based guidelines have evaluated CAUTI preventive strategies as well as emerging evidence regarding intervention bundles. Implementation strategies are important because reducing UC use involves changing well-established habits.

THE PROBLEM
Urinary tract infection (UTI) has long been considered the most common healthcare-associated infection (HAI), with the vast majority of these infections occurring after placement of the convenient, uncomfortable,1 often unnecessary2–4 and easily forgotten urinary catheter.5 With an estimated6–7 449 334 healthcare-associated catheter-associated urinary tract infections (CAUTIs) per year, associated with an additional cost (in 2007) of US$749–10077–9 per admission (or an estimated US$3744 when complicated by blood stream infections),10 it is not surprising that CAUTIs were among the first hospital-acquired conditions selected for non-payment by Medicare as of October 2008,11 and have been further targeted for complete elimination12 as a ‘never event,’ with a national goal to reduce CAUTI by 25% by 2014.13 These national initiatives renewed public and research interest in the prevention of CAUTI, prompting updates of several comprehensive guidelines14–17 and reviews of strategies to prevent CAUTI released since the 2001 Making Health Care Safer report.18

WHAT STRATEGIES MAY PREVENT CATHETER-ASSOCIATED URINARY TRACT INFECTIONS?
Similar to other HAIs — such as central line-associated blood stream infection — many CAUTI prevention strategies have been ‘bundled’ into a composite of
multimodal sets of interventions known as ‘bladder bundles’. These bundles consist of educational interventions to improve appropriate use and clinical skill in catheter placement, behavioural interventions such as catheter restriction and removal protocols, and use of specific technologies such as the bladder ultrasound. Despite some early success in implementing a bladder bundle to reduce urinary catheterisation rates, CAUTI prevention has proven challenging for several important reasons. For example, monitoring urinary catheter use and CAUTI rates to inform and sustain urinary catheter-related interventions is very resource intensive. Perhaps more importantly, improving practice regarding urinary catheter placement and removal also requires interventions to change the expectations and habits of nurses, physicians and patients about the need for urinary catheters.

To help organise and prioritise the many potential interventions to prevent CAUTI, we use the conceptual model of the ‘lifecycle of the urinary catheter’ to highlight that the highest yield interventions to prevent CAUTI will target at least one of the four ‘stages’ of the catheter’s ‘life.’ As illustrated in figure 1, the ‘lifecycle’ of the catheter (1) begins with its initial placement, (2) continues when it remains in place, day after day, (3) ceases when it is removed and (4) may start over if another catheter is inserted after removal of the first one.

Because avoiding unnecessary urinary catheter use is the most important strategy in prevention of CAUTI, we review the evidence on two types of interventions that target unnecessary urinary catheter use: (1) protocols and interventions to decrease unnecessary placement of urinary catheters (catheter lifecycle stage 1), and (2) interventions that prompt removal of unnecessary urinary catheters (catheter lifecycle stage 3).

**REVIEW PROCESS**

The evidence summarised in this chapter was generated using a literature search conducted for a prior systematic review and meta-analysis along with a focused update of the published peer-reviewed literature (from August 2008 to October 2012) through a MEDLINE search for intervention studies to reduce use of unnecessary urinary catheters in the acute care of adults. A CINAHL database search was also performed for interventions developed and implemented by nurses related to urinary catheter use. Studies were included if at least one outcome involving catheter use or CAUTI events (table 1) was reported as a result of the intervention, and with a comparison group (either preintervention vs postintervention, or a separate control group). Details of the systematic literature searches and methods employed for selection and reporting of the studies for this review are provided in the online supplementary appendix. The online supplementary appendix table summarises all the intervention studies described in this review, including study designs, patient populations and the interventions employed to avoid unnecessary catheter placement or to prompt catheter removal. This review was supported by the Agency for Healthcare Research and Quality (AHRQ), which had no role in the selection of outcomes evaluated.

**Table 1** Description of outcomes evaluated (adapted from the prior meta-analysis)

| Measures of Catheter-associated Urinary Tract Infection (CAUTI) development | Number of CAUTI episodes per 1000 catheter-days was recorded and a rate ratio was calculated to compare preintervention vs postintervention. When rates of both asymptomatic and symptomatic CAUTI were reported separately, the rates of symptomatic CAUTI were used for the meta-analysis. Cumulative risk of CAUTI during hospitalisation (ie, the percentage of patients who developed CAUTI) was also extracted for each study, and a risk ratio was calculated to compare risks before and after the intervention for the meta-analysis. |
| Measures of urinary catheter use | Mean number of days of urinary catheter use per patient was recorded before and after the intervention, and a standardised mean difference was calculated to compare the two groups for the meta-analysis. Percentage of patient days in which the catheter was in place (reported by the study directly, or calculated from ratio of catheter days/patient days if provided in the study), for the comparison group (before intervention or control group) and postintervention. Percentage of patients studied who had a urinary catheter placed during the study period, for the comparison group (before intervention or control group) and postintervention. |
| Need for catheter replacement | Recatheterisation need was extracted as the number and percent of patients who required replacement of a catheter after prior removal of an indwelling catheter. |
or review of the evidence or the decision to submit this manuscript for publication.

WHAT STRATEGIES MAY REDUCE UNNECESSARY CATHETER USE?

Strategies to avoid unnecessary placement of indwelling urinary catheters

Simply put, patients without urinary catheters do not develop CAUTI. Yet, multiple studies show that between 21% and 55.7% of urinary catheters are placed in patients who do not have an appropriate indication and, therefore, may not even need a catheter. Over the past decade, several studies have employed interventions to decrease unnecessary catheter placement (described in the online supplementary appendix table). Although educational interventions are a common and important first step to decrease inappropriate catheter use, more effective and potentially more sustainable interventions go a step further by instituting restrictions on catheter placement. Protocols that restrict catheter placement can serve as a constant reminder for providers about the appropriate use of catheters, can suggest alternatives to indwelling catheter use (such as condom catheters or intermittent straight catheterisation), but perhaps most importantly, can generate accountability for placement of each individual urinary catheter. A fairly typical approach for developing a catheter restriction protocol is to begin with a list of appropriate catheter uses (such as the list provided in the Centers for Disease Control and Prevention’s Healthcare Infection Control Practices Advisory Committee (HICPAC) guideline, this list (see box 1) can then be tailored to include other indications based on local opinion and specialised patient populations.

The technology required to implement catheter placement restrictions ranges from low-technology strategies, such as a hospital or unit policy on appropriate catheter placement, or preprinted catheter orders with limited indications, to higher-technology strategies, such as computerised orders for catheter placement. Catheter restriction protocols have been a common component of successful multimodal interventions to decrease catheter use and/or CAUTI rates, including hospital-wide interventions and interventions tailored for specific environments, such as the emergency department, inpatient units (including general medical, surgical wards and ICU), and in the perioperative setting. Urinary retention protocols are a type of catheter restriction protocols that often incorporate the use of a portable bladder ultrasound to verify retention prior to catheterisation, and recommend use of intermittent catheterisation rather than indwelling catheters to manage a common and often temporary issue.

### Box 1 Indications for indwelling urethral catheter use (from 2009 Centers for Disease Control and Prevention guideline)

**A. Examples of appropriate indications for indwelling urethral catheter use**

- Patient has acute urinary retention or bladder outlet obstruction
- Need for accurate measurements of urinary output in critically ill patients
- Perioperative use for selected surgical procedures:
  1. Patients undergoing urologic or other surgery on contiguous structures of genitourinary tract
  2. Anticipated prolonged surgery duration; catheters inserted for this reason should be removed in postanesthesia care unit
  3. Patients anticipated to receive large-volume infusions or diuretics during surgery
  4. Need for intraoperative monitoring of urinary output
- To assist in healing of open sacral or perineal wounds in incontinent patients
- Patient requires prolonged immobilisation (eg, potentially unstable thoracic or lumbar spine, multiple traumatic injuries such as pelvic fractures)
- To improve comfort for end-of-life care if needed

**B. Examples of inappropriate uses of indwelling catheters**

- As a substitute for nursing care of the patient or resident with incontinence
- As a means to obtain urine for culture or other diagnostic tests when patient can voluntarily void
- For prolonged postoperative duration without appropriate indications (eg, structural repair of urethra or contiguous structures, prolonged effect of epidural anesthesia, etc.)

**Strategies to prompt removal of unnecessary urinary catheters**

Urinary catheters are commonly left in place when no longer needed. In most hospitals, four steps are required to remove a urinary catheter: (1) a physician recognises the catheter is in place, (2) the physician recognises the catheter is no longer needed, (3) the physician writes the order to remove the catheter and (4) a nurse removes the catheter. Thus, by default, hours and sometimes days may pass before an unnecessary catheter is recognised and removed. Because every additional day of urinary catheter use increases the patient’s risk of infectious complications, and catheter use is also associated with non-infectious catheter-related complications, interventions that facilitate prompt removal of unnecessary catheters can have a strong impact. We describe below the evidence regarding strategies that may accelerate...
or bypass some of these four steps to prompt catheter removal.

Perhaps the most important CAUTI prevention strategy after placement of the catheter is to maintain awareness of the catheter’s existence (in lifecycle stage 2 of figure 1), as healthcare providers may be unaware the catheter is in place. Thus, a key step in prompting removal of unnecessary catheters is frequently (by day or by shift) reminding nurses and physicians that the catheter remains in place. Catheter reminder interventions include a daily checklist or verbal/written reminder to assess continued catheter need, a sticker reminder on the patient’s chart or catheter bag, or an electronic reminder that a catheter is still in place. Reminder interventions can be generated by nurses, physicians or electronic order sets, and can be targeted to remind either nurses or physicians about the catheter. Some reminder interventions have employed nurses dedicated to detecting unnecessary catheters. Reminder interventions can also serve to remind clinicians of appropriate catheter indications.

Unfortunately, reminder interventions can also be easy to ignore and catheters may remain in place without action. The next type of intervention to prompt removal of unnecessary catheters which goes a step further, is a ‘stop order’ that requires action. Stop orders prompt the clinician (either nurse or physician) to remove the catheter by default after a certain time period has elapsed or condition has occurred, unless the catheter remains clinically appropriate. For example, catheter stop orders can be configured to ‘expire’ in the same fashion as restraint or antibiotic orders, unless action is taken by a clinician. Stop orders directed at physicians require an order to be renewed or discontinued on the basis of review at specific intervals, such as every 24–48 h after admission or postprocedure. Stop orders directed at nurses either require the nurse to obtain a catheter removal order from physicians, or can empower nurses to remove the catheter without requesting a physician order on the basis of an appropriate indication list. Admittedly, implementing a nurse-empowered catheter removal protocol may be less effective than anticipated, as early qualitative research of nurse-empowered interventions indicate some nurses are uncomfortable with this autonomy and might not remove catheters as expected.

**BENEFITS AND HARMS**

What is the impact of strategies to avoid unnecessary urinary catheter use?

Impact of interventions to avoid unnecessary catheter placement

Multiple before-and-after studies have found that interventions to decrease inappropriate catheter placement (such as catheter placement restrictions and urinary retention protocols) have resulted in a decrease in the use of urinary catheters, and a reduction in the proportion of catheters in place without a physician order and without an appropriate indication.

**Impact of reminder and stop-order interventions on catheter use and CAUTIs**

As an update to our prior systematic review and meta-analysis of 14 studies published prior to August 2008, this systematic review (through October 2012) identified a total of 30 studies employing reminders and/or stop orders to prompt removal of unnecessary urinary catheters that reported at least one CAUTI or urinary catheter use measure defined in table 1. Table 2 summarises each of these 30 studies, including the outcomes reported, and a brief summary of the interventions employed (with more details regarding the interventions provided in the online supplementary appendix table). The majority (28) of studies were prepost designs, including three with concurrent controls; one study was a randomised control trial (RCT) and one study was a non-randomised crossover trial.

With very similar results to the prior meta-analysis, the updated meta-analysis using 11 studies (figure 2, stratified by reminder vs stop order, and also see online supplementary appendix figure, stratified by study’s focus on intensive care patients) indicated the rate of CAUTI (episodes per 1000 catheter-days) was reduced by 53% (rate ratio 0.47; 95% CI 0.30 to 0.64, p<0.001) with use of a reminder or stop order, with five of these studies also including interventions to restrict initial catheter placement. Based on this updated meta-analysis, reminders and stop orders could result in large numbers of avoided CAUTI episodes per 1000 catheter-days, particularly when baseline rates of CAUTI are high (table 3). Eight studies provided sufficient detail for pooling of the cumulative risk of CAUTI during the study period; the risk ratio for CAUTI was 0.72 (95% CI 0.52 to 0.99; p=0.045) for the intervention versus comparison groups (figure 3).

Using nine studies with sufficient detail for pooling (figure 4), the pooled standardised mean difference (SMD) in duration of catheterisation was −1.06 days overall (p=0.065) including a statistically significant decrease in studies that used a stop order (SMD −0.37; p<0.001) but not in those that used a reminder (SMD, −1.54; p=0.071). Many studies reported other outcomes for urinary catheter use (detailed in table 2), but none of the studies identified since the prior meta-analysis provided sufficient detail (eg, number of patients in intervention or control groups, and measures of variability such as SD) to update the prior meta-analyses for these other urinary catheter use outcomes.
Table 2  Summary of CAUTI and urinary catheter (UC) outcomes reported for studies with reminder or stop-order interventions, evaluated as potential studies to include in meta-analyses

<table>
<thead>
<tr>
<th>1st author (year)</th>
<th>Interventions*</th>
<th>CAUTI outcomes</th>
<th>% Patients who developed CAUTI</th>
<th>Mean days of UC use per patient</th>
<th>% Patient days with UC in use</th>
<th>% Patients with UC used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adams (2010)</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apsarnthanarak (2007)</td>
<td>R</td>
<td>21.5 → 5.2t</td>
<td></td>
<td>11.0 → 3.0t</td>
<td>82 → 84</td>
<td>All catheterised†</td>
</tr>
<tr>
<td>Brumineht (2010)</td>
<td>R</td>
<td>7.02 → 2.08t§</td>
<td></td>
<td></td>
<td></td>
<td>All catheterised†</td>
</tr>
<tr>
<td>Crouzet (2007)</td>
<td>R</td>
<td>12.3 → 1.8t</td>
<td>10.6 → 1.1t</td>
<td>8.4 → 6.7</td>
<td></td>
<td>All catheterised†</td>
</tr>
<tr>
<td>Elpern (2009)</td>
<td>P, R</td>
<td>4.7 → 0t</td>
<td></td>
<td></td>
<td></td>
<td>All catheterised†</td>
</tr>
<tr>
<td>Fuchs (2011)</td>
<td>P, S</td>
<td>2.88 → 1.46</td>
<td></td>
<td></td>
<td></td>
<td>All catheterised†</td>
</tr>
<tr>
<td>Gotelli (2008)</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>All catheterised†</td>
</tr>
<tr>
<td>Huang (2004)</td>
<td>R, B, A</td>
<td>3.8 → 2.4</td>
<td></td>
<td>7.0 → 4.6t</td>
<td>74 → 76</td>
<td>All catheterised†</td>
</tr>
<tr>
<td>Knoll (2011)</td>
<td>P, R, S, B, O</td>
<td>2.1 → 2.1</td>
<td></td>
<td></td>
<td>Mean daily UC prevalence: 15.2 → 13.7$</td>
<td>All catheterised†</td>
</tr>
<tr>
<td>Murphy (2007)</td>
<td>R, E</td>
<td>Reduced UTI rates by 30%, no details</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Robinson (2007)</td>
<td>S</td>
<td>40.0 → 13.3</td>
<td>8.6 → 4.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rothfield (2010)</td>
<td>P, S</td>
<td>3.2 → 2.4</td>
<td></td>
<td>33.3 → 18.5t</td>
<td>33.3 → 18.8</td>
<td></td>
</tr>
<tr>
<td>Saint (2005)</td>
<td>R</td>
<td></td>
<td></td>
<td>0.6 → 0.4t</td>
<td>14 → 13</td>
<td></td>
</tr>
<tr>
<td>Schultz (2011)</td>
<td>P, S</td>
<td>5.0 → 4.9</td>
<td>4.3 → 3.0</td>
<td>Median 5.0 → 4.0t</td>
<td>90–95 → 76–84</td>
<td></td>
</tr>
<tr>
<td>Sequin (2010)</td>
<td>S</td>
<td>45.8 → 18.6t</td>
<td>5.0 → 3.9t</td>
<td>92.7 → 91.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stephan (2006)</td>
<td>P, S, E</td>
<td>13.3 → 4.0t</td>
<td></td>
<td></td>
<td>UC Utilisation rates of ICU beds with UCs:100 → 73</td>
<td>All catheterised†</td>
</tr>
<tr>
<td>Voss (2009)</td>
<td>S</td>
<td></td>
<td></td>
<td>16 → 10t</td>
<td></td>
<td>All catheterised‡</td>
</tr>
<tr>
<td>Weitzel (2008)</td>
<td>R</td>
<td>37 → 6.7</td>
<td>8.6 → 4.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wenger (2010)</td>
<td>S, E, A</td>
<td>2.26 → 1.02t</td>
<td></td>
<td>4.9 → 3.9</td>
<td>26 → 10</td>
<td>33 → 15.3</td>
</tr>
</tbody>
</table>

A grey-shaded table cell indicates that the outcome was not reported in the study.

*Intervention key (note: interventions described in more detail in online supplementary appendix table).

†Difference of p<0.05 reported between comparison group (before intervention or control) → post-intervention group.

‡Not applicable, as only catheterised patients were included for these studies (so 100% catheterised).

§Reporting first published post-intervention result, for this study that reported serial post-intervention results.

P=Intervention to avoid unnecessary catheter Placement (eg, restricted indications of use, bladder scanner protocols, etc).

R=Reminder intervention that UC is still present, could be directed at either physician or nurse.

S=Stop order intervention, prompting/removing removal of the UC based on time or clinical criteria.

E=Education regarding UC placement or maintenance.

B=Bladder bundle of interventions (which included UC placement, maintenance care standardisation).

A=Antimicrobial UCs.

O=Other CAUTI or catheter-related interventions, detailed in online supplementary appendix table.

CAUTI, catheter-associated urinary tract infection; CCU, coronary care units; ICU, intensive care units; UTI, urinary tract infection.
The one RCT that used a urinary catheter stop order warrants further discussion. In this study focusing on catheterised general medicine patients, urinary catheter use decreased more in the 347 patients in the stop-order group compared to 345 patients receiving usual care by -1.34 days (95% CI -2.05 to -0.64, p<0.001). Unexpectedly, symptomatic CAUTI rates did not change, occurring in 2.1% of both stop-order and usual-care groups (p=0.99). Of note, Loeb et al did not report CAUTIs per 1000 catheter days, so these results could not be included in pooled rate ratios (figure 2), but were included in pooled risk ratios (figure 3). There are several potential reasons why a decrease in CAUTIs was not seen in this study, including high rates of antimicrobial use in both controls and stop-order groups (protective against CAUTI, and a variable not often reported in these comparative studies), and the possibility that a 1-day reduction in catheter use may not be sufficient to demonstrate an effect on the risk of UTI, although the effects on rates of UTI (by tracking catheter days) are not known.

Potential for unintended harm by catheter removal interventions
Interventions that facilitate removal of urinary catheters pose the risk of premature urinary catheter removal, with patients then requiring unnecessary recatheterisation; any catheterisation event is associated with procedure-related discomfort and other potential complications. Thus, monitoring the need for recatheterisation is important to avoid unintended patient harm. In the meta-analysis of reminder and stop-order studies, only four of the 14 studies reported rates of recatheterisation with low recatheterisation rates noted in both intervention and control groups. None of the 16 more recent studies involving reminders or stop orders to prompt catheter removal reported data on potential patient harm, such as premature removal.

**SUMMARY OF OTHER STRATEGIES TO PREVENT CAUTI**
Several recent evidence-based guidelines have focused on preventing CAUTI, and have assessed the evidence and provided recommendations for implementing prevention strategies. Key recommendations in the Centers for Disease Control and Prevention (CDC) guideline, in addition to appropriate catheter use (box 1), include (1) aseptic insertion of urinary catheters by properly trained personnel, using aseptic...

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**Table 3**

<table>
<thead>
<tr>
<th>Baseline rate of CAUTI episodes per 1000 catheter days</th>
<th>Number of avoided CAUTI episodes per 1000 catheter days anticipated by the type of intervention to prompt catheter removal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reminder</td>
</tr>
<tr>
<td>5</td>
<td>3.0</td>
</tr>
<tr>
<td>10</td>
<td>6.0</td>
</tr>
<tr>
<td>20</td>
<td>11.9</td>
</tr>
</tbody>
</table>

CAUTI, catheter-associated urinary tract infections.
technique and sterile equipment (with an exception being that clean technique is appropriate for chronic intermittent catheterisation) and (2) proper urinary catheter maintenance with a sterile, closed drainage system permitting unobstructed urine flow. Aseptic insertion is primarily recommended as a standard of care for which limited evidence exists. Stronger evidence (epidemiological and clinical) supports the

**Figure 3** Meta-analysis of risk ratios for percentage of patients who developed catheter-associated urinary tract infection, for intervention versus control groups, stratified by type of intervention to prompt catheter removal.

<table>
<thead>
<tr>
<th>Study (Year)</th>
<th>RR (95% CI)</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reminder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Huang (2004)</td>
<td>0.64 (0.49, 0.86)</td>
<td>22.54</td>
</tr>
<tr>
<td>Crouzet (2007)</td>
<td>0.10 (0.01, 0.75)</td>
<td>2.41</td>
</tr>
<tr>
<td>Subtotal (I-squared = 69.7%, p = 0.069)</td>
<td>0.33 (0.06, 1.95)</td>
<td>24.95</td>
</tr>
<tr>
<td>Stop Order</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comia (2003)</td>
<td>1.57 (0.41, 6.09)</td>
<td>4.79</td>
</tr>
<tr>
<td>Topal (2005)</td>
<td>0.63 (0.33, 1.22)</td>
<td>12.89</td>
</tr>
<tr>
<td>Robinson (2007)</td>
<td>0.35 (0.14, 0.86)</td>
<td>8.78</td>
</tr>
<tr>
<td>Loeb (2008)</td>
<td>0.99 (0.35, 2.80)</td>
<td>7.25</td>
</tr>
<tr>
<td>Seguin (2010)</td>
<td>0.71 (0.40, 1.28)</td>
<td>14.66</td>
</tr>
<tr>
<td>Subtotal (I-squared = 4.2%, p = 0.383)</td>
<td>0.68 (0.47, 0.97)</td>
<td>48.38</td>
</tr>
<tr>
<td>Both</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Van den Broek (2011)</td>
<td>1.01 (0.93, 1.09)</td>
<td>26.67</td>
</tr>
<tr>
<td>Subtotal (I-squared = .5%, p = .)</td>
<td>1.01 (0.93, 1.09)</td>
<td>26.67</td>
</tr>
<tr>
<td>Overall (I-squared = 68.0%, p = 0.003)</td>
<td>0.72 (0.52, 0.99)</td>
<td>100.00</td>
</tr>
</tbody>
</table>

**NOTE:** Weights are from random effects analysis

**Figure 4** Meta-analysis of the standardised mean difference in days of urinary catheter use, for intervention versus control groups, stratified by type of intervention to prompt catheter removal.

<table>
<thead>
<tr>
<th>Study (Year)</th>
<th>SMD (95% CI)</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reminder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Huang (2004)</td>
<td>-2.81 (-2.67, -2.54)</td>
<td>11.17</td>
</tr>
<tr>
<td>Saint (2005)</td>
<td>-0.08 (-0.16, -0.01)</td>
<td>11.17</td>
</tr>
<tr>
<td>Apsirathanark (2007)</td>
<td>-4.52 (-4.67, -4.37)</td>
<td>11.15</td>
</tr>
<tr>
<td>Crouzet (2007)</td>
<td>-0.19 (-0.45, 0.07)</td>
<td>11.11</td>
</tr>
<tr>
<td>Reilly (2008)</td>
<td>-0.28 (-0.56, 0.00)</td>
<td>11.10</td>
</tr>
<tr>
<td>Subtotal (I-squared = 99.9%, p &lt; 0.001)</td>
<td>-1.54 (-3.20, 0.13)</td>
<td>55.70</td>
</tr>
<tr>
<td>Stop Order</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comia (2003)</td>
<td>-0.72 (-1.21, -0.24)</td>
<td>10.95</td>
</tr>
<tr>
<td>Stephan (2006)</td>
<td>-0.20 (-0.37, -0.03)</td>
<td>11.15</td>
</tr>
<tr>
<td>Loeb (2008)</td>
<td>-0.28 (-0.43, -0.13)</td>
<td>11.15</td>
</tr>
<tr>
<td>Andreessen (2012)</td>
<td>-0.62 (-0.97, -0.27)</td>
<td>11.05</td>
</tr>
<tr>
<td>Subtotal (I-squared = 60.4%, p = 0.056)</td>
<td>-0.37 (-0.56, -0.18)</td>
<td>44.30</td>
</tr>
<tr>
<td>Overall (I-squared = 99.8%, p &lt; 0.001)</td>
<td>-1.06 (-2.18, 0.07)</td>
<td>100.00</td>
</tr>
</tbody>
</table>

**NOTE:** Weights are from random effects analysis
的重要性。"Execute, Evaluate." 64 65 在使用中，在多种格式中，一个工具包描述了这种方法19：在有症状的CAUTI。63

提供显着和临床重要的减少（例如银合金和硝酸furazone-releasing导管）在选择的患者中高风险感染。在2012年11月，一个期待已久的多中心RCT表现了一个缺少导管替代物在选定的结局上的临床意义，和在选定的结局上进一步研究是需要的，包括一个全州的倡议20

bundles作为减少导管替代物的重要手段。例如，一个膀胱束由密歇根公共卫生和医院协会（MHA）Keystone中心的患者安全及质量是‘ABCDE’方法19：

- 遵守一般感染控制原则是重要的（如，手卫生和使用反馈、无菌插入和维护教育）。
- 尿道声波可能避免留置导尿。
- 导尿管或其他替代品作为留置导尿管，应该在合适的患者中使用。
- 不应该使用留置导尿管，除非你必须！
- 早期移除导管使用一个指征或护士发起移除程序，出现了可预见的结果。

几个研究24 28 44 46 包括膀胱束作为减少导管使用和/或CAUTI的手段，包括一个全州的倡议20 导致显著增加在合适情况下导管使用适当的指征（范围从44.3%到57.6%，p=0.005）。

**实施考虑**

**What methods have been used to improve the implementation of interventions to prevent catheter-associated urinary tract infections?**

减少不必要的导管使用经常要求改变已成习惯和信念的护士和医生，实施计划的挑战不应该被低估。为了提高CAUTI预防的实施，使用了约翰霍普金斯大学的协作模型。这个模型基于四个方面：Engage, Educate, Execute, Evaluate。64 在“Engage”和“Educate”步骤中，医院提供了信息在多种格式中，并提供了一个工具包描述了实施步骤和结果。在“Execute”步骤中，医院被强烈鼓励选择一个护士倡导者50 65（例如，一个护理长，护士协调员，或临床护士专家）来领导计划和组织一个护理包团队，包括至少一个医生，并参与研讨会和电话会议，与其他参与医院提供额外的专家内容和实践指导。在“Execute”步骤中，每天患者圆桌（在一些医院被称为“导管巡逻”）被推荐为评估导管使用和必要性，可反馈到具体的单位和重评估任何障碍的进步和可持续性。

实施挑战在CAUTI预防中应该被预期66并相应管理。定性评估聚焦于HAI预防已经识别出两种重要的潜在障碍到HAI预防性努力：活跃抵触者和‘组织性便秘患者’。67 活动抵触者是医院人员谁强烈并公开地反对改变，在权威强制遵守性的，收集数据和硬反馈。67 活动抵触者是影响性，可能有助于超出活动性抵触。65 66 ‘组织性便秘患者’通常中等的或高级的执行官为障碍改变的预防或延迟某些行动需要来实施新的实践。67 保护目标地址这个抵触者的人在早期讨论中来提高买和动机，围绕这个人，或替换这个抵触者。

一个独特的挑战在于实施尿道移除策略时，一些护士不习惯移除导管，66 即使护士是‘授权’的。在一些情况下，护士可能作为活动抵触者，对不同意与导管政策和/或一个愿望避免不便和增加患者的接触频率，导管政策/或一个愿望避免不便和增加患者的接触频率，导管政策/或一个愿望避免不便和增加患者的接触频率。需要考虑导管的护理意外。其他护士报告他们可能不习惯移除导管，59 移除导管的便利和舒适。
catheter without explicit orders from the physician, which is ironic considering that many nurses place catheters without orders. Nursing comfort with catheter removal can be increased with peer support and education, and may be facilitated by directly addressing the workload concerns associated with the removal of indwelling catheters. Indeed, a survey of nurses during implementation of a nurse-empowered catheter removal protocol indicated increased nursing and patient satisfaction, despite the expected increase in workload. Recent successful and sustainable multimodal interventions to decrease catheter use including nurse-driven efforts had bedside nurses who, by survey, viewed themselves as responsible for evaluation of catheter presence and need, had confidence in their knowledge, and viewed physicians as receptive to their requests regarding catheter removal.

Even though CAUTI is a very common HAI, Krein and colleagues reported that CAUTI preventive practice is lagging behind efforts to prevent central line-associated bloodstream infection and ventilator-associated pneumonia, with room for improvement in adopting catheter removal and CAUTI preventive strategies demonstrated again in two recent large surveys of hospitals and ICUs. Fortunately, many resources exist (http://www.catheterout.org) to help hospitals develop and implement programmes to decrease catheter use and prevent CAUTI, including a range of tools and educational materials to address implementation challenges. Hospital and unit-level leadership also play a key role in preventing infection.

Monitoring and providing feedback on catheter use and CAUTI rates

Inappropriate urinary catheter use is an easy habit to start and a difficult one to break. Consequently, many studies have emphasised the importance of on-going surveillance and feedback as an intervention to reduce HAIs, such as CAUTI, and sustain strategies. Prevention efforts. New national efforts to reduce CAUTI (http://www.onthecuspstophais/) incorporate periodic feedback to participating units on urinary catheter use and CAUTI rates. The CAUTI rates evaluated include the National Healthcare Safety Network (NHSN) and the newly described population-based rates. The population-based CAUTI rate incorporates both the NHSN rate and the device utilization ratio, to account for interventions focused on reduction in catheter use and improvements in placement and maintenance.

Importantly, the next steps to address CAUTI involve developing strategies to decrease the effort, and resources required to monitor catheter use and CAUTI rates. Advanced informatics tools have recently been shown to increase the impact of this feedback loop to the extent that rates of CAUTI were lower in facilities that deployed these tools compared to those that did not. Careful selection or development of datasets used for implementing hospital payment changes and public reporting for CAUTI events is also recommended. Unfortunately, the current administrative data used to implement non-payment for hospital-acquired CAUTIs, and to publicly report hospital performance, likely captures few CAUTI events, given documentation and coding challenges to translate a UTI event from a medical record into hospital-acquired CAUTI in the administrative datasets.

What is the cost of implementing a CAUTI prevention program?

The cost of implementing a CAUTI prevention programme will vary based on the level of technology used (eg, computerised vs preprinted catheter orders, and whether portable bladder ultrasounds are purchased) and the time invested in implementing and evaluating the interventions. Saint and colleagues, in their study of a written urinary catheter reminder generated by a research nurse to remind physicians which of their inpatients had urinary catheters, found that the intervention was either cost-neutral or modestly cost-saving depending on the assumptions made. More recently, a study of five hospitals in The Netherlands employed a multimodal intervention including reminders in four hospitals, and a stop order in the fifth hospital. The programme was found to be cost saving, with the mean amount saved being €537 (or ~$US$700) per 100 hospitalised patients.

DISCUSSION

In summary, healthcare providers should strongly consider employing interventions to avoid unnecessary catheter placement (such as catheter placement restrictions) and to prompt removal of unnecessary catheters by reminders and stop orders, with special consideration for nurse-initiated removal protocols. The strength of the evidence is moderate to high. These interventions appear to be low cost, low risk, effective and sustainable strategies to address a common hospital-acquired infection in the USA, with some unique but not impossible challenges for implementation. Moreover, UTIs are increasingly caused by multidrug-resistant organisms (MDROs) including strains that are resistant to all available therapeutic agents; preventing CAUTI may help patients avoid MDRO infection.

Identifying and supporting an appropriate ‘champion’ who is influential among staff can be crucial to help overcome resistance to change behaviour regarding catheter use and facilitate the adoption of preventive strategies. Monitoring and providing feedback of catheter use and CAUTI rates is important in the implementation and continued use of CAUTI preventive strategies. Furthermore, reducing indwelling catheter use addresses the non-infectious complications of...
urinary catheter use such as catheter-related patient discomfort and immobility. Unfortunately, hospitals’ surveys have repeatedly demonstrated low and only slowly improving adoption of CAUTI preventive strategies, such as reminders, stop orders and condom catheters compared to higher rates of adoption of antimicrobial urinary catheters in non-federal hospitals. Yet, the negative results of a recent randomised controlled trial on the effectiveness of antimicrobial urinary catheters is expected to translate into reduced use of these catheters.

Interest and resources for preventing CAUTI is likely to grow due to expanding national initiatives focused on reducing hospital-acquired infections, including CAUTI, being implemented with a combination of mandated public reporting and reduced pay to hospitals. Current prevention efforts include a 50-state initiative—’On the CUSP: Stop CAUTI’—that is funded by the AHRQ and led by the Health Research and Educational Trust (HRET) of the American Hospital Association. AHRQ has made available a toolkit for CAUTI prevention (http://www. onthecusptopahai.org/on-the-cusptop-cauti/toolkits-and-resources/). This initiative is providing resources and implementation expertise to hospitals and state organisations that are beginning CAUTI prevention programmes, with a goal of reducing CAUTI rates by 25% by focusing on high-yield interventions such as those reducing urinary catheter use.

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**Contributors**  JM and SS designed the systematic review, conceived the manuscript, and assembled the authorship team. JM performed the systematic review and abstracted the data required for the review overall (as summarised in text and tables) and the meta-analysis, and wrote the first draft of the manuscript. JM and MAMR had full access to the data reviewed and analysed for this study; MAMR conducted the meta-analysis, and interpreted the results. JM and MAMR take responsibility for the integrity and accuracy of the data for the meta-analysis; JM (the guarantor) also takes responsibility for the integrity and accuracy of all data summarised in the manuscript. MAMR and SS also reviewed and revised the manuscript critically for important intellectual content. SLK, MGF, and RNO also contributed substantially to design of the manuscript, and reviewed and edited the manuscript for important intellectual content. All authors approved the final version to be published.

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**Key summary points**

- Multiple before-and-after studies have found that interventions to decrease inappropriate catheter placement (such as catheter placement restrictions or urinary retention protocols) have resulted in decreased catheter use, fewer catheters in place without physician orders, and fewer catheters in place without an appropriate indication.
- An updated systematic review and meta-analysis found that catheter reminders or stop orders decreased catheter-associated urinary tract infections (CAUTIs) by 53%. An updated literature review identified many recent interventions with reminders or stop orders reducing CAUTI rates and/or urinary catheter use.
- Bundles of interventions focusing on strategies to reduce unnecessary catheter use (by avoiding unnecessary placement and prompt removal) and decrease CAUTI rates by general infection control principles (hand hygiene, surveillance/feedback, aseptic insertion, etc) have been successful, particularly when coupled with implementation strategies to address common barriers encountered when trying to change well-established habits of physicians and nurses.
- The role of antimicrobial catheters in preventing CAUTI has been addressed by a recent large randomised controlled trial showing no significant additional benefit in reducing symptomatic CAUTIs.
- CAUTI prevention costs vary by programme, but such programmes have been demonstrated to be cost saving.
interests exist. All statements expressed in this work are those of the authors and should not in any way be construed as official opinions or positions of the RAND Corporation, US Department of Veterans Affairs, AHRQ, or the US Department of Health and Human Services.

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