

# Systematic Review and Meta-Analysis: Reminder Systems to Reduce Catheter-Associated Urinary Tract Infections and Urinary Catheter Use in Hospitalized Patients

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**Background.** Prolonged catheterization is the primary risk factor for catheter-associated urinary tract infection (CAUTI). Reminder systems are interventions used to prompt the removal of unnecessary urinary catheters. To summarize the effect of urinary catheter reminder systems on the rate of CAUTI, urinary catheter use, and the need for recatheterization, we performed a systematic review and meta-analysis.

**Methods.** Studies were identified in MEDLINE, the Cochrane Library, Biosis, the Web of Science, EMBASE, and CINAHL through August 2008. Only interventional studies that used reminders to physicians or nurses that a urinary catheter was in use or stop orders to prompt catheter removal in hospitalized adults were included. A total of 6679 citations were identified; 118 articles were reviewed, and 14 articles met the selection criteria.

**Results.** The rate of CAUTI (episodes per 1000 catheter-days) was reduced by 52% ( $P < .001$ ) with use of a reminder or stop order. The mean duration of catheterization decreased by 37%, resulting in 2.61 fewer days of catheterization per patient in the intervention versus control groups; the pooled standardized mean difference (SMD) in the duration of catheterization was  $-1.11$  overall ( $P = .070$ ), including a statistically significant decrease in studies that used a stop order (SMD,  $-0.30$ ;  $P = .001$ ) but not in those that used a reminder (SMD,  $-1.54$ ;  $P = .071$ ). Recatheterization rates were similar in control and intervention groups.

**Conclusion.** Urinary catheter reminders and stop orders appear to reduce the rate of CAUTI and should be strongly considered to enhance the safety of hospitalized patients.

Catheter-associated urinary tract infection (CAUTI) is common in hospitalized patients. Given its potential preventability, hospital-acquired CAUTI was among the first complications selected for nonpayment by the Centers for Medicare and Medicaid Services [1–4]. The greatest risk factor for CAUTI is prolonged catheterization [5, 6]. Urinary catheters often are placed unnecessarily [7], remain in use without physician awareness [8], and are not removed promptly when no longer needed [7, 9]. Catheters also cause discomfort, restrict

mobility, and delay hospital discharges [10–12]. Interventions that prompt removal of unnecessary catheters may therefore enhance patient safety. Yet a recent national study demonstrated that hospitals direct little attention to monitoring or reducing urinary catheter use [13], thus permitting many catheters to remain in place by default. We hypothesized that CAUTIs could be decreased by interventions that facilitate the removal of unnecessary catheters. We thus performed a systematic literature review and meta-analysis to evaluate the effect of interventions that remind clinicians of the presence of urinary catheters to prompt the timely removal of catheters during hospitalization.

## METHODS

**Data sources and searches.** We searched the medical literature regarding interventions to decrease CAUTIs. In August 2008, we searched the literature by means of the MEDLINE and Cochrane databases (using Ovid),

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**Figure 1.** Study selection process.

the PubMed Journals and Medical Subject Heading (MeSH) databases, the ISI knowledge databases (Web of Science and Biosis Previews), and the CINAHL and EMBASE databases. Our searches used variations and combinations of the following Medical Subject Heading terms (tailored for each database, as detailed in the Appendix, which appears only in the online version of the journal): *urinary tract infection, urinary catheterization, indwelling catheter, inpatient, reminder system, device removal, and intervention studies*. We also evaluated the reference lists of articles, which yielded an additional article for consideration. A research librarian provided guidance to improve search completeness.

**Study selection.** The main inclusion criterion required the study to evaluate an intervention that functioned to remind physicians or nurses to remove unnecessary urinary catheters. The second criterion required the inclusion of at least 1 relevant outcome (either CAUTI rates, urinary catheter use, or need for catheter replacement) and a comparison group. The study selection process is shown in Figure 1. Correspondence was initiated with 24 authors to clarify details regarding the reminder intervention and outcomes; responses were received from 11 authors [9, 14–23]. Four authors provided unpublished numeric data necessary for statistical pooling [16–18, 21].

**Data extraction and quality assessment.** Two authors

(J.M. and M.M.) independently reviewed and abstracted data from the 16 articles that appeared to meet the inclusion criteria. Abstracted data included setting, study population characteristics, inclusion and exclusion criteria, definitions used, health outcomes, and quality issues. A third investigator (S.S.) resolved any differences in abstraction and reviewed the joint decisions made to exclude 2 [20, 24] of the 16 articles that no longer met the inclusion criteria after further review during abstraction.

**Reminder system interventions.** Abstractors classified the reminder system intervention as either a reminder only or as a stop order. A reminder intervention functioned simply to remind either a physician or nurse that the catheter was still in place and that removal was recommended if no longer necessary; some reminders included a list of appropriate indications. In contrast, a stop-order intervention served to prompt the clinician to remove the catheter by default after either a certain time period or a set of clinical conditions occurred, unless the catheter remained clinically appropriate. Catheter stop orders “expire” in the same fashion as restraint or antibiotic orders, unless action was taken by physicians. Stop orders directed at physicians [25] required an order to renew or discontinue the catheter on the basis of review at specific intervals, such as every 24 to 72 h or on specific postprocedure days. Stop orders directed at nurses empowered nurses to remove the catheter on the basis of a list of indications [17, 19, 22, 26] without requiring the nurse to obtain a physician-signed order before removing the catheter.

**Data synthesis and analysis.** As defined in Table 1, out-

**Table 1. Description of Outcomes Evaluated**

Outcome, measure	Description
<b>Outcome 1: Measures of CAUTI development</b>	
Measure 1: Mean no. of CAUTI episodes per 1000 catheter-days	The mean no. of CAUTI episodes per 1000 catheter-days was extracted, and a rate ratio was calculated to compare pre- vs post-intervention data. When rates of both asymptomatic and symptomatic CAUTI were reported separately [19], the rates of symptomatic CAUTI were used for the meta-analysis.
Measure 2: Cumulative risk of CAUTI during hospitalization	The cumulative risk of CAUTI during hospitalization (ie, the percentage of patients who developed CAUTI) was extracted for each study, and a risk ratio was calculated to compare risks before and after the intervention.
<b>Outcome 2: Measures of urinary catheter use</b>	
Measure 1: Mean no. of days of urinary catheter use per patient	The mean no. of days of urinary catheter use per patient was extracted from before and after the intervention. A SMD was calculated to compare the 2 groups.
Measure 2: Percentage of patient-days during which the catheter was in place	The percentage of patient-days during which the catheter was in place was calculated before and after the intervention, and a SMD was determined for each study.
<b>Outcome 3: Need for urinary catheter replacement</b>	
	The recatheterization need was extracted as the no. and percentage of patients who required replacement of a urinary catheter after prior removal of an indwelling catheter.

**NOTE.** CAUTI, catheter-associated urinary tract infection; SMD, standardized mean difference.

**Table 2. Characteristics of the 14 Studies Selected for Systematic Review**

Source (country)	Study design	Population, total no.	Description of reminder system intervention	Other interventions
Stop order to remove UC				
Loeb et al, 2008 (Canada) [19]	Randomized controlled trial	Medical (non-ICU), $n = 692$ patients	Prewritten stop order in chart for nurses to discontinue UC on the basis of criteria; no additional physician order needed	None
Topal et al, 2005 (United States) [26]	Pre-post	Medical (non-ICU), $n = 245$ patients	Computerized order entry system-generated stop order to prompt physicians to remove/reorder UC if placed in emergency department or in place for >48 h; nurses empowered to remove UCs no longer needed by protocol criteria	UC care education, bladder scanner protocol for urinary retention
Stephan et al, 2006 (Switzerland) [22]	Pre-post with concurrent nonequivalent control subjects	Surgery: ward plus ICU; pre-post intervention group: <sup>a</sup> orthopedic surgery, $n = 539$ ; control group: abdominal surgery, $n = 489$	Preoperative written stop order to remove UC on postoperative day 1 or 2, depending on surgery	UC placement restrictions, UC care education, urinary retention protocol
Cornia et al, 2003 (United States) [25]	Nonrandomized crossover trial	Medical (non-ICU), $n = 70$ patients	Computer-generated stop order; physicians to discontinue or renew UC order 72 h after placement	UC placement restriction, UC care education
Dumigan et al, 1998 (United States) [17]	Pre-post	ICU: med-surgical, $n = 27,103$ patient-days	Daily use of UC indication protocol by nurse empowered to remove UC no longer meeting criteria without requesting physician order	UC placement restriction, UC care education
Reminder to remove UC				
Apisarntharak et al, 2007 (Thailand) [15]	Pre-post	All inpatients, $n = 2412$ patients	Nurse-generated daily bedside verbal reminders to encourage physicians to remove unnecessary UC	None
Crouzet et al, 2007 (France) [16]	Pre-post	All inpatients, $n = 234$ patients	Daily reminders from nurses to physicians to remove unnecessary UC $\geq 4$ days after insertion	None
Saint et al, 2005 (United States) [21]	Pre-post with concurrent nonequivalent control subjects	Pre-post intervention group: <sup>a</sup> medical, $n = 3027$ ; control group: med-surgical, $n = 2651$	Study nurse-generated sticker placed in chart reminding physician to generate stop order after 48 h of UC use if no longer needed	None
Huang et al, 2004 (Taiwan) [31]	Pre-post	ICU: med-surgical, $n = 6297$ patients	Nurse-generated daily reminder to physician to remove unnecessary UC 5 days after insertion	None
Fakih et al, 2008 (United States) [9]	Pre-post with concurrent control subjects	Med-surgical (non-ICU); pre-post intervention group: <sup>a</sup> $n = 3736$ patient-days; control group: $n = 4041$ patient-days	Nurse-generated reminder to physician to remove UC when no appropriate indication	None

**Table 2. (Continued.)**

Source (country)	Study design	Population, total no.	Description of reminder system intervention	Other interventions
Reilly et al, 2008 (United States) [29]	Pre-post	ICU: med-surgical, <i>n</i> = 207 patients	Daily use of checklist of appropriate UC indications by nurse, reminding nurse to contact physician to recommend UC removal	UC placement restriction, UC care education, urinary retention protocol
Jain et al, 2006 (United States) [18]	Pre-Post	ICU: med-surgical, <i>n</i> = 13,471 catheter-days (neither no. of patients nor no. of patient-days were available)	Daily use of checklist in multidisciplinary rounds to determine if UC still indicated; nurse reminded to contact physician for order to remove UC if no longer indicated	"Bladder bundle": UC care steps, selected use of silver alloy UC, regular assessment of UC need
Weitzel et al, 2008 (United States) [23]	Pre-post	Medical (unclear if ICU), <i>n</i> = 50 patients	Daily use of protocol by nurse to review if UC is still indicated; unclear if protocol allowed for UC removal without physician order	None
Murphy et al, 2007 (United States) [30]	Pre-post	Not explained, no. not provided	Foley bag sticker with time and date of insertion to remind nurse to notify physician when Foley bag in place >48 h to request removal	UC care education

**NOTE.** ICU, intensive care unit; med-surgical, medical and surgical patients; pre-post, preintervention-postintervention quasi-experimental study; UC, urinary catheter.

<sup>a</sup> This study was 1 of 3 pre-post intervention trials with concurrent controls. However, in the meta-analysis the preintervention group served as the control group to permit similar comparisons with other pre-post studies that did not provide concurrent control groups and because some control groups [21, 22] were from patient populations with important differences in diagnoses (compared with the pre-post intervention groups) that may affect urinary tract infection and catheter use rates (such as surgical vs medical patients). Thus, data from the concurrent controls in these 3 studies were not included in the meta-analysis.

comes were evaluated for CAUTI development (reported as the mean number of CAUTI episodes per 1000 catheter-days or the cumulative risk of CAUTI during hospitalization), urinary catheter use (reported as the mean number of days of urinary catheter use per patient or the percentage of patient-days during which the catheter was in place), and recatheterization need.

DerSimonian-Laird random effects models [27] were used to obtain pooled estimates of effect. When feasible, results were stratified by type of intervention (reminder vs stop order) and whether the study included only intensive care unit (ICU) patients. Heterogeneity among studies was assessed using between-study variance ( $\tau^2$ ), the Cochran Q test of heterogeneity, and Higgins and Thompson  $I^2$  (percentage of variability in the intervention attributable to heterogeneity) [28]. Metainfluence analyses were conducted to assess the effect on the pooled results of removing 1 study at a time. The number of avoided CAUTI episodes per 1000 catheter-days was calculated separately for reminder and stop-order interventions, given differing baseline rates of infection. The type I error rate was set at .05; all tests were 2-sided. Analyses were conducted using Stata/SE, version 10 (StataCorp).

## RESULTS

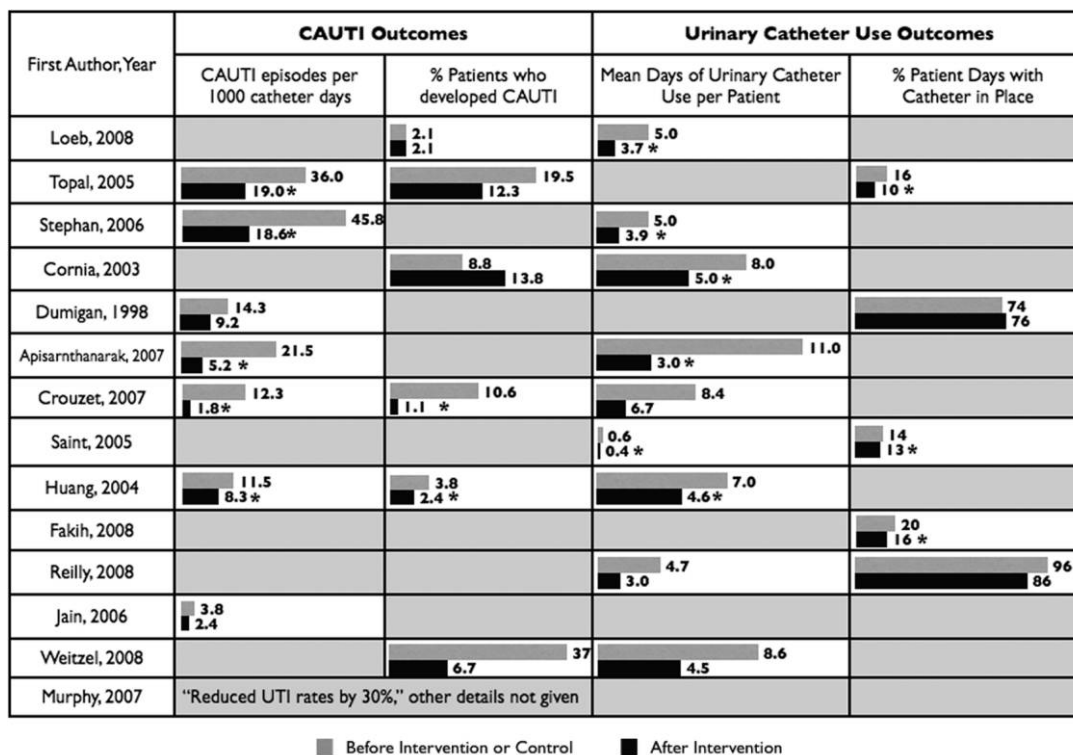
### Description of Studies

Our literature search yielded 6679 citations, of which 14 articles used a reminder or stop-order intervention to prompt removal of urinary catheters and reported pre- and postintervention outcomes for CAUTI rates, urinary catheter use, or recatheterization need that occurred without intervention (from the preintervention or control group) and after the intervention. Table 2 summarizes the characteristics of the 14 studies. Studies varied in the definitions used regarding CAUTI development and urinary catheter use, as detailed in Table 3.

The studies were performed in the United States [9, 17, 18, 21, 23, 25, 26, 29, 30], Canada [19], France [16], Switzerland [22], Taiwan [31], and Thailand [15]. All patients were >15

**Table 3. Study Characteristics regarding Urinary Tract Infection (UTI) and Catheter Use Definitions**

The table is available in its entirety in the online version of *Clinical Infectious Diseases*.



**Figure 2.** Summary of catheter-associated urinary tract infection (CAUTI) and urinary catheter use outcomes reported in selected studies. UTI, urinary tract infection. \* $P < .05$  (significant difference reported between before the intervention or control and after intervention).

years old and admitted for acute hospitalization. Some studies involved all inpatients [15, 16], yet most studies included only specific medical and/or surgical services [9, 19, 21–23, 25, 26] or focused on ICU patients only [17, 18, 29, 31].

Of the eligible studies, 1 was a randomized controlled trial. The 13 other trials were preintervention-postintervention quasi-experimental trials, including 1 nonrandomized crossover trial [25] and 3 preintervention-postintervention trials with concurrent control subjects [9, 21, 22]. In the meta-analysis, we used the concurrent control subjects as the comparison group for the randomized controlled trial [19] and the crossover trial [25]. For the remaining trials, the comparison group was the preintervention group.

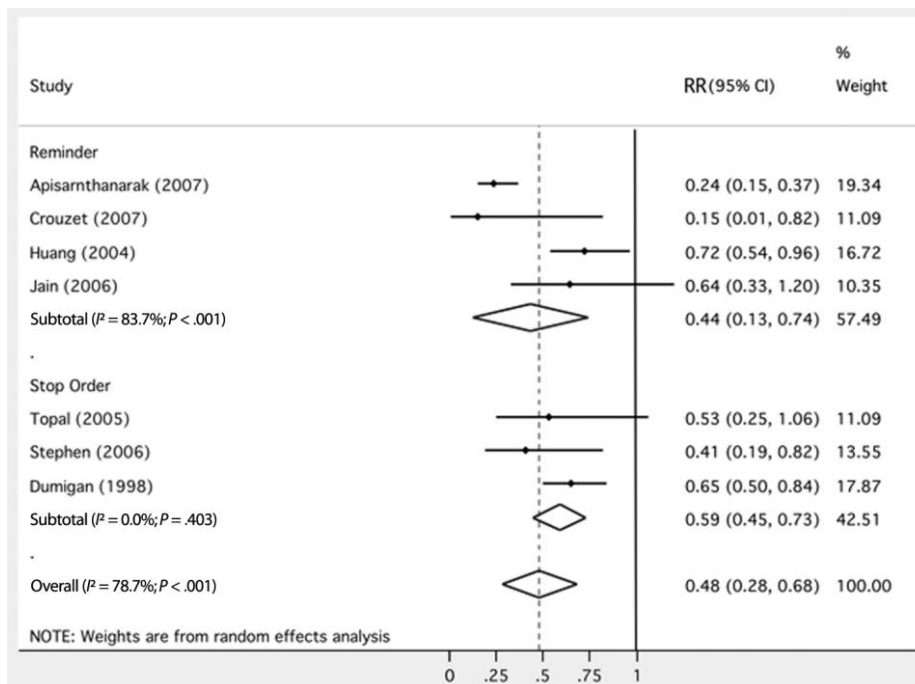
Although most studies reported sample size in terms of number of patients studied (ranging from 50 to 6297 patients), other studies reported sample size only in terms of patient-days and/or catheter-days [9, 17, 18]. One study did not provide any unit of sample size [30].

Intervention details varied among studies (Table 2). Five studies used stop orders, and 9 studies used reminder interventions. Intervention formats (detailed in Table 2) included routine verbal reminders, written or printed reminders or stop orders, and computerized order entry system-generated stop orders. Some reminders and stop orders were implemented as part of a daily checklist. Half of the studies examined a reminder

or stop order as the only intervention to decrease CAUTIs [9, 15, 16, 19, 21, 23, 31]. The remaining studies evaluated other interventions in addition to the reminder or stop-order intervention, such as education regarding hand hygiene and sterile catheter insertion [17, 18, 22, 25, 26, 29, 30] and urinary catheter restriction protocols [17, 22, 25, 29], often including evaluation of urinary retention by means of bladder scanners and alternatives to indwelling catheterization [22, 26, 29].

The duration of data collection varied, ranging from collection periods of days (range, 5–53 days) [9, 23, 26] to months (range, 2–30 months) [15–18, 21, 22, 25, 31], and was unspecified in 2 studies [29, 30]. Additionally, while most studies only collected 1 set of postintervention measures, a few studies collected 2 postintervention measures, with varying degrees of intervention implementation during a second postintervention period. For our meta-analysis, we used only the first postintervention measurements.

Follow-up time varied across studies for evaluation of each patient for CAUTI development, urinary catheter use, and recatheterization, such as follow-up until discharge from a particular service, until discharge from the hospital, or for a specific number of days after removal of the catheter. The most common quality issues seen throughout the studies included lack of information regarding incomplete data collection and blinding procedures used for research team members responsible for



**Figure 3.** Meta-analysis of rate ratios (RRs) for catheter-associated urinary tract infection (CAUTI) episodes per 1000 catheter-days, for intervention versus control groups. CI, confidence interval.

assessing catheter use or UTI status. No studies were reportedly funded by industry.

### Systematic Review of Evidence and Meta-analysis

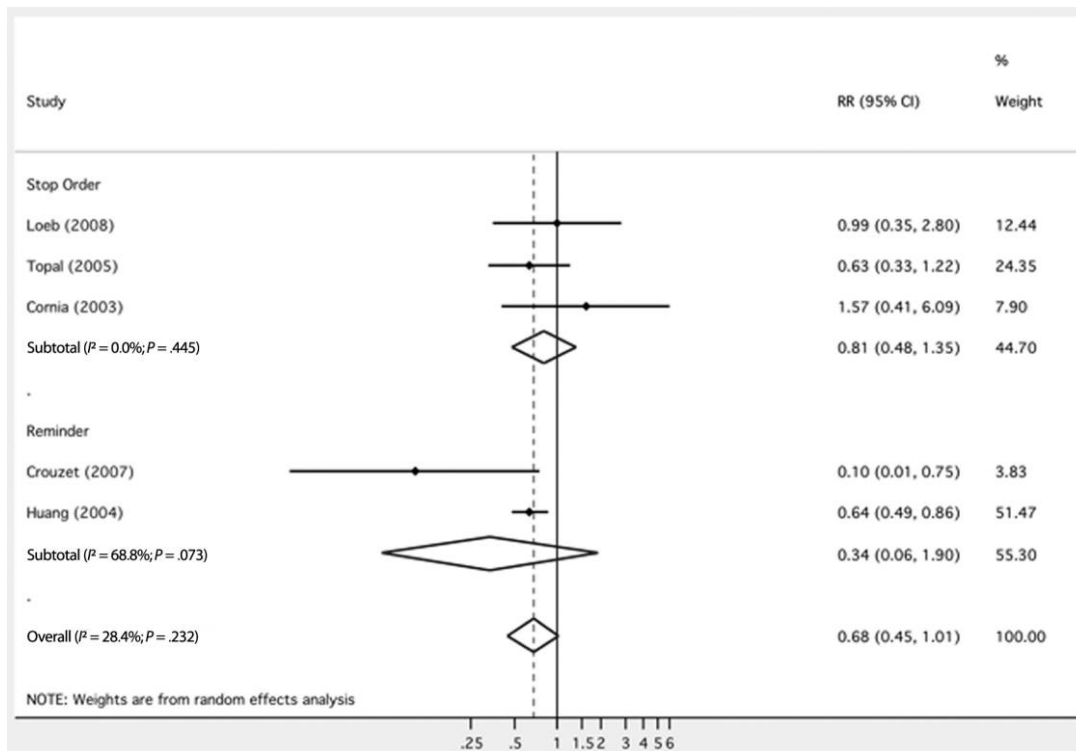
**CAUTI development.** Seven studies reported CAUTI episodes per 1000 catheter-days, the preferred reporting method requested by the National Health Safety Network surveillance program. All 7 reported a decrease in CAUTI episodes per 1000 catheter-days (Figure 2), and 5 demonstrated statistically significant results [15, 16, 22, 26, 31]. Use of a reminder intervention reduced the rate of CAUTI by 56% (rate ratio, 0.44; 95% confidence interval [CI], 0.13–0.74;  $P = .005$ ) (Figure 3). A stop-order intervention reduced the rate of CAUTI by 41% (rate ratio, 0.59; 95% CI, 0.45–0.73;  $P < .001$ ). Overall, the rate of CAUTI episodes per 1000 catheter-days was reduced by 52% (rate ratio, 0.48; 95% CI, 0.28–0.68;  $P < .001$ ) with the use of a reminder or stop order. Heterogeneity was much lower among the studies with interventions categorized as stop orders ( $I^2 = 0\%$ ;  $P = .403$ ;  $\tau^2 = 0.0000$ ) rather than as reminders ( $I^2 = 83.7\%$ ;  $P < .001$ ;  $\tau^2 = 0.0754$ ). When stratified by focus on ICUs (Figure 4), the use of either a reminder or stop order significantly reduced the rate of CAUTI in studies focused on ICUs by 33% (95% CI, 20%–45%;  $P < .001$ ) and in studies that were not restricted to ICUs by 73% (95% CI, 63%–83%;  $P < .001$ ). ICU service explained much of the heterogeneity in effect across studies, with  $I^2 = 0$  for both ICU-focused studies and other studies not restricted to ICU patients. Restriction of the

analyses to only those studies without additional interventions [9, 15, 16, 19, 21, 23, 31] did not change the findings; there was a significant reduction in CAUTI rates when the only intervention was the reminder or stop order (rate ratio, 0.38; 95% CI, 0.03–0.74;  $P = .036$ ). In addition, metainfluence analyses indicated that no individual study changed the reduction in risk.

Six studies reported the cumulative risk of CAUTI during a hospital stay for both intervention and comparison groups (Figure 2), and 5 provided sufficient detail for pooling (Figure 5). The risk ratio for CAUTI was 0.68 (95% CI, 0.45–1.01;  $P = .058$ ) for the intervention versus comparison groups. Stratification by type of intervention (Figure 5) did not yield significant differences in risk ratios for CAUTI for either stop-order (risk ratio, 0.81; 95% CI, 0.48–1.35;  $P = .412$ ) or reminder (risk ratio, 0.34; 95% CI, 0.06–1.90;  $P = .218$ ) interventions. When stratified by intensive care focus, the risk of CAUTI was significantly reduced by 36% (95% CI, 14%–51%;  $P = .002$ ) in the single study of ICU patients only but was not significantly

The figure is available in its entirety in the online edition of *Clinical Infectious Diseases*.

**Figure 4.** Meta-analysis of rate ratios (RRs) for catheter-associated urinary tract infection (CAUTI) episodes per 1000 catheter-days, stratified by focus on intensive care units (ICUs).



**Figure 5.** Meta-analysis of the risk ratios (RRs) for percentage of patients who developed catheter-associated urinary tract infections (CAUTIs), for intervention versus control groups. CI, confidence interval.

reduced in studies not restricted to ICU patients (risk ratio, 0.70; 95% CI, 0.33–1.50).

**Number of avoided CAUTI episodes per 1000 catheter-days.**

On the basis of the meta-analysis results (Figure 3), reminders and stop orders would be anticipated to result in larger numbers of avoided CAUTI episodes per 1000 catheter-days when baseline rates of CAUTI were higher (Table 4). The numbers of avoided CAUTI episodes per 1000 catheter-days were similar when stratified by intervention type (reminders vs stop orders); the analysis was limited by the small number of studies using each type of intervention.

**Urinary catheter use.** Overall, decreased catheter use was reported in all 11 studies publishing at least 1 outcome of catheter use [9, 15, 16, 19, 21–23, 25, 26, 29, 31] (Figure 2), with 8 studies revealing a statistically significant decrease between nonintervention groups and the first postintervention measure [9, 15, 19, 21, 22, 25, 26, 31]; only one study's unpublished data appeared to suggest slightly higher (but non-significant) urinary catheter use [17].

Nine studies reported urinary catheter use in terms of mean number of days of urinary catheter use per patient [15, 16, 19, 21–23, 25, 29, 31] (Figure 2). All 9 studies reported decreased catheter use with the intervention, including 6 with statistically significant decreased catheter use [15, 19, 21, 22, 25, 31]. The

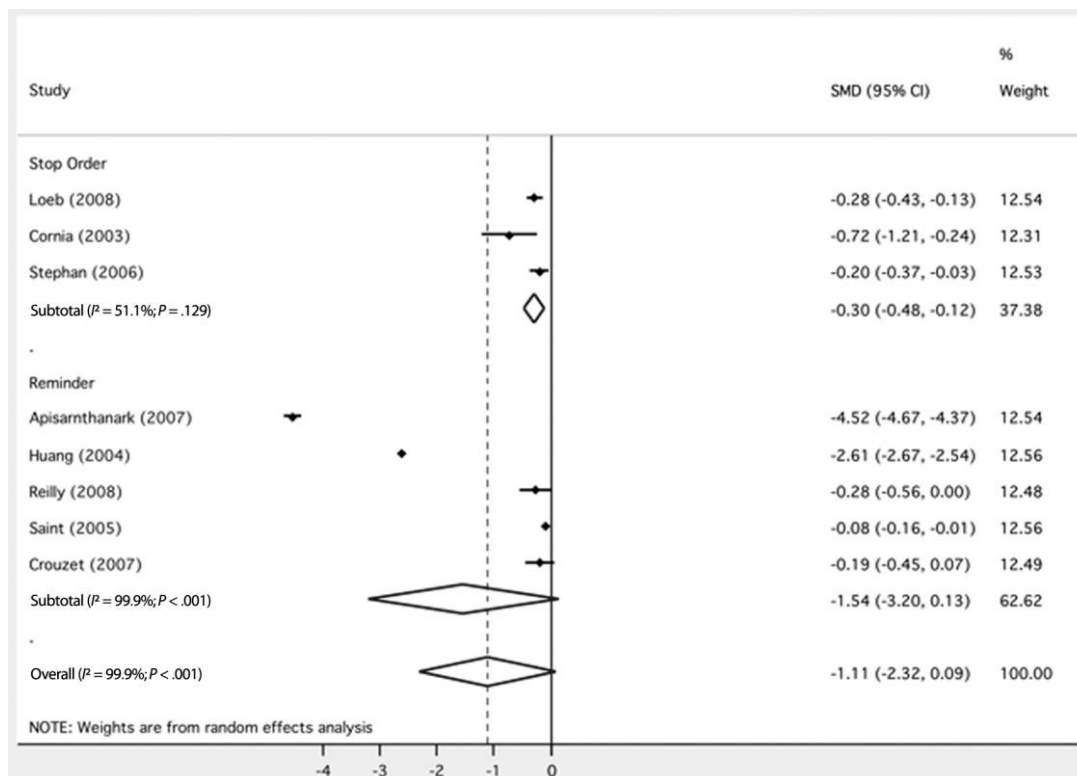
mean duration of catheterization decreased by 37%, resulting in 2.61 fewer days of catheterization per patient in the intervention versus control groups (Figure 2). Eight studies provided sufficient data to enable statistical pooling to assess the effect of the intervention on duration of catheterization (Figure 6); the pooled standardized mean difference (SMD) was  $-1.11$ , although this reduction was not significantly different from the null (95% CI,  $-2.32$  to  $+0.09$ ;  $P = .070$ ). A stop order sig-

**Table 4. Avoided Catheter-Associated Urinary Tract Infection (CAUTI) Episodes**

Baseline rate of CAUTI <sup>a</sup>	Intervention type		Overall (95% CI)
	Reminder only	Stop order	
5	2.8	2.0	2.6 (1.6–3.6)
10	5.6	4.1	5.2 (3.2–7.2)
20	11.2	8.2	10.4 (6.4–14.4)
30	16.8	12.3	15.6 (9.6–21.6)
40	22.4	16.4	20.8 (12.8–28.8)

**NOTE.** Data are the anticipated no. of avoided CAUTI episodes per 1000 catheter-days, both overall and by the type of intervention used to prompt removal of a urinary catheter. CI, confidence interval.

<sup>a</sup> No. of CAUTI episodes per 1000 catheter-days.



**Figure 6.** Meta-analysis of the standardized mean difference (SMD) in days of urinary catheter use, for intervention versus control groups. CI, confidence interval.

nificantly reduced urinary catheter use, with a SMD of  $-0.30$  (95% CI,  $-0.48$  to  $-0.12$ ;  $P < .001$ ). A reminder did not significantly reduce days of catheter use, yielding a SMD of  $-1.54$  (95% CI,  $-3.20$  to  $+0.13$ ;  $P = .071$ ). Heterogeneity was lower among the studies with interventions categorized as stop orders [19, 22, 26] ( $I^2 = 51.1\%$ ;  $P = .129$ ;  $\tau^2 = 0.012$ ) rather than as reminders [15, 16, 21, 29, 31] ( $I^2 = 99.9\%$ ;  $P < .001$ ;  $\tau^2 = 3.61$ ), although the direction of the effect (ie, reduction from the null) was consistent across all studies.

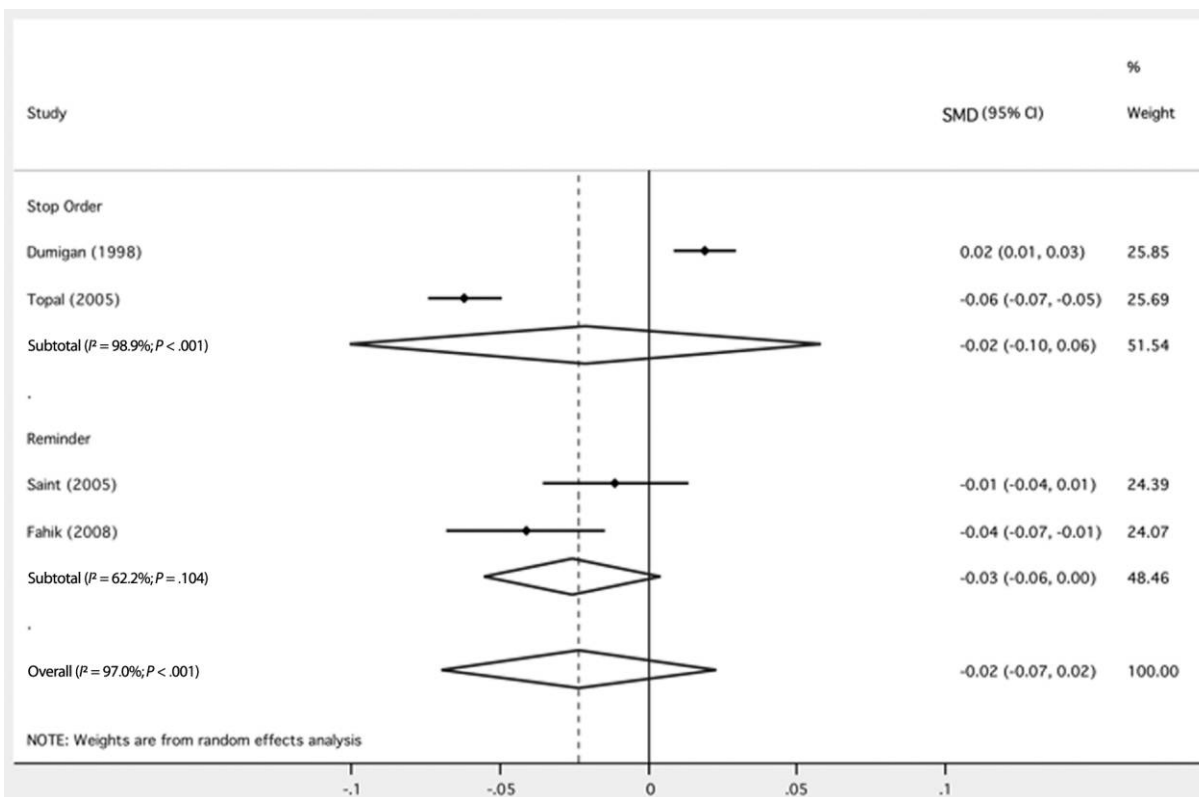
Five studies reported or collected data on urinary catheter use in terms of percentage of patient-days with urinary catheter used [9, 17, 21, 26, 29] (Figure 2). When pooled, the difference between the intervention group and the comparison group trended toward fewer patient-days with urinary catheters, yet the difference was not statistically significant overall (Figure 7) for either stop orders ( $P = .597$ ) or reminders ( $P = .087$ ). Heterogeneity was greater among the studies with interventions categorized as stop orders [17, 26] ( $I^2 = 98.9\%$ ;  $P < .001$ ;  $\tau^2 = 0.0032$ ) than in studies with reminders [9, 21] ( $I^2 = 62.2\%$ ;  $P = .104$ ;  $\tau^2 = 0.0003$ ).

**Need for replacement of urinary catheter after removal.** Only 4 studies reported rates of recatheterization [16, 19, 21, 25]. Recatheterization rates were similarly low for both intervention and control groups (Table 5).

## DISCUSSION

Urinary catheter reminders and stop orders decreased the rate of CAUTI by half. Through the routine use of reminder or stop orders, we estimate that among hospitalized adults 10 CAUTI episodes would be avoided for every 1000 catheter-days if baseline rates are high (ie, 20 episodes per 1000 catheter-days) and that 3 episodes would be avoided for every 1000 catheter-days if baseline rates are low (ie, 5 episodes per 1000 catheter-days). The mean duration of catheterization was consistently lower in the intervention group across all studies but was not statistically different from that in the control group ( $P = .070$ ). Even 1 fewer day of catheter use could be clinically important, given that the risk of CAUTI increases daily [5, 6]. There are also significant noninfectious benefits to limiting the use of urinary catheters [10–12].

In most hospitals [32], 4 key steps are required in the life cycle of the urinary catheter before removal from the patient: (1) the physician recognizes that a urinary catheter is present; (2) the physician recognizes that the catheter is unnecessary; (3) the physician writes the order for catheter removal; and (4) the nurse removes the catheter in response to the physician order. In contrast, the catheter reminders and stop orders evaluated in this study have the potential to bypass several of these



**Figure 7.** Meta-analysis of the standardized mean difference (SMD) in percentage of days catheterized, for intervention versus control groups. CI, confidence interval.

steps, leading to the routine and prompt removal of unnecessary catheters. Thus, reminders and stop orders can be important and simple tools to enhance patient safety and comfort. Given that catheter reminders and stop orders were beneficial regardless of the technology used—from verbal bedside reminders to computer-generated stop orders—these interventions appear to be low-cost strategies that could be implemented in any health care system.

Several limitations of the existing literature and our review and analyses deserve comment. The available 14 studies in-

cluded only 1 randomized controlled trial, with the remaining 13 trials using either preintervention versus postintervention comparisons or concurrent control subjects. There were differences across studies in terms of the populations investigated and details of the reminder and stop-order interventions (Table 2), as well as inclusion and exclusion criteria regarding the outcomes of urinary catheter use and CAUTI development (Table 3). Fortunately, we were provided with many additional details in our communications with authors, filling in important gaps. Half of the studies evaluated other interventions

**Table 5. Need for Urinary Catheter Replacement after Removal**

Study	Reported needs for recatheterization
Loeb et al, 2008 [19]	In this randomized controlled trial, 7.0% ( $n = 22$ ) of 345 catheterized patients in the control group required recatheterization, and 8.6% ( $n = 27$ ) of 347 catheterized patients in the intervention group required recatheterization; rates were not significantly different ( $P = .45$ )
Crouzet et al, 2007 [16]	7.8% ( $n = 11$ ) of 141 preintervention catheterized patients required recatheterization after catheter removal, and 12.9% ( $n = 12$ ) of 93 postintervention catheterized patients required recatheterization after catheter removal; rates were not significantly different ( $P = .19$ )
Saint et al, 2005 [21]	0.75% ( $n = 20$ ) of 2651 concurrent control patients (including those who were never catheterized) required recatheterization the same day as catheter removal, and 0.63% ( $n = 19$ ) of 3027 pre- and postintervention patients (including noncatheterized patients) required recatheterization; recatheterization rates were not significantly different between the pre- and postintervention patients and the control patients ( $P = .41$ )
Cornia et al, 2003 [25]	7.1% ( $n = 5$ ) of patients in the total study population required recatheterization, and for only 1 of these patients had the catheter been removed in response to a stop order

aimed at reducing infection risk or catheter use, in addition to the reminder or stop-order intervention (Table 2). However, restriction to studies using only a reminder or stop-order intervention also yielded a significantly reduced rate of CAUTI, suggesting that it was this particular intervention that produced the reduction in infection rates.

Of all pooled results, only the summary measures for rates of CAUTI episodes per 1000 catheter-days were statistically significant. These results were robust to various sensitivity analyses. Of the 2 measures of CAUTI evaluated (Table 1), CAUTI episodes per 1000 catheter-days is the preferred measure for determining the incidence of infection because it more accurately reflects both the occurrence of infection in the patient and the time at risk (ie, time being incorporated in the denominator of the rate). On the other hand, the risk ratio (percentage of patients who developed CAUTI) does not use time within the measure; therefore, patients should be observed for a consistent amount of time for comparison purposes. We suspect that the lack of significance of the pooled results for the risk ratio could in part be due to variability in the time under observation across the studies. In addition, the pooled results regarding mean number of days catheterized did not reach significance ( $P = .070$ ). Because each of the studies found fewer mean numbers of days catheterized for the intervention group, variation in the number of days catheterized for individual patients within each study (yielding higher standard deviations) may have contributed to the nonsignificance in the pooled SMD. Furthermore, interventions that restricted initial catheter placement [17, 22, 25, 29] may have resulted in an overall benefit—with fewer patients being catheterized and fewer CAUTIs—yet this could manifest as less of an effect on urinary catheter use per *catheterized* patient, given that some studies included and reported only urinary catheter outcomes for catheterized patients [25, 29].

In summary, interventions to routinely prompt physicians or nurses to remove unnecessary urinary catheters significantly decrease the rate of CAUTI, and no evidence indicates that these interventions increase the need for recatheterization. Urinary catheter reminders and stop orders have the potential to improve patient safety by changing the default status of urinary catheters from persistent use to timely removal. Given the large burden of CAUTI, it is surprising that only ~1 in 10 US hospitals use reminders or stop orders [13]. We hope that our results will encourage more hospitals to adopt reminders or stop orders as low-cost interventions that enhance patient safety.

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