Catheter-Associated Urinary Tract Infections in the Adult Patient Group: A Qualitative Systematic Review on the Adopted Preventative and Interventional Protocols From the Literature

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Abstract

Catheter-associated urinary tract infections (CA-UTIs) are among the most common nosocomial infections associated with urinary catheters, use, and the need for re-catheterization on the rate of CA-UTIs, we performed a systematic review. A rapid evidence analysis was carried out in the Medline (via Ovid) and the Cochrane Library for the periods of January 2005 till April 2021. The main inclusion criterion required to be included in this review was symptomatic CA-UTI in adults as a primary or secondary outcome in all the included studies. Only randomized trials and systematic reviews were included, reviewed, evaluated, and abstracted data from the 1145 articles that met the inclusion criteria. A total of 1145 articles were identified, of which 59 studies that met the inclusion criteria were selected. Studies of relevance to CA-UTIs were based on: duration of catheterization, indication for catheterization, catheter types, UTI prophylaxis, educational proposals and approaches, and mixed policies and interventions. The duration of catheterization is the contributing risk factor for CA-UTI incidence; longer-term catheterization should only be undertaken where needed indications. The indications for catheterization should be based on individual base to base cases. The evidence for systemic prophylaxis instead of when clinically indicated is still equivocal. However, antibiotic-impregnated catheters reduce the risk of symptomatic CA-UTIs and bacteriuria and are more cost-effective than other impregnated catheter types. Antibiotic resistance, potential side effects and increased healthcare costs are potential disadvantages of implementing antibiotic prophylaxis.

Introduction And Background

Catheter-associated urinary tract infection (CA-UTI) is defined as a urinary tract infection that occurs with the use of an indwelling urinary catheter. A prevalence survey from 2006 about hospital-acquired infections in acute hospitals in Ireland revealed that UTIs account for 22.5% in a hospital setting, of which 56.2% were catheter-related [1]. A urinary tract infection (UTI) is an infection to the epithelium of the urinary tract in response to the colonization of the pathogen. Urinary tract infections (UTIs) are one of the most common hospital community-acquired infections (HCAI), with up to 70–80% attributable to the presence of indwelling urinary catheters [2]. Between 10% to 25% of hospitalized patients, during their hospitalization, will receive indwelling urinary catheters, of whom 20% develop UTIs [3,4]. The risk of catheter-related infection increases by 5% each subsequent day the catheter remains in situ, with the risk increasing to 35% and 70% after seven and 14 days of indwelling catheterization, respectively. Around 50% of patients with indwelling catheters after 15 days of installation will develop UTIs, and almost 100% of the patients will develop UTI in one month [5]. Results of the 2009 pilot study for the European HCAI (HALT) study in long-term care facilities revealed that urinary tract infections accounted for 30% of the reported HCAIs and that almost half of all systemic antimicrobials were prescribed for an infection related to the urinary tract (48.9%) [6].

In line with the literature findings, it is clear that there is no standardization or even consensus among practitioners and hospitals institutions regarding the protocols carried out of urinary catheter’s insertion and maintenance. Regarding antibiotics prophylaxis, type of catheter to use, dwell time of the catheter, perirectal cleansing with anti-septic or sterile solutions etc., non-standardized practices in managing catheterized patients are noticed. A study by Conway et al. revealed that implementation protocol guidelines for CA-UTI prevention in the ICUs (intensive care units) is inadequate and insufficient, with 42% of ICUs reported having existing evidence-based practices (EBP) and policies for prophylaxis [7]. Therefore, there is a need for competent healthcare workers to set up and adhere to preventive and management protocols to reduce the probability of catheter-related infection. This article aims to provide a general overview of urinary catheterization and its association with UTI and preventative strategies by presenting the available results and recommendations in the literature.

Review

Method

A literature search was carried out in April 2021 in the Medline (via Ovid) and the Cochrane Library...
databases. Our searches used the following joint search term variations of the following Medical Subject Heading terms, specifically tailored for each database. The search terms—“urinary tract infections,” “bacteriuria,” “catheter,” “indwelling catheter,” “urinary catheterization,” “asymptomatic bacteriuria,” “intervention studies”—were looked at both as free texts and MeSH terms. We also evaluated the reference lists of articles, which provided us with further articles for consideration. Only full-text publications in English were considered. While catheter-associated asymptomatic bacteriuria was mentioned and compared to CA-UTI, it was decided not to be included.

Study Selection

A rapid evidence analysis was carried out in the Medline (via Ovid) and the Cochrane Library for January 2005 to April 2021. The main inclusion criterion required to be included in this review was symptomatic catheter-associated UTI in adults as a primary or secondary outcome in all the included studies. Only randomized trials and systematic reviews were included in this systematic analysis. One thousand one hundred forty-five articles were identified, of which 1086 were excluded, as explained in figure 1. The final review is thus based on 59 articles.

Data Extraction and Quality Assessment

The two authors of this review (HA and MG) independently reviewed and abstracted data from the 1145 articles that met the inclusion criteria. Extracted data included primary study objectives, patient population characteristics, inclusion criteria, terms and definitions used and quality issues. The data from the literature search were evaluated and shortlisted by the first author according to methodological/theoretical rigor and trustworthiness and data relevance on CA-UTI as a primary or secondary outcome.

Study Characteristics for Inclusion

Our database search included publications published in the English language. We did not exclude studies based on the number of residents or patients included (gender, age, catheter type, use of antibiotic), duration of pre and post-intervention periods, study withdrawals, or whether follow-ups were done or not.

Data Source and Searching the Literature

The following data sources were searched: Ovid MEDLINE, Cochrane Library via Wiley and CINAHL. Only systematic search strategies were performed in the process of collecting the data (Figure 1). The first systematic search was conducted using the previously mentioned data sources to find searches associated with indications and need for catheterization, type of catheterization, duration of catheterization, infection prophylaxis, education programs, and interventions at reducing UTIs. The second systematic search was conducted in the described above data sources Ovid MEDLINE & Cochrane to identify RCT or studies to reduce UTI incidences use of antimicrobial coated catheters in settings such as hospitals, nursing homes, communities and rehabilitation units and spinal cord injury or orthopaedic programs, which do compromise a considerable population with chronic catheter needs.

Study Selection & Data Extraction

A data collection instrument was adapted and used for characterization of the selected studies containing items such as the descriptors used, title, authors, area of work, year of publication, language, design, objectives, method, results, conclusion, recommendations, limitations and level of scientific evidence, among others. The three phases of this systematic review are detailed in figure 1 [8].
The first systematic search was filtered by title and abstract and applied a few exclusions (no symptomatic UTI/CA-UTI related outcomes were analyzed). Identified duplicate studies, reviewed, and assigned potentially relevant studies and categorized them into groups such as review articles, clinical trials, comparative studies, and meta-analyses. Co-authors HA & MG filtered the records by title and abstract and reviewed the reference lists, of the included studies in this review, for additional relevant articles. Each author scored the studies, and the individually obtained results were later compared. Both authors’ discrepancies in the scores were re-revised to ensure that the doubts concerning each studies inclusion were eliminated. Duplicates were removed. As exclusion criteria, the authors chose articles with non-relevancy to the issue of urinary catheterization, UTI or CA-UTI.

The Jadad scale assessed the selected articles for evaluating the methodological quality of the selected RCT. The articles were graded from zero to five according to their methodological rigor and quality. One point is awarded for each of the following three questions: the description of randomization, the method of blinding, and withdrawals and dropouts. An extra point is attributed for each appropriately described randomization and blinding, up to a maximum of five points. A score of over three points constitutes an RCT of methodological rigor, and under three points were lower thoroughness. The extracted data from the 59 studies which made up this review are included in the results and discussion sections.

Outcomes

We researched studies including CA-UTI from the usage of an indwelling Foley urinary catheter or CA-UTI due to other catheter types such as intermittent or suprapubic catheters.

Results
Analysis of the Literature Search

The database search yielded 1145 results (Figure 7), of which 59 relevant studies were included in this review (Table 1). The included studies are grouped thematically: duration of catheterization (n = 9), type of catheterization (n = 13), assessing indication/necessity for catheterization (n = 2), maintenance and care of catheterized patients (n = 5), prophylactic measures (n = 17), preventative and/or educational initiatives (n = 10), and studies with multiple interventions (n = 3). A total of 23 systematic reviews (including 6 Cochrane reviews) and 56 randomized, controlled trials (RCTs) were identified.

| First Author, Year, Citation | Study design | Studies' objectives | Selection criteria of patients | Details of intervention | Main Results | Author's exact conclusion | Notes |
|-----------------------------|--------------|---------------------|-------------------------------|------------------------|--------------|--------------------------|-------|
| Hakvoort et al., 2011 [9]   | RCT, meta-analyses | To compare clean intermittent catheterization with transurethral catheterization for the treatment of abdominal post void residual bladder volume (PVR) following vaginal prolapse surgery. | Patients older than 14 years experiencing abdominal PVR following vaginal prolapse surgery. | Group A (98 patients) clean intermittent catheterisation (CIC) for 3 days. Group B (85 patients) transurethral catheterisation (TUC) for 9 days. Prophylactic antibiotics were given to all patients during surgery. A 16-French-balloon transurethral catheterisation and a vaginal gauze were used after surgery. The catheter removal on the first postoperative day. | Group A : n=98 (81% patients), CIC, p=0.50 in the OR (95% CI 0.21-1.11). | Clean catheterization is preferable over indwelling catheterization for 3 days in the treatment of abdominal PVR following vaginal prolapse surgery. |       |
| Hällding Nyman et al., 2013 [10] | RCT, cost analysis | To investigate differences between intermittent and indwelling urethral catheterization in men in relation to measured UTI and cost-effectiveness. | Patients aged 65 and undergoing hip surgery or hip replacement surgery due to osteoarthritis. | A: 66 (69 patients) intermittent urinary catheterisation. B: 69 (70 patients) indwelling urinary catheterisation. No antibiotic prophylaxis for either group. Foley catheter 11 was used, and simple techniques for bedside antiseptic shaving. | URT: numbers N=8 in the intermittent catheterisation group, 89% vs. the indwelling catheterisation group. | Both intermittent and indwiering methods could be appropriate in clinical practice. Both methods have advantages and disadvantages but both use routine instillation catheterization, unnecessary catheterization might be avoided in this patient group. |       |
| Zhang et al., 2015 [11]    | SR on RCTs & RCTs | To compare the sides of indwelling (UTI) and suprapubic (SP) catheterization in patients undergoing gynecologic surgery including vaginal hysterectomy. | Pathologic results indwelling urinary catheterisation vs. intermittent urinary catheterisation in women undergoing vaginal hysterectomy and related quality of life (QoL). | A: 20%   B: 31%  OR 0.31, 95% CI (0.185-0.512).   | Both methods showed no significant difference in the rate of UTI. | Both catheterisation methods were safe and effective in gynecologic surgery patients. |       |
| Hunter et al., 2013 [12]   | SR | To examine research activity comparing appropriate catheterisation to other methods of chronic bladder emptying such as intermittent and indwelling catheterisation in adults in relation to complications, patient satisfaction, and health-related quality of life (QoL). | Adult patients | A: Suprapubic catheterisation. Group B: Urthral catheterisation. | No significant difference between urethral and SP catheterisation. No evidence that favours suprapubic. | Most studies focused on clinical outcomes rather than patient understanding of appropriate catheterisation. Satisfaction, stigma and side effects, or health-related QoL. |       |
| D'Hoore et al., 2015 [13]  | RCT | To compare the use of intermittent urethral catheterisation with transurethral indwelling catheterisation in women undergoing surgery for anorectal or urological pathology. | Women undergoing surgery for anorectal or urological pathology and/or stress urinary incontinence. | Group A (28 patients) suprapubic catheterisation. Group B (27 patients) intermittent catheterisation. | No significant difference in UTI incidence: A, n=28; B, n=27; 95% CI 0.43-2.22. | Selective anorectal or urological surgery is associated with a non-reducible return to normal micturition and a shorter hospital stay, although the clinical significance of the difference is perhaps limited. |       |
| Dohringer et al., 2011 [14] | RCT | To compare the effect of suprapubic and tranurethral catheterisation on postural residual volumes (PRV) after cystectomy. | Women who underwent pelvic organ prolapse surgery including cystocoele repair. | Group A: suprapubic catheterisation (n = 46). Group B: Transurethral catheterisation (n = 45). | No significant difference in residual bladder volume (P>0.05), RR 0.57 (0.30-1.08). | Suprapubic catheterisation was comparable to transurethral catheterisation in the prevention of postoperative voiding dysfunction after vaginal prolapse surgery, but it was associated with a higher rate of complications. |       |
| Healy et al., 2012 [15]    | SR on RCTs | To compare suprapubic and centrifugal catheterisation. | Women undergoing gynecologic surgery. | 12 RCTs included: 5,525 patients. Group A: Suprapubic. Group B: Urthral. | No statistical differences: A: n=21; B: n=21; OR 1.21 (95% CI 0.83-1.76). | Based on the best available evidence, no route for bladder drainage in gynecologic patients is clearly superior. The reduced rate of infection associated with suprapubic catheterisation is offset by a higher rate of complications and costs. |       |
| Reference | Year | Type of Study | Patient Characteristics | Intervention | Outcome Measures |
|-----------|------|---------------|-------------------------|--------------|------------------|
| Wang et al., 2005 | [19] | Systematic Review | Patients older than 18 years old. | Cauterisation of the urethra before removal of an indwelling urinary catheter, with or without clamping, is a common practice in gynecologic populations. | To determine the advantages and disadvantages of alternative names of short-term bladder catheterization. |
| Fernandes et al., 2015 | [20] | SR on RCTs | Adults with spinal cord injury diagnosed with neurogenic bladder and treated with a long-term indwelling transcutaneous suprapubic bladder catheter. |Experimental Group A (80 patients): indwelling catheter removed within 24 hours of bladder training. Control Group B (80 patients): indwelling catheter removed within 24 hours of bladder training. |To assess the impact of using the StatLock securing device on suprapubic bladder catheters secured in place by using the StatLock device. Control Group B (80 patients): traditional methods that included tape, Velcro strap, Cath-Secure or none. |
| Gong et al., 2017 | [21] | SR on RCTs | Patients with symptomatic urinary tract infection. |Group B (30 patients): indwelling urinary catheter left in place for 48 hours before removing it. Group C (30 patients): indwelling urinary catheter removed without clamping. |To determine the effects of clamping the indwelling urinary catheter before its removal on the incidence of urinary tract infection. |
| Kang et al., 2014 | [22] | SR on RCTs | Adults with chronic kidney disease. |Group A (80 patients): Intermediately clamping the indwelling transcutaneous suprapubic bladder catheter. |To determine the effects of clamping the indwelling transcutaneous suprapubic bladder catheter in people in all ages. |

**Table Notes:**
- **Group A:** Cauterisation of the urethra before removal of an indwelling urinary catheter.
- **Group B:** Suprapubic catheterisation.
- **Group C:** Indwelling catheter left in place for 48 hours before removing it.
- **Group D:** Indwelling catheter removed without clamping.

**Key Findings:**
- Cauterisation of the urethra before removal of an indwelling urinary catheter is a common practice in gynecologic populations.
- The use of the StatLock securing device reduces the incidence of symptomatic urinary tract infections.
- Clamping the indwelling urinary catheter before removal is not necessary in most cases.

**References:**
- Wang et al., 2005
- Fernandes et al., 2015
- Gong et al., 2017
- Kang et al., 2014
short term patients, drainage until removal: in rehospitalization due, rare rate of urinary tract infection OR 0.84, 95% CI 0.53, 1.35 Reduced and urinary tract injuries. Further investigation requires higher quality methodologies and more disease study designs.

| Authors et al., 2006 [21] | RCT | Assessing immediate versus delayed catheter removal. | Randomly assigned who underwent hysterectomy for various benign diseases. | Three groups (28 women for each group). Group A: immediate removal of the catheter in the operating room. Group B: removal of catheter at 6 h after the operation. Group C: removal of catheter at 12 h after the operation. All patients received a single dose of antibiotic prophylaxis before hysterectomy. 10F latex catheters with a 15 ml balloon were used as well. | There could be an association between necessity of re- catheterization and the type of surgery. [20] or the type of anastomosis (laparoscopic). Simple re- catheterization rate, early removal of indwelling catheters immediately after uncomplicated hysterectomy seems to decrease hospitalization time and hospital stay.

| Authors et al., 2006 [22] | RCT | To assess whether early or immediate removal of a 12Fr indwelling Foley catheter after total abdominal hysterectomy affects the trend of subjective pain assessment postoperatively. | 98 women aged between 40 and 88 years who underwent anterior colporrhaphy. | The women were divided into two groups: A: removal immediately after surgery; B: removal at least 24 h later OP. n=74 for both groups | Early removal of an indwelling catheter immediately after anterior colporrhaphy was not associated with adverse events and an increased rate of re-catheterization. In this group, symptomatic urinary tract infection was significantly lower. Moreover, early removal of indwelling catheters immediately after surgery seemed to decrease the ambulation time and hospital stay.

| Alasad et al., 2001 [23] | RCT | To compare whether or not immediate removal of an indwelling urethral catheter is associated with less urinary tract infection and a shorter hospital stay. | 201 women underwent total abdominal hysterectomy for benign gynecological diseases and were randomly distributed into three groups. On the morning of surgery, all patients received a single dose of prophylactic antibiotics (metronidazole 750 mg i.m. intramuscularly). | Group A (77 patients) catheter removed immediately after surgery. Group B (91 patients) catheter removed on a postoperative day one, i.e. 24 hours after the operation. Group C (97 patients) catheter removed 48 h post-surgery. | Symptomatic urinary tract infection, n (%) A: 1 (0.3) B: 3 (3.7) C: 10 (10.3) p value: 0.006 There are pros and cons regarding the policy of one-day in-indwelling catheterization compared to immediate catheter removal.

| Khuri et al., 2014 [24] | RCT | To assess whether immediate (0h) versus delayed catheter removal (after 6h) or delayed (after 24h) remoal of an indwelling urinary catheter after uncomplicated abdominal hysterectomy affects the rate of urinary tract infections. | 300 eligible women admitted for elective cesarean section. | The women were randomized into two equal groups: Group A: post cesarean hysterectomy removal immediately after the procedure; Group B: post cesarean hysterectomy removal 6h post-surgery. Symptomatic urinary tract infection: Group A: 1/32 = 3.1% Group B: 4/30 = 13.3% (p=0.039) | Immediate removal of an indwelling catheter after elective cesarean section is associated with a lower risk of urinary tract and earlier postoperative mobilization.

| Jho et al., 2017 [25] | RCT | To determine whether catheterization is necessary after vaginal surgery for pelvic organ prolapse. | 260 patients with symptomatic POP undergoing one anterior or two anterior repairs. | Two groups were created: Group A (91 patients) symptomatic catheter until 48 h (day 2 postoperatively). Group B (79 patients) immediate removal of one dose of intravesical prophylactic antibiotics administered. | Rate of symptomatic bacteriuria (bacteria > 10³ CFU/mL) B: 8 (6.5) p<0.05 Early removal of a catheter reduces urinary tract infection and significantly decreases hospital stay. Such a policy would result in improved patient satisfaction and reduced hospital costs.

| Steventon et al., 2011 [26] | RCT | To compare the number of temporary catheter replacements and urinary tract infections after indwelling catheterization for 2 versus 6 days following anterior colporrhaphy. | 260 patients with symptomatic POP undergoing one or two anterior repairs were eligible. | Two groups were assigned Group A: catheter for 2 days. Group B: catheter for 6 days. | Urinary tract infection percentage Group A: 23% proven by a culture with >10⁵ colony forming units per ml. Group B: 37%. OR: 0.3 (95% CI: 0.15-0.55) p = 0.036 Removal of an indwelling catheter after 2 versus 6 days following anterior colporrhaphy is associated with a lower rate of urinary tract infections, fewer hospital stay. Moreover when the incidence of catheter-associated UTI following LAVH was confronted by the use of prophylactic antibiotics in our study, the data suggested that the
To determine if certain washout regimens are better than others in prevention of CA-UTIs through catheterization, no heterogeneity in the outcomes with an incidence of UTIs after TURP (RR 0.69, 95% CI 0.30 to 1.03). 1 trial of patients who had their indwelling bladder catheters removed 5 days after rectal resection reported a higher incidence of urinary tract infection, in comparison to the patients who had their indwelling urethral catheters removed 1 day after surgery (RR 0.05, 95% CI 0.01 to 0.80).

The data from two trials comparing different washout volumes, washout solutions, washout times, or the use of antiseptics did not suggest a clear advantage of one method over the other. The data from one trial comparing different washout techniques with regard to CA-UTI incidence rates.

To evaluate the best cleaning methods of urethral catheterization versus placebo for the prevention of CA-UTIs through conducting a network meta-analysis of the literature using the Bayesian method. 7 different methods of urethral cleaning versus placebo were included, no heterogeneity in the outcomes with an incidence of UTIs after TURP (RR 0.69, 95% CI 0.30 to 1.03). No difference in the incidence of CA-UTIs. Chlorhexidine ranked first in the network of the Bayesian analysis and is recommended for preventing CA-UTIs.

To compare the risk of acquiring symptomatic urinary tract infections through the conventional practice of using 0.05% chlorhexidine gluconate versus sterile water for percutaneous cholecystectomy in adults. The results of this study showed that percutaneous cholecystectomy using sterile water was associated with a lower incidence of symptomatic urinary tract infections compared to 0.05% chlorhexidine gluconate (RR 0.69, 95% CI 0.30 to 1.03).

To compare different washout regimens for the maintenance of long-term indwelling urinary catheters on urinary tract infections. The data from five trials comparing different washout regimens with regard to CA-UTI incidence rates.

| Maintenance and care of catheterized patients |
|-----------------------------------------------|
| **Sinclair et al., 2011** | **MA of RCT and SR** |
| **Cheung et al., 2018** | **RCT and Indwelling catheter care** |
| **Cao et al., 2018** | **RCT** |
| **Briole et al., 2013** | **SR** |
| **Fernandez et al., 2016** | **Image 33x802 to 74x811** |

The use of an indwelling catheter with a clean technique results in low rates of complications or infections compared to the use of an intermittent catheter. The removal of the catheter up to 33 hours after surgery and the use of an antimicrobial impermeated cutaneous seal.

To determine if certain washout regimens are better than others as there are no significant differences in different washout conditions versus placebo. The data from five trials comparing different washout regimens with regard to CA-UTI incidence rates.

The data from two trials comparing different washout volumes, washout solutions, washout times, or the use of antiseptics did not suggest a clear advantage of one method over the other. The data from one trial comparing different washout techniques with regard to CA-UTI incidence rates.
To prospectively investigate the effects on urinary tract infection (UTI) of indwelling urinary catheter placement during cesarean delivery.

Patients during cesarean delivery

Group A (n=111): no catheterisation

Group B (n=110): Catheterisation, control

The non-catheterised group had a lower incidence of UTIs in both the new RCT and the last review (RR 0.36; 95% CI 0.22, 0.57) respectively.

To determine if certain antibiotic prophylaxes are better than others in terms of prevention of urinary tract infections, complications, quality of life and cost-effectiveness in short-term catheterisation in adults.

Patients during effective antibiotic prophylaxis (based on a 1:1:1 ratio and 90 patients): UUTI as a result from antibiotic prophylaxis versus no prophylaxis.

The non catheirzed group had a greater increase in intraoperative complications, as well as others.

Studies on UTI prophylaxis
### Table 1: Summary of included studies

| Study Reference | Design | Setting | Participants | Intervention | Outcomes | Results |
|-----------------|--------|---------|--------------|--------------|----------|---------|
| Pickard et al., 2012 | RCT, multicenter | 2008 Johnson et al., 2011 | al., 2012 | Bonfill et al., 2017 | Pickard et al., 2012 | SR of SR and RCT | 14 hospitals (n=222): Noble metal alloy-coated catheter. Group A (n=222): Noble metal alloy-coated catheter. Group B (n=2153): nitrofurazone-impregnated silicone urinary catheters. Group C (n=2153): control group. pooled OR 0.96 [0.49-1.87]. | No study was able to definitively determine if catheters reduce the incidence of symptomatic UTI. The adjusted symptomatic UTI ratio: Group A: 1.01; (p=0.031) Silver alloy vs Control PTFE: OR 0.81 (0.65 to 1.01); p=0.031 | The collective evidence suggested that silver-alloy coated urinary catheters might be cost-effective for the UK NHS. The trial ruled out the possibility that silver-coated catheters might reach the pre-set degree of clinical effectiveness and that there was no evidence to be cost-effective. Future research should be conducted by patients, clinicians and healthcare policymakers to determine whether or not a change in practice is worthwhile. Further research should be aimed at determining the maximum clinically important difference in terms of CA-UTI prevention in comparative trials, and to identify reliable methods that can detect the impact of the intervention on quality of life and other drivers of cost, where the intervention is a substantial part of overall treatment plans. |
| Berthet et al., 2017 | RCT, 14 hospitals (ESGAR trial) | 2013 [21] | 2013 [21] | 2013 [21] | To assess whether antifungal prophylaxis reduces the rate of catheter-associated urinary tract infections. | To assess whether antifungal prophylaxis reduces catheter-associated urinary tract infections. | 12 trials included: nitrofurazone-coated silicone urinary catheters. Group B (n=246): silicone or silicone-latex catheters. Group C (n=2144): control group, polytetrafluoroethylene (PTFE) coated catheter. | Patients undergoing elective orthopaedic surgery undergoing catheter removal significantly reduced the rate of symptomatic UTI. No significant difference was found between experimental and control groups. | The results of the study do not support the use of nitrofurazone coated silicone urinary catheters in patients undergoing elective orthopaedic surgery. However, UTIs associated to long-term urinary catheters are rare, and further investigations are still needed. |
| John et al., 2013 [21] | RCT | 2013 [21] | 2013 [21] | 2013 [21] | To assess whether antifungal prophylaxis reduces catheter-associated urinary tract infections. | To assess whether antifungal prophylaxis reduces catheter-associated urinary tract infections. | 11 total studies: 6 SR/MA & 5 RCT. | No study was able to definitively determine if catheters reduce the incidence of symptomatic UTI. The adjusted symptomatic UTI ratio: Group A: 1.01; (p=0.031) Silver alloy vs Control PTFE: OR 0.81 (0.65 to 1.01); p=0.031 | The collective evidence suggested that silver-alloy coated urinary catheters might be cost-effective for the UK NHS. The trial ruled out the possibility that silver-coated catheters might reach the pre-set degree of clinical effectiveness and that there was no evidence to be cost-effective. Future research should be conducted by patients, clinicians and healthcare policymakers to determine whether or not a change in practice is worthwhile. Further research should be aimed at determining the maximum clinically important difference in terms of CA-UTI prevention in comparative trials, and to identify reliable methods that can detect the impact of the intervention on quality of life and other drivers of cost, where the intervention is a substantial part of overall treatment plans. |
| Bastide et al., 2011 | SR at BP and RCT | 2011 [21] | 2011 [21] | 2011 [21] | To assess whether antifungal prophylaxis reduces catheter-associated urinary tract infections. | To assess whether antifungal prophylaxis reduces catheter-associated urinary tract infections. | 11 total studies: 6 SR/MA & 5 RCT. | No study was able to definitively determine if catheters reduce the incidence of symptomatic UTI. The adjusted symptomatic UTI ratio: Group A: 1.01; (p=0.031) Silver alloy vs Control PTFE: OR 0.81 (0.65 to 1.01); p=0.031 | The collective evidence suggested that silver-alloy coated urinary catheters might be cost-effective for the UK NHS. The trial ruled out the possibility that silver-coated catheters might reach the pre-set degree of clinical effectiveness and that there was no evidence to be cost-effective. Future research should be conducted by patients, clinicians and healthcare policymakers to determine whether or not a change in practice is worthwhile. Further research should be aimed at determining the maximum clinically important difference in terms of CA-UTI prevention in comparative trials, and to identify reliable methods that can detect the impact of the intervention on quality of life and other drivers of cost, where the intervention is a substantial part of overall treatment plans. |
| Johnsen et al., 2008 [11] | RCT | 2008 [11] | 2008 [11] | 2008 [11] | To assess whether antifungal prophylaxis reduces catheter-associated urinary tract infections. | To assess whether antifungal prophylaxis reduces catheter-associated urinary tract infections. | 11 total studies: 6 SR/MA & 5 RCT. | No study was able to definitively determine if catheters reduce the incidence of symptomatic UTI. The adjusted symptomatic UTI ratio: Group A: 1.01; (p=0.031) Silver alloy vs Control PTFE: OR 0.81 (0.65 to 1.01); p=0.031 | The collective evidence suggested that silver-alloy coated urinary catheters might be cost-effective for the UK NHS. The trial ruled out the possibility that silver-coated catheters might reach the pre-set degree of clinical effectiveness and that there was no evidence to be cost-effective. Future research should be conducted by patients, clinicians and healthcare policymakers to determine whether or not a change in practice is worthwhile. Further research should be aimed at determining the maximum clinically important difference in terms of CA-UTI prevention in comparative trials, and to identify reliable methods that can detect the impact of the intervention on quality of life and other drivers of cost, where the intervention is a substantial part of overall treatment plans. |
| Phipps and et al. | RCT | 2011 [21] | 2011 [21] | 2011 [21] | To assess whether antifungal prophylaxis reduces catheter-associated urinary tract infections. | To assess whether antifungal prophylaxis reduces catheter-associated urinary tract infections. | 11 total studies: 6 SR/MA & 5 RCT. | No study was able to definitively determine if catheters reduce the incidence of symptomatic UTI. The adjusted symptomatic UTI ratio: Group A: 1.01; (p=0.031) Silver alloy vs Control PTFE: OR 0.81 (0.65 to 1.01); p=0.031 | The collective evidence suggested that silver-alloy coated urinary catheters might be cost-effective for the UK NHS. The trial ruled out the possibility that silver-coated catheters might reach the pre-set degree of clinical effectiveness and that there was no evidence to be cost-effective. Future research should be conducted by patients, clinicians and healthcare policymakers to determine whether or not a change in practice is worthwhile. Further research should be aimed at determining the maximum clinically important difference in terms of CA-UTI prevention in comparative trials, and to identify reliable methods that can detect the impact of the intervention on quality of life and other drivers of cost, where the intervention is a substantial part of overall treatment plans. |
To evaluate whether cranberry concentrate prophylaxis prevents postoperative urinary tract infection in patients undergoing non-genitourinary reconstructive surgery, participants undergoing pelvic reconstructive surgery were randomized to cranberry concentrate or placebo, until the catheter was removed. The results showed a significantly lower rate in the group with cranberry concentrate compared to the placebo group (RR 0.20, 95% CI 0.06 to 0.66, p = 0.008).

To evaluate the safety and efficacy of cranberry concentrate prophylaxis in preventing UTI following surgery, 227 female patients were screened for UTI symptoms. 217 female patients 60 years and older, with hip fractures, were randomized to cranberry concentrate or placebo. There was no evidence that cranberry concentrate prophylaxis increases the risk of developing a UTI in elderly patients with hip fractures.

To evaluate the safety and efficacy of cranberry concentrate prophylaxis in preventing UTI following surgery, 100 patients scheduled to undergo major surgery, such as an abdominal operation or hip surgery, were randomized to cranberry concentrate or placebo. The results showed that cranberry concentrate prophylaxis is associated with a significantly reduced rate of UTI compared to the placebo group (RR 0.988, 95% CI 0.457–2.135).

To evaluate whether cranberry concentrate prophylaxis reduces the rate of UTI following surgery, 217 female patients with hip fractures were randomized to cranberry concentrate or placebo. The results showed that cranberry concentrate prophylaxis is associated with a significantly reduced rate of UTI compared to the placebo group (RR 0.94, 95% CI 0.49–1.87).

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To investigate whether intermittent catheterisation with a hydrophilic-coated catheter delays the onset of the first symptomatic urinary tract infection (UTI) and reduces the number of asymptomatic UTIs in patients with acute spinal cord injury (SCI), compared with IC with standard, uncoated catheters.

295 subjects with traumatic SCI of less than 3 months duration who were intermittently catheterised. The position of the study included 2 periods: 1 medically based period (in acute care or rehabilitation ward) and 2 community period (after discharge from the hospital or rehabilitation ward).

Group A (110 patients): hydrophilic-coated, polyurethane Nelaton (SpeediCath) catheter was a sterile, ready-to-use. The coating consists mainly of polyvinyl-pyrrolidone. Group B (214 patients): polyvinyl chloride, uncoated (Conveen) catheters.

Total UTI/UTI episodes ratio: Group A: 0.95 (95% CI, 0.66 to 1.33) vs. Group B: 1.33 (95% CI, 0.86 to 2.1)

The use of a hydrophilic-coated catheter for IC is associated with a delay in the onset of the first antibiotic-treated symptomatic UTI and with a reduction in the incidence of asymptomatic UTI in patients with SCI. However, the duration of follow-up after discharge should be considered to ensure the generalizability of this finding. Antimicrobial agents may prove to be significant as a well-conducted study. The present results provide good evidence to inform infection control guidelines in catheter management.

To evaluate the effectiveness of antimicrobial education for family caregivers involved in the care of nursing home residents with urinary tract infection prevention practices and related hygiene promotion. Five control groups.

Our multimodal targeted infection program intervention reduced the prevalence of multidrug-resistant organisms (MDROs) and incident device-related infections. In catheter-associated urinary infections.

Stop orders for urinary catheterisation appear to reduce the rate of CA-UTI and should be strongly considered to enhance the safety of hospitalised patients.

To investigate whether interventions (of a reminder or stop order) to remind treating doctors or nurses to remove unnecessary urinary catheters reduces the duration of inappropriate urinary catheterisations.

11 studies included interventions (of a reminder or stop order) to remind treating doctors or nurses to remove unnecessary urinary catheters.

The ratio of CA-UTI episodes per 1000 catheter-days was reduced by 50% (P = .001) with the use of a reminder or stop order.

Our study considered caregivers as partners in caring for patients with incontinence, and we examined an intention to evaluate the self-efficacy of FCs in reducing the occurrence of CA-UTIs. The results showed that the efficacy of the intervention did not differ statistically. The self-efficacy of caregivers and the occurrence of CA-UTIs in patients to the two groups were statistically equivalents.

To test whether a multimodal targeted infection program (MIP) reduces the prevalence of multidrug-resistant organisms (MDROs) and incident device-related infections.

With the prevalence rates high risk MDRO carriers with urinary catheters, feeding tubes, or both.

Group A interventions: Multimodal, including (1) prescription barrier for CA-UTIs, (2) active surveillance for MDROs and catheters, with data feedback, (3) NPH staff education on key infection prevention practices and hand hygiene promotion. Five control groups.

Urinary catheter number of cases: A: 258 (81.1%) vs. B: 30.9 %. First-ever clinically defined CA-UTIs in 186 residents: HR 5.56 (95% CI, 3.03-10.33) All (including recurrent) clinically defined CA-UTIs: HR 4.89 (95% CI, 3.03-8.08).

Our multimodal targeted infection program intervention reduced the overall prevalence of MDROs and incidence of CA-UTIs in patients with MDRO-related infections. The importance of catheter-related infections in high-risk MDRO carriers with catheter devices.

To undertake a systematic review and meta-analysis of studies investigating the effectiveness of antiseptic catheter reminder systems on the incidence of catheter-associated urinary tract infection (CA-UTI) and the incidence of inappropriate urinary catheterisation.

Patients admitted to hospital with indwelling urinary catheters (n=444).

Group A (n=28): Stop order group, Group B (n=20): usual care group

Group A: 51/252 = (20%) vs. Group B: 51/252 = (20%) RR 0.94, (95% CI, 0.66 to 1.33)

Stop orders for urinary catheterisation significantly reduced the duration of inappropriate urinary catheterisations in hospitalised patients who did not reduce the rate of UTI. The present results provide good evidence to inform infection control guidelines in catheter management.

To analyse the effect of various bladder re-sterilization systems on the rate of CA-UTI, urinary catheterisation and the need for re-catheterisation.

14 studies included interventions (of a reminder or stop order) to remind treating doctors or nurses to remove unnecessary urinary catheters.

The self-efficacy of FCs in caring for patients with urinary catheters can diminish the incidence of catheter-associated urinary tract infections. In catheter management.

To determine whether the catheter-based reminder system would reduce the use of urinary catheterisation and the incidence of catheter-associated urinary tract infections.

224 subjects with traumatic SCI of at least 1 year. Group A (30 patients): nurse attended a 4 h education on key infection prevention practices and related hygiene promotion. Group B (147 patients): (Intervention group) antiseptic catheter Group B: no antiseptic catheter.

Our multimodal targeted infection program (MIP) reduced the duration of inappropriate urinary catheterisations in patients with acute spinal cord injury. The findings showed that the efficacy of the intervention did not differ statistically. The self-efficacy of caregivers and the occurrence of CA-UTIs in patients to the two groups were statistically equivalents.
To determine the effectiveness of a self-management intervention to reduce CA-UTI in nursing homes residents.

202 adults living in 36 nursing homes in 13 tertiary hospitals.

Group A: teaching catheter-related self-monitoring and self-management skills (n = 161). Group B: usual care (n = 41).

The median CA-UTI rate of 1.55 to 10.29). In the clamp and release group (RR 4.00, 95% CI 1.52 to 10.27) a p value < 0.05. In the group of catheter removal: one was used following surgery (RR 3.66, 95% CI 1.50 to 9.06). The data gave only an imprecise estimate of any difference in catheterization if a catheter was not used postoperatively. The data gave only an

MDM et al., 2017 [35]

SR as comparative studies

To identify strategies to reduce UTIs in nursing homes residents.

28 records describing 19 interventions were included. 8 randomized controlled trials, 10 pre-post observational studies, and 1 nonrandomized study with concurrent controls. nursing home residents participated.

Interventions involving urinary catheter use such as improving appropriate use, employing placement, maintenance, care, and prompting the removal of unnecessary catheters. The 19 studies explored 13 UTI outcomes, 9 CA-UTI outcomes, 3 bacteriuria outcomes, and 2 catheter use outcomes. Four studies showed CA-UTI infection (none significantly). 4 studies showed UTI reduction (none significantly). It studies showed reduced bacteriuria infection (none significantly). Four studies showed reduced reduced catheter use (1 significantly).

Several practices, often implemented in bundles, appear to reduce UTI or CA-UTI in nursing homes residents such as improving hand hygiene, reducing and improving catheter care, managing incontinence without catheters, and enhancing barrier pre-CA-UTI and pre-CA-UTI use.

Incidence of CA-UTIs was significantly reduced with a mean effect lasting duration of infection control; physician and nursing education, reminders for the clinical necessity of catheters and appropriate assign of a urinary catheter with the corresponding indication in urinary catheters days.

Miscellaneous studies concerning UTI:

1. All urinary catheterization, by unilateral, suprapubic or both routes. + Zone of 2-way or 3-way catheters of all sizes: 2. Zone of Foley; silicone or latex catheters. 3. Use of bladder drainage in surgical wound. 4. Use of pan-catheters regardless of type of catheter.
Route of administration and catheterization selection type

Comparing Intermittent Catheterization & Short-term Indwelling Catheters?

Two RCTs [9,10] and two SR [11,12] were identified in which intermittent (self-)catheterization was compared with the use of temporary indwelling catheters. Including the 182 patients who underwent hip fracture or hip replacement surgery that Hälleberg Nyman et al. included; The absolute risk difference of CA-UTI in the intermittent catheterization group was a low 2.4% with a Confidence interval of 6.9 to 11.6%, a statistically insignificant difference (8 out of 85 patients (9.4%) with CA-UTI in the intermittently catheterized group, compared to 10 out of 85 patients (11.8) with indwelling catheters [10]). When comparing transurethral indwelling with intermittent catheters, Hakvoort et al. reported a (p = 0.03) lower CA-UTI rate compared with the use of temporary indwelling catheters. Including the 182 patients who underwent hip drainage (i.e., hysterectomy) plus an optional further procedure for the diagnosis of UTI and other common outcomes.

Nine RCTs with 1771 patients were included in a meta-analysis by Zhang et al. There was no significant difference in the rate of UTIs between indwelling catheterization and intermittent catheterization groups (RR: 1.25; CI 95% [0.85; 1.76], P>0.05). At the same time, Hunter et al. concluded that the evidence was equivocal for symptomatic urinary tract infection [11].

Comparing Temporary Transurethral to Suprapubic Catheterization

Two RCTs compared the use of transurethral and suprapubic catheterization in patients who required urological interventions; suprapubic catheterization was comparable to transurethral catheterization with little to no difference in the rate of infection [13,14]. Two SRs [12,15] and one Cochrane review [16] were also identified. When comparing suprapubic to urethral, all revealed that there is no statistically significant difference in the rates of CA-UTI. In a systematic review and meta-analysis (included twelve RCTs) by Healy et al., suprapubic catheterization was associated with a significant reduction in postoperative UTIs (20%; OR: 0.31; 95% CI, 0.185-0.512; p < 0.01) compared to 31% for urethral catheterization in the selected gynecologic patients [15]. Patients are three times more likely to develop a UTI with a transurethral catheter than a suprapubic catheter. Although Healy pointed out the increased noninfectious complication rate that suprapubic catheterization was associated with (29% compared to 11%; OR: 4.14; 95% CI, 1.33-12.9; p = 0.03), these were tube malfunction related with no visceral injuries reported among the 1,300 participants [15].

However, a Cochrane systematic review comparing short-term indwelling urethral catheters to suprapubic catheters found that indwelling catheterizations lead to more incidents of bacteriuria (RR 2.6, 95% CI 2.12,
symptoms. The incidence of UTIs was 5.7% in the catheterized group for the 24 h postoperative and 2.9% for the non-catheterized patients showing no significant difference (P<0.001) between the catheterized and non-catheterized patients regarding UTI rates. Studies that considered duration: RCT); the RR in the single NCRT was 0.10 with 95% CI 0.02, 0.57 [15].

Li et al. suggested that the routine use of indwelling urinary catheters for caesarean delivery is not necessary and is associated with fewer UTIs and no increase in postoperative adverse urinary events (relative risk [RR] = 1.03). A statistically significant difference in CA-UTI rate was reported in one RCT that compared catheterization for 1 vs 5 days after rectal resection. The five-day rate was almost as twice as high as the one-day rate (RR: 2.25; [0.63, 8.08]).

One RCT [19] and three SRs [20,21,65] evaluated the necessity of bladder clamping before removing a urinary catheter. The RCT by Gong et al. did not report any statistically significant difference between the two groups (CA-UTI in the clamping group was 22.9% vs 20.3% for the control group). Wang et al. revealed no statistically significant difference between clamping and free drainage. There was no significant difference between clamping and unclamping groups found across four studies included in their study (OR 0.76, 95% CI (0.53, 1.73)). Gong et al. and Wang et al. concluded no significant difference between the clamping and unclamping groups in the outcomes of UTI and patients bladder function [19, 21].

Fernandez et al. [20] delineated and compared three timepoints of catheter management as follows: (Group A) within 24 hours removal after free drainage, (Group B) within 72 hours removal, (Group C) within 24 hours removal in addition to bladder re-education. No significant differences were reported in the rates of CA-UTI in the 24 hours group (RR: 1.12 [0.24; 5.18]) or in the 72 hours group (RR: 0.55 [0.15; 2.01]). There was no statistically significant difference in the UTI rates for clamping compared to free drainage for 24 or 72 hours before catheterization removal. In contrast, a Cochrane review that included one study favoured free immediate catheter removal with RR 4.00 (1.55, 10.29) [20].

Duration of catheterization and minimizing dwell time

The time a catheter is in place for a particular time associated with operative gynaecological interventions was studied in seven RCTs [22-28]. The catheters in the trials were either immediately removed postoperatively or within 24 hours in the following RCTs [22-25]. While Bray et al. set the catheter removal 48 to 72 hours after the intervention, Weenhoff et al. compared catheterization duration of two vs five days and its association with temporary catheter replacements, temporary catheter clamping and unclamping groups found across four studies included in their study (OR 0.76, 95% CI (0.53, 1.73)). Gong et al. and Wang et al. concluded no significant difference between the clamping and unclamping groups in the outcomes of UTI and patients bladder function [19, 21].

Phipps et al. conducted a Cochrane systematic review dealing with transurethral and suprapubic catheterization focusing on the following durations of catheterization: one vs two days (one study: RR: 0.52; [0.05; 5.40]), one vs three days (three un-pooled studies: RR: 0.11; [0.03; 0.43]), one day vs five days (two un-pooled studies, RRs 0.11 [0.03; 0.43]; 0.70 [0.29, 1.67]), and one vs 14 days (one study, RR: 0.21 [0.03, 1.65]) [65]. Out of the 11 trials, seven trials with data suggested urinary tract infections when a catheter was removed earlier. Although the studies did not indicate any statistical significance in the confidence interval of CA-UTI incidences, the point estimators conclusively indicated that the shorter duration resulted in the overall better outcome [65].

Fernandez et al. was the one study that purely focused on the duration of the catheterization and set different catheterization duration before the removal of short-term indwelling urethral catheters [30]. Four trials out of the eight showed no significant differences in CA-UTI rates in patient outcome after TURP (RR 0.55, 95% CI 0.30 to 1.05). A statistically significant difference in CA-UTI rate was reported in one RCT that compared catheterization for 1 vs 5 days after rectal resection. The five-day rate was almost as twice as high as the one-day indwelling catheterization [30]. Similarly, Phipps et al. suggested fewer urinary tract infections occur when a catheter is removed earlier (for example, 1 vs 5 days, RR 0.50, 95% CI 0.29 to 0.87) [65].

It is worth noting that both the Lam et al. and Lasardi et al. reviews evaluated the expected duration of internal bladder catheters for up to 14 days. Whether they including a large number of interventions to be evaluated affected the calculated incidence rate of urinary tract infection in their studies or not remains to be unknown [38, 39].

Assessing indication/necessity for catheterization

Li et al. suggested that the routine use of indwelling urinary catheters for caesarean delivery is not necessary and is associated with fewer UTIs and no increase in postoperative adverse urinary events (relative risk [RR] = 0.82) of urinary tract infection compared with the use of indwelling urinary catheters, the non-catheterized patients had a significantly lower incidence of UTIs (RR 0.08; with 95% confidence interval 0.01, 0.64 (study design: RCT); the RR in the single NCRT was 0.10 with 95% CI 0.02, 0.57) [37].

Regarding the incidence of UTIs in another cesarean-related study, Naar et al. found no statistically significant difference (P<0.001) between the catheterized and non-catheterized patients regarding UTI symptoms. The incidence of UTIs was 5.7% in the catheterized group for the 24 h postoperative and 2.9% for...
**Maintenance and care of catheterized patients**

*Cleansing or Disinfection of the External Urethral Orifice*

A network meta-analysis by Ercole et al. summarized data from thirty-three studies with seven different methods of urethral cleaning versus disinfection of the external urethral orifice was included (normal saline vs tap water vs soapy water vs antibacterial vs iodine vs chlorhexidine) [31]. No evidence of heterogeneity (P=0.05) was observed among the studies. The results showed no statistical difference in the incidence of CA-UTIs (P=0.05 for all) when analyzing the different urethral cleaning methods versus disinfection [31].

Cao et al., through twenty-eight RCTs and nine SRs, that they included in their review, presents that the rate of urinary tract infection is not predicated on whether the perineum is cleaned with or without sterile water, or with the use of the povidone-iodine solution or chlorhexidine, or even with the use of clean or sterile technique, no difference in the incidence of CA-UTIs when comparing the different urethral cleaning methods versus disinfection (P > 0.05 for all), this was postulated based upon thirty-three trials including 6390 patients with seven different urethral cleanings versus disinfection methods [32]. Similarly, studies that, prior to intermittent or indwelling catheterization, used anti-septic or non-medicated agents to clean peri-urethral or meatal areas showed no statistical significance in reducing its association with the incidence rate of UTI [33].

It was suggested that cleaning the peri-urethral area before catheter insertion can be undertaken, non-sterile water would be an equally weighted option, and the economical alternative as its effectiveness compared to the sterile water. Anti-septic solutions (chlorhexidine and PVP-I) were as equal. More studies about UTI development and saved expenditure on costs were not looked at and needed to be confirmed [31-33].

Even though a consistent level of hygiene was scrutinized with short-term catheter use in their RCT, Fasughla et al. failed to result in a substantial reduction in CA-UTI rates for long-term catheterization [54].

*Irrigations and Washouts*

The practice of irrigating long-term indwelling urinary catheters has also been assessed by two systematic reviews [34,35], including reports of various solutions and regimens. One of the RCTs in a dedicated RCT conducted by Shepherd et al. [35]. Four trials studied the following: (any washout vs no washout, saline washout versus no washout, citric acid washout versus no washout). The authors were uncertain if comparing washout and no washout had any significant effect on the rate of symptomatic UTI or duration of catheterization in situ. The evidence was not adequate to conclude if washouts were beneficial or harmful due to the poor methodological quality and reporting [35].

Both Systematic reviews have five studies that were labelled to be of poor quality and concluded inconclusive effective at either reducing symptomatic CA-UTIs or duration of first catheter change [34,35].

**Prophylactic measures**

*Antiseptic-coated Compared to Standard Non-septic Catheters*

Lam, Pickard, Bonfill, and Jahn, most notably, from the studies we included, compared the effect of antiseptic catheter surfaces vs the non-septic catheters, respectively [38,40-42]. Two Cochrane reviews conducted by Lam et al. and Jahn et al. have not revealed any advantageous benefits of silver-coated catheters over the standard one (4241 patients; RR: 0.99; [0.85; 1.16]) and (20 patients; RR: 10; [0.83; 1.2]) respectively [38,42]. Jahn et al. concluded evidence should not be treated as a reliable basis for practical implications due to the small sample of the trials and that very few trials have compared several types of catheters for long-term bladder drainage [42].

While Lam et al. [38] concluded that the antiseptic-coated catheters resulted in no statistically significant reduction in symptomatic CA-UTI and was considerably expensive, Pickard’s 2012 RCT further stated that silver alloy-impregnated catheters might be less cost-effective than the antibiotic (Nitrofurazone) coated with OR 0.96 (0.78 to 1.19); p=0.69 compared to OR 0.81 (0.65 to 1.01) p=0.031, respectively [40].

There is no unequivocal evidence supporting the use of either anti-septic, or antimicrobial coated catheters is more beneficial than using standard catheters in reducing UTI in patients who require long term catheterization, no sufficient data to decide which type is the go-to for CA-UTI prevention [41,42].

*Antiseptic-coated Compared to Antibiotic-impregnated*

One large trial included in a Cochrane review SR from 2014 compared silver alloy-coated (antiseptic-coated) catheters versus antimicrobial-coated (nitrofurazone) catheters; they suggested an advantage of antiseptic-impregnated catheters over nitrofural-impregnated catheters (one study; 4250 patients; RR: 0.84; [0.71; 1.00]) [38]. The results showed that people were less likely to have asymptomatic CA-UTI with nitrofurazone-impregnated (228 in 2153 patients, 10.6%) than silver alloy-coated (263 in 2097 patients 12.5%). However, the magnitude of reduction was not statistically significant and hence may not be clinically important (RR 0.84, 95% CI 0.71 to 1.00) [38].

Beattie et al. emphasized that the heterogeneity was too significant for them to calculate an estimate for all studies combined but stated that there was nothing to suggest that one approach was better than the other [43]. The low number of participants, wide confidence intervals and risk of systematic errors and biases...
in one of the studies means that the methodological quality should be considered to be a low one, and
cannot conclude if whether silver-alloy urinary catheters reduce CA-UTI compared with standard silicon or
lace urinary catheters [43].

Antibiotic-related Prophylaxis

Either comparing prophylactic antibiotic administration with no antibiotic prophylaxis or using antibiotic-
impregnated catheters were discussed in eleven studies; five are RCTs [40,44-48], two are RCTs [38,39,47,52],
and four Cochrane Database SRs [38,39,43,52]. In one trial, conducted by Nil-Weise et al., in comparing
antibiotic prophylaxis with antibiotics administration when clinically indicated in the female surgical
patients who had a urethral catheter for more than 24 hours, symptomatic UTI was less frequent in the
prophylaxis group (RR 0.20, 95% CI 0.06 to 0.66) [52]. Likewise, Berroondo et al., in their prospective,
randomized, controlled trial, using antibiotic prophylaxis with oral ciprofloxacin before urinary catheter
removal after radical prostatectomy did not decrease UTI rate [49].

Moreover, in adults requiring short-term urinary urethral and suprapubic catheterization up to and
including 14 days, the patients who received the following systemic antibiotic prophylaxis (cefotaxime,
trimethoprim/sulfamethoxazole, ciprofloxacin, or Nitrofurantoin) antibiotic prophylaxis was associated with
an absolute reduction in risk of urinary tract infection of 5.8% with a risk ratio of 0.45 and a 95% CI between
0.28 to 0.72 [47]. Marshall et al. reported a number needed to treat of 17 (95% confidence interval, 12 to 30)
to prevent a single CA-UTI [47]. However, Van Hees et al. concluded that their results do not support
antibiotic prophylaxis for urinary catheter removal in non-genitourinary surgical patients. Their study
included patients who underwent surgery and received a single prophylactic antibiotic dose 2 hours before
catheter removal (ciprofloxacin 500 mg [n = 45], co-trimoxazole 960 mg [n = 46], placebo [n = 51]) [48].

Lam et al. reported a significant difference in the use of nitrofural-impregnated catheters compared to
standard catheters (one trial that included 4297 patients concluded a RR of 0.84 with a 95% confidence
interval of [0.71; 0.99]) [38]. While Lusardi et al. for the systemic intravenous administration of
trimethoprim/sulfamethoxazole (single trial; 90 patients; RR 0.20; [0.06; 0.66]) [39].

Phytotherapeutic Cranberry Extracts

Both Foxman et al. and Gunnarsson et al. reviewed whether the prophylactic use of cranberry extract tablets
during the postoperative period will reduce or even prevent the occurrence of CA-UTI [50,51]. In the study by
Gunnarsson et al., 227 female patients, aged 60 years and older, with hip fractures were randomized to either
receive 550 mg of cranberry powder three times daily or placebo capsules daily until five days
postoperatively [51]. There was no difference between the groups of patients with postoperative positive
urine cultures at either day 5 or 14 days postoperatively (p = 0.973): 13 of 33 (39%) in the placebo group and
13 of 47 (28%) in the cranberry group (P=0.270) had a positive urine culture. However, this difference was
not statistically significant (P=0.270) [51].

Foxman et al. concluded that patients undergoing elective gynecologic surgery involving urinary
catheterization, the use of cranberry tablets during the postoperative period reduced the rate of UTI by at
least a half; 15 of 80 patients (19%) for the intervention group in comparison to 30 of 80 patients (38%) for
the placebo group with positive urine culture; (RR=0.38; 95% CI: 0.19, 0.79; p=0.008) [50].

Educational Protocols & Preventative Implementations

Educational and raising patient awareness approaches were discussed in eleven studies, five SRs [56,61-
64] and five RCTs [35,57-60]. Meddings et al., who reviewed catheter discontinuation strategies for
hospitalized patients and pooled their results of 7 seven trials, reported that the ‘stop order’ intervention to
prompt removal of unnecessary catheters reduced the duration of catheters in place by 1.06 days, and the
use of either ‘reminders or stop orders’ decreased the CA-UTI rate by 53%, (RR: 0.48; [0.28; 0.68]; p =
0.001) [56]. Another review of nineteen studies by Meddings et al. reported that CA-UTI decreased with
compliance with hand hygiene protocols during urethral-catheter administrations and any follow-up
catheter cares [63]. While Wilde et al. determined in their study in the experimental group (learning-
catheter-related self-monitoring and self-management skills during home visits), the baseline CA-UTI rate of
6.93/1000 catheter days decreased to 4.89 with a 29% relative reduction while in the control group from
5.5/1000 catheter days to 4.12 with a 25% relative reduction [60].

Another systemic review by Mody et al. confirmed that the efficacy of implementing preventive protocols in
nursing homes did reduce the catheter-associated UTI rates decreased from 6.78 to 2.65 infections per 1000
catheter-days [59]. With use of the random-effects negative binomial regression models, the rates decreased
from 6.42 to 3.53 (incidence rate ratio [IRR]: 0.46; 95% CI, 0.36-0.58; P < .001) [59]. This was the only
intervention that demonstrated a statistically significant reduction in CA-UTI in chronically catheterized
patients due to the implemented comprehensive program that limited antimicrobial use, improved hand
hygiene, and promote standardized CA-UTI definitions and active drug-resistant organisms surveillance
protocol [59].

Miscellaneous & Coupled Interventions

One Cochrane review, following urogenital surgery in adults, examined seven trials that compared the
postoperative duration of catheter use; these trials suggested that shorter-term catheterization was
associated with fewer UTI incidences and more patients required re-catheterization following a urethral
compared to a suprapubic catheter [65]. While Ercole et al. showed that the use of an intermittent catheter
with clean technique results in low rates of complications or infections compared to the use of an indwelling
catheter, in the same review, postoperative catheter removal up to 24 hours and the use of an antimicrobial-
impregnated or hydrophilic-coated catheter resulted in lower urinary tract infection [51].

One RCT conducted by Kringel et al. reported that transurethral catheters left in for 24 hours cause lower
infection compared to suprapubic catheters left in for a longer period of around 96 hours (p = 0.054) [66].
Discussion

We included fifty-nine combined studies, including thirty-six RCTs and twenty-three SRs, which shed light on more than fifty measures. Ten of these measures were studied. The bulk of the studies was published in the 2010s period. Since we identified numerous studies with different evidence and measures regarding the prevention and management of CA-UTI in different patient groups and settings, the data regarding catheterization, duration, and prophylactic measure are clinically heterogeneous states of the evidence not conclusive. Although several review authors have identified a couple of studies for some interventions, they could not perform meta-analyses due to the highly heterogeneous finding between the included studies. Three contributing factors for the resulted heterogeneity might be as follows:

Study Groups

The patient groups that were compared varied from one study to the other. Patients with different diagnoses, anatomies and health/immunological status may have different preconditions and predispositions to infections, which in turn makes it harder to combine and group studies to obtain enough participants with similar physical and immunological conditions in comparison to be able to report an efficient data for the prevention of catheter-associated urinary tract infections.

Interventions

Different interventions lead to large variations in what was compared. Studies that were conducted before the first half of the first decade in the 2000s were excluded due to the fear that the applicability and practicality of their findings—in particular, relating to the guidelines related to administration of prophylactic antibiotics or types of education programs would not resonate not translate to the current clinical practices; as the perception about prescribing practices and awareness around resistance may well have over the time. Therefore, to avoid the need to examine the preparations or methods used at the time in the study today or whether there have been other changes over the years, 2005 was agreed on.

Measurement of Outcome Measures

The terms Urinary tract infection, bacteriuria and catheter-associated urinary tract infection were loosely used and varied between the studies. Some studies have not even defined the criteria for their used outcome. Some studies used the terms CA-UTI and catheter-associated asymptomatic bacteriuria or catheter-associated bacteriuria interchangeably. Additionally, terms like Bacteriuria and UTI were differently defined. If we look at three publication as an example, definitions of urinary tract infection in those studies, for instance, were: > = 105 CFU/ml with >10 leukocytes per mm3 of urine [38], > = 105 CFU/ml with one of the following symptoms: fever, pyuria, hematuria, chills, and/or dysreflexia [39], > = 105 CFU/ml [42].

All Catheter types are susceptible to biofilm formation and catheter encrustation; hence administering prophylactic antibiotics may delay the pathogenesis of CA-UTIs rather than preventing their occurrence. The use of low-dose, prophylactic antibiotics might aid in creating “persister” cells that are genetically capable of invading the uroepithelium and result in infection and integration with urinary bladder microbiota. Therefore, contributing more to sepsis and infection [68].

The duration of a catheter is generally based on individual cases rather than evidence-based knowledge and therefore varies among clinical practice. In-dwelling catheters have been associated with positive urine cultures, which can subsequently lead to urinary tract infection can which, as a result, increases the duration of hospital stay, costs and risk of morbidity. The risk of developing a CA-UTI is related to catheter dwell time [69,70]. For catherterized patients, the rate of development of catheter-associated bacteriuria is between 3% to 7% per day [71,72]. The likelihood of bacteriuria approaches 100% if a patient has an indwelling urinary catheter for >90 days [73,74], which is part of the rationale for why a urine culture alone is not sufficient to diagnose a CA-UTI. While bacteriuria is a risk factor for UTI, the frequency of progression from bacteriuria to CA-UTI is low and treating ASB does not decrease the risk of future CA-UTI. Other risk factors for the development of CA-UTI include urinary tract instrumentation, diabetes mellitus, and malnutrition [75,76]. The two principal factors that lead to CA-UTIs are unnecessary urinary catheter placement and unacceptable delay in removing a catheter when it is no longer needed [77]. Unfortunately, 38% of attending physicians are unaware that their patients have a urinary catheter in place, which might be due to the ambiguity of catheter placement indication in approximately 50% of cases [78].

An analysis by Hutton et al. [79] showed that implementing their multimodal intervention program led to 8.7 fewer CA-UTIs and 2.9 fewer resident hospitalizations per nursing home per year. 120-bed NH would have program costs of $20,279/year. The cost of disease treatment would be reduced by $54,316 per year, resulting in a net cost savings of $34,037 for the healthcare system. As well as 0.2 more QALYs (quality-adjusted life-years) than their control group.

Duszyńska et al. estimated the cost of HAIs in a Polish ICU to range from EUR 10,035 to 22,411 [80]. While in the, an estimate of 449,334 healthcare-associated catheter-associated urinary tract infections (CA-UTIs) per year, associated with an additional cost of US$349–10077-9 per admission in 2007 (or an estimated US$3744 when complicated by blood septicemia) (77,81). An Australian study revealed that staffing costs for infection prevention nurses exceed AUD 100million per year and that 36% of their time is spent on patient monitoring. Another study confirmed that those undertaking active surveillance on patients had never been trained, and skills like reporting data to hospital executives are either not appropriately done [82,83]. This means that much of the CA-UTI data being collected might not be a true reflection of the magnitude of catheter complications and makes it harder to analyze the infection rate in an efficient, productive manner. Saint et al. surveyed 719 acute-care American hospitals for their CA-UTI prevention protocols in 2005; more than 70% of the surveyed hospitals documented their rates of CA-UTI, 44% documented which patient had a urinary catheter inserted, and 26% documented the duration of catheterization. No widely accepted protocol to prevent CA-UTI was reported.

We included fifty-nine combined studies, including thirty-six RCTs and twenty-three SRs, which shed light on more than fifty measures. Ten of these measures were studied. The bulk of the studies was published in the 2010s period. Since we identified numerous studies with different evidence and measures regarding the prevention and management of CA-UTI in different patient groups and settings, the data regarding catheterization, duration, and prophylactic measure are clinically heterogeneous states of the evidence not conclusive. Although several review authors have identified a couple of studies for some interventions, they could not perform meta-analyses due to the highly heterogeneous finding between the included studies. Three contributing factors for the resulted heterogeneity might be as follows:

Study Groups

The patient groups that were compared varied from one study to the other. Patients with different diagnoses, anatomies and health/immunological status may have different preconditions and predispositions to infections, which in turn makes it harder to combine and group studies to obtain enough participants with similar physical and immunological conditions in comparison to be able to report an efficient data for the prevention of catheter-associated urinary tract infections.

Interventions

Different interventions lead to large variations in what was compared. Studies that were conducted before the first half of the first decade in the 2000s were excluded due to the fear that the applicability and practicality of their findings—in particular, relating to the guidelines related to administration of prophylactic antibiotics or types of education programs would not resonate not translate to the current clinical practices; as the perception about prescribing practices and awareness around resistance may well have over the time. Therefore, to avoid the need to examine the preparations or methods used at the time in the study today or whether there have been other changes over the years, 2005 was agreed on.

Measurement of Outcome Measures

The terms Urinary tract infection, bacteriuria and catheter-associated urinary tract infection were loosely used and varied between the studies. Some studies have not even defined the criteria for their used outcome. Some studies used the terms CA-UTI and catheter-associated asymptomatic bacteriuria or catheter-associated bacteriuria interchangeably. Additionally, terms like Bacteriuria and UTI were differently defined. If we look at three publication as an example, definitions of urinary tract infection in those studies, for instance, were: > = 105 CFU/ml with >10 leukocytes per mm3 of urine [38], > = 105 CFU/ml with one of the following symptoms: fever, pyuria, hematuria, chills, and/or dysreflexia [39], > = 105 CFU/ml [42].

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50% of the surveyed hospitals reported the regular use of antimicrobial catheters, 14% reported condom catheters in men, and a mere 9% used catheter remiders or stop-orders [84].

Conclusions
In terms of implications to clinical practice, the results of this review suggest that healthcare workers should think of 2 strategies to reduce rates of CA-UTI: limit catheter use and shorten the duration of catheterization. The literature also supports either daily scheduled reviews or stop orders to safely reduce the duration of inappropriate urinary catheterization in hospitalized patients. Based on the current state of evidence, there are insufficient data to determine whether transurethral or suprapubic routes are most appropriate for catheterization. The reduced morbidity rate of supragenic catheterization is offset by higher rates of catheter-related complications and doesn't necessarily mean a shorter hospital stay. No good evidence exists to adequately conclude if washouts were beneficial or harmful due to poor methodological quality and the substantial risk of bias of the included studies. No significant difference was found between the clamping and unclamping groups. Given the scant state of evidence, periodic clamping of indwelling urinary catheters should not be favoured over free drainage. No significant differences have been demonstrated among the various methods of cleansing or disinfecting the external urethral orifice. Evidence from studies that, before intermittent or indwelling catheterization, used either anti-septic or non-medicated agents to clean peri-urethral or meatal area showed no statistical significance in reducing its association with the incidence rate of UTI. Evidence of antiseptically coated catheters, compared to standard uncoated catheters, is equivocal. Antibiotic-impregnated catheters seem to be more documented in the literature and reduce the rate of catheter-associated symptomatic urinary tract infection. The current evidence on phytophtherapy using cranberry extracts to prevent UTIs remains debatable, in part due to the trials were small and methodological weaknesses were shown. Therefore, the evidence was not a reliable basis for any clinical conclusions. So, there is no well-justification in recommending it highly.

Additional Information
Disclosures
Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: Payment/services info: All authors have declared that no financial support was received from any organization for the submitted work. Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. Other relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

References
1. Smyth ET, McEvney G, Emstone IE, et al.: Four country healthcare associated infection prevalence survey 2006: overview of the results. J Hosp Infect. 2008, 69:230-48. 10.1016/j.jhin.2008.04.020
2. Saint S, Chenoweth CE: Biofilms and catheter-associated urinary tract infections. Infect Dis Clin North Am. 2005, 17:411-32. 10.1016/j.idc.2005.03.001:4
3. Jain P, Parada JP, David A, et al.: Overuse of the indwelling urinary tract catheter in hospitalized medical patients. Arch Intern Med. 1995, 155:1425-1429. 10.1001/archives.1995.01011301342
4. Gould CV, Unsworth CA, Agarwal RK, Kuntz G, Peggas DA, HPAPC: Guidelines for prevention of catheter-associated urinary tract infections 2009. Infect Control Hosp Epidemiol. 2010, 31:519-26. 10.1086/631091
5. Shuman EM, Chenoweth CE: Recognition and prevention of healthcare-associated urinary tract infections in the intensive care unit. Crit Care Med. 2010, 38:373-7. 10.1097/CCM.0b013e3181ee0c0f
6. Latour K, Jans B: The HALT management team (2009) Healthcare-associated infections in long-term care facilities. Results of the pilot point prevalence survey. The Scientific Institute of Public Health (WIV-ISP), Brussels, 2009.
7. Consay LJ, Pogorzelska M, Larson E, et al.: Adoption of policies to prevent catheter-associated urinary tract infections in United States intensive care units. Am J Infect Control. 2012, 40:705-10. 10.1016/j.ajic.2011.09.020
8. Page MJ, McKenzie JE, Bossert PM, et al.: The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021, 372:71. 10.1136/bmj.n71
9. Halvorset RA, Thijl SD, Buusmeester FW, et al.: Comparing clean intermittent catheterisation and transurethral indwelling catheterisation for incomplete voiding after vaginal prolapse surgery: a multicentre randomised trial. BJOG. 2013, 118:1051-60. 10.1111/bjog.2013.1191025.x
10. Nyman MH, Gustafsson M, Langius-Ekof A, Johansson JE, Norlin R, Hagberg L: Intermittent versus indwelling urinary catheterisation in hip surgery patients: a randomised controlled trial with cost-effectiveness analysis. Int J Nurs Stud. 2013, 50:1389-98. 10.1016/j.ijnurstu.2013.03.007
11. Zhang W, Liu A, Hu D, et al.: Indwelling versus intermittent urinary catheterization following total joint arthroplasty: a systematic review and meta-analysis. PLoS ONE. 2015, 10:e0136036. 10.1371/journal.pone.0136036
12. Hunter KF, Bharma A, Moore KN: Long-term bladder drainage: suprapubic catheter versus other methods: a scoping review. Neurourol Urodyn. 2015, 32:946-51. 10.1002/nau.22356
13. Dixon L, Dolan LM, Brown K, Hilton P: RCT of urethral versus suprapubic catheterisation. Br J Nurs. 2010, 19:87-93. 10.12968/bjon.2010.19.Sup9.79663
14. Stekolinger E, van der Linden PJ: A comparison of suprapubic and transurethral catheterization on postoperative urinary retention after vaginal prolapse repair: a randomized controlled trial. Gynecol Obstet Invest. 2011, 72:109-16. 10.1159/000328287
15. Healy EF, Walsh CA, Cotter AM, Walsh SR: Suprapubic compared with transurethral bladder catheterization for gynecologic surgery: a systematic review and meta-analysis. Obstet Gynecol. 2012, 120:678-87. 10.1097/AOG.0b013e3182657f84
16. Kidl EA, Stewart F, Kaski NC, Hom O, Omar MD: Urethral (indwelling or intermittent) or suprapubic routes for short-term catheterisation in hospitalised adults. Cochrane Database Syst Rev. 2015, 10:1465-1858. 10.1002/14651858.CD004203.pub5
17. van den Elfke E, Grifiths P: Catheter valves for indwelling urinary catheters: a systematic review. Br J Community Nurs. 2006, 11:111-114. 10.12968/bjn.2006.11.3.20586
18. Danouiche BO, Goetz L, Kidl T, Cerra-Stewart C, AlShafaf A, Priebe M: Impact of StatLock securing device on symptomatic catheter-related urinary tract infection: a prospective, randomized, multicenter clinical trial. Am J Infect Control. 2006, 34:555-60. 10.1016/j.ajic.2006.03.010
19. Gong Y, Zhao L, Wang L, Wang F: The effect of clamping the indwelling urinary catheter before removal in cervical cancer patients after radical hysterectomy. J Clin Nurs. 2017, 26:1131-6. 10.1111/jocn.13579
1. Beattie M, Taylor J: Urinary tract infection after surgery: results of a randomized trial comparing immediate versus delayed catheter removal following hysterec- tomy. Acta Obstet Gynecol Scand. 2006, 85:716-20. 10.1080/000163406006976.

2. Sekhavat L, Farajkhoda T, Dovar R: The effect of early removal of indwelling urinary catheter on postoperative urinary complications in anterior colporrhaphy surgery. Aust N Z J Obstet Gynaecol. 2008, 48:348-52. 10.1111/j.1479-828X.2008.08042.x.

3. Chai J, Pan TC: A prospective randomized trial to compare immediate and 24-hour delayed catheter removal following total abdominal hysterectomy. Acta Obstet Gynecol Scand. 2011, 90:478-82. 10.1111/j.1600-0412.2011.01104.x.

4. Ahmed MR, Sayed Ahmed WA, Atwa KA, Metwally L: Timing of urinary catheter removal after uncomplicated total abdominal hysterectomy: a prospective randomized trial. Eur J Obstet Gynecol Reprod Biol. 2014, 176:60-5. 10.1016/j.ejogrb.2014.02.038.

5. El-Mazny A, El-Sharkawy M, Hassan A: A prospective randomized clinical trial comparing immediate versus delayed removal of urinary catheter following elective cesarean section. Eur J Obstet Gynecol Reprod Biol. 2014, 181:111-4. 10.1016/j.ejogrb.2014.07.054.

6. Bray R, Cartwright R, Digesu A, Fernando R, Khullar Y: A randomized controlled trial comparing immediate versus delayed catheter removal following vaginal prolapse surgery. Eur J Obstet Gynecol Reprod Biol. 2017, 210:514-8. 10.1016/j.ejogrb.2017.01.013.

7. Woonhoff M, Wassen MM, Korzen I, Kamphoeve PH, Roumen FJ: Postoperative catheterization after anterior colporrhaphy: 2 versus 5 days. A multicentre randomized controlled trial. Int Urogynecol J. 2011, 22:477-85. 10.1007/s00192-010-1394-8.

8. Li L, Wen J, Wang L, Li YP, Li Y: Antibiotic prophylaxis for short-term indwelling catheterization in adults: a systematic review of the evidence. J Wound Ostomy Continence Nurs. 2012, 39:348-52. 10.1097/00152192-200603000-00008.

9. Ercole FF, Macleira TG, Wencelsau LC, Martins AR, Campos CC, Chianca TC: Integrative review: evidences on the practice of intermittent/meshing indwelling urethral catheterization. Rev Lat Am Enfermagem. 2013, 21:459-68. 10.1590/S0104-11692013001000001.

10. Cao Y, Gong Z, Shan J, Gao Y: Comparison of the preventive effect of urethral cleaning versus disinfection for catheter-associated urinary tract infections in adults: a network meta-analysis. Int J Infect Dis. 2018, 76:182-8. 10.1016/j.ijid.2018.09.038.

11. Cheung K, Leung P, Wong YC, et al.: Water versus antisepptic perurethral cleansing before catheterization among home care patients: a randomized controlled trial. Am J Infect Control. 2008, 36:575-80. 10.1016/j.ajic.2007.05.004.

12. Sinclair L, Hagen S, Cross S: Washout policies on long-term indwelling catheterization in adults: a short version cochrane review. Neurourol Urodyn. 2011, 30:1208-12. 10.1002/nua.21063.

13. Shepherd AJ, Mackay WG, Hagen S: Washout policies in long-term indwelling urinary catheterization in adults. Cochrane Database Syst Rev. 2017, 5:CD006122. 10.1002/14651858.CD006122.pub4.

14. Naur AM, Elbigawy AF, Abdelamid AE, Al-Khulaidi S, Al-Inany HG, Sayed EH: Evaluation of the use vs nonuse of urinary catheterization during cesarean delivery: a prospective, multicenter, randomized controlled trial. J Perinatol. 2009, 29:416-21. 10.1038/jp.2009.4.

15. Li L, Wen J, Wang L, Li YP, Li Y: Is routine indwelling catheterization of the bladder for cesarean section necessary? A systematic review. HERG. 2011, 118:400-9. 10.1111/j.1471-0528.2010.01020.x.

16. Lam TB, Omar MI, Fisher E, Gillies K, MacLennan S: Types of indwelling urethral catheters for short-term catheterization in hospitalised adults. Cochrane Database Syst Rev. 2014, 9:CD004103. 10.1002/14651858.CD004103.pub4.

17. Lusardi G, Lippi A, Shaw C: Antibiotic prophylaxis for short-term catheter bladder drainage in adults. Cochrane Database Syst Rev. 2015, 7:CD004528. 10.1002/14651858.CD004528.pub3.

18. Pickard R, Lam T, MacLennan G, et al.: Types of urethral catheter for reducing symptomatic urinary tract infections in hospitalised adults requiring short-term catheterisation: multicentre randomised controlled trial and economic evaluation of antimicrobial- and antiseptic-impregnated urinary catheters (the CATHERET trial). Health Technol Assess. 2012, 16:1-197. 10.3310/hta16470.

19. Bonfigli X, Rigau D, Esteban-Fuertes M, et al.: Efficacy and safety of urinary catheters with silver alloy coating in patients with spinal cord injury: a multicentric pragmatic randomized controlled trial. the ESCHAR trial. Spine J, 2017, 17:650-7. 10.1016/j.spinee.2017.05.025.

20. John P, Beutner L, Langer G: Types of indwelling urethral catheters for long-term bladder drainage in adults. Cochrane Database Syst Rev. 2012, 10:CD004997. 10.1002/14651858.CD004997.pub5.

21. Beattie T, Taylor J: Silver alloy vs. uncated urethral catheter: a systematic review of the literature. J Clin Nurs. 2011, 20:2098-108. 10.1111/j.1365-2702.2010.05561.x.

22. Johnson JR, Kuokkala MA, Wilt TJ: Systematic review: antimicrobial urinary catheters to prevent catheter-associated urinary tract infection in hospitalized patients. Ann Intern Med. 2006, 144:116-26. 10.7326/0003-4838-144-2-20060117-00009.

23. Pfefferkorn U, Lea S, Moldenhauer J, Peterli R, von Flüe M, Ackermann C: Antibiotic prophylaxis at urinary catheter removal prevents urinary tract infections: a prospective randomized trial. Ann Surg. 2009, 249:573-5. 10.1097/SLA.0b013e31819c73c2.

24. Dietert AA, Amundsen CL, Edelfeldt AL, Kawasaki A, Levin PJ, Visco AG, Siddiqui NY: Oral antibiotics to prevent postoperative urinary tract infection: a randomized controlled trial. Obstet Gynecol. 2014, 123:96-101. 10.1097/AOG.0000000000000204.

25. Marshall J, Carpenter CR, Fowler S, Trautner BW: Antibiotic prophylaxis for urinary tract infections after removal of urinary catheter: meta-analysis. BJM. 2013, 346:f5417. 10.1136/bmj.f5417.

26. van Hees BC, Vlijbergh PL, Hoornje LE, Wiltink EH, Go PM, Tersmette M: Single-dose antibiotic prophylaxis for urinary catheter removal does not reduce the risk of urinary tract infection in surgical patients: a randomized double-blind placebo-controlled trial. Clin Microbiol Infect. 2011, 17:1991-4. 10.1111/j.1469-0691.2010.03547.x.

27. Bernardo C, Feng C, Kukreja JB, et al.: Antibiotic prophylaxis at the time of catheter removal after radical prostatectomy: a prospective randomized clinical trial. Urol Oncol. 2019, 37:181-7. 10.1016/j.suronc.2018.10.029.

28. Fonman B, Cronenwett AE, Spino C, Berger MB, Morgan DM: Cranberry juice capsules and urinary tract infection after surgery: results of a randomized controlled trial. Am J Obstet Gynecol. 2015, 213:194.e1-8. 10.1016/j.ajog.2014.04.005.
51. Gunnarsson AR, Gunningberg L, Larsson S, Jonsson KB: Cranberry juice concentrate does not significantly decrease the incidence of acquired bacteria in female hip fracture patients receiving urinary catheter: a double-blind randomized trial. Clin Interv Aging. 2017;12:137-43. 10.2147/CA.113597

52. Niël-Weise BS, van den Broek PJ: Antiobiotic prophylaxis for short-term catheter bladder drainage in adults. Cochrane Database Syst Rev. 2001, 3:CD000428. 10.1002/14651858.CD000428.pub2

53. Cardenas DD, Moore KN, Daniels-McClure A, Scutari WM, Graves DE, Brooks M, Gardner A: Intermittent catheterization with a hydrophilic-coated catheter delays urinary tract infections in acute spinal cord injury: a prospective, randomized, multicenter trial. PM R. 2011, 3:408-17. 10.1016/j.pmr.2011.01.001

54. Fasugba O, Roemer J, Mitchell BG, Gardner A: Meal cleaning with antibiotics for the prevention of catheter-associated urinary tract infections: A discussion paper. Infect Dis Health. 2017, 22:135-6. 10.1016/j.idh.2017.08.004

55. Loeb M, Hunt D, O’Halloran K, Cansino SC, Dubhe N, Walter SD: Stop orders to reduce inappropriate urinary catheterization in hospitalized patients: a randomized controlled trial. J Gen Intern Med. 2008, 23:816-20. 10.1007/s11033-008-9060-2

56. Maddings J, Rogers MA, Mary M, Saint S: Systematic review and meta-analysis: reminder systems to reduce catheter-associated urinary tract infections and catheter use in hospitalized patients. Clin Infect Dis. 2010, 51:530-60. 10.1086/653133

57. Chen YY, Chi MM, Chen YC, Chan YJ, Chou SS, Wang FD: Using a criteria-based reminder to reduce use of indwelling urinary catheters and decrease urinary tract infections. Am J Crit Care. 2013, 22:105-14. 10.4037/ajcc201364

58. Lee KC, Cho YF, Wang YM, Lin PC: A nurse-family partnership intervention to increase the self-efficacy of family caregivers and reduce catheter-associated urinary tract infection in catheterized patients. Int J Nurs Pract. 2013, 21:711-9. 10.1111/jin.12131

59. Mody L, Evin SL, Saint S, et al.: A targeted infection prevention intervention in nursing home residents with indwelling devices: a randomized controlled trial. JAMA Intern Med. 2015, 175:714-23. 10.1001/jamainternmed.2015.132

60. Wilde MH, McMahon JM, McDonald MV, et al.: Self-management intervention for long-term indwelling urinary catheter users: randomized clinical trial. Nurs Res. 2015, 64:24-34. 10.1097/NNR.0000000000000071

61. Durant DJ: Nurse-driven protocols and the prevention of catheter-associated urinary tract infections: A systematic review. Am J Infect Control. 2017, 45:1331-41. 10.1016/j.ajic.2017.07.020

62. Gould D, Gaa S, Dwyer N, Cooper T: Implementing clinical guidelines to prevent catheter-associated urinary tract infections and improve catheter care in nursing homes: Systematic review. Am J Infect Control. 2017, 45:471-6. 10.1016/j.ajic.2016.09.015

63. Maddings J, Saint S, Kevin SL, et al.: Systematic review of interventions to reduce urinary tract infection in nursing home residents. J Hosp Med. 2017, 12:356-68. 10.12788/jhm.2724

64. Potugari BR, Umuokele PE, Vedro JG: Multimodal intervention approach reduces catheter-associated urinary tract infections in a rural tertiary care center. Clin Med Res. 2020, 18:140-144. 10.5551/cm2020.1553

65. Phippa S, Lin VN, McInton S, Barry C, Rane A, N’Dow J: Short term urinary catheter policies following urogential surgery in adults. Cochrane Database Syst Rev. 2006, 2:CD004374. 10.1002/14651858.CD004374.pub2

66. Kringel U, Reimer T, Tomczak S, Green S, Kundt G, Gerber B: Postoperative infections due to bladder catheters after anterior colporrhaphy: a prospective, randomized three-arm study. Int Urogynecol J. 2010, 21:1499-504. 10.1007/s00192-010-1221-2

67. Abdel-Aleem H, Aboelnasr MF, Jayousi TM, et al.: Indwelling bladder catheterization as part of intraoperative and postoperative care for caesarean section. Cochrane Database Syst Rev. 2014, 45:170-6. 10.1002/14651858.CD010322.pub2

68. Gonneau LW, Yeoh NS, MacDonald RW, Cadieux PA, Burton JP, Razvi H, Reid G: Selective target inactivation rather than global metabolic dormancy causes antibiotic tolerance in uropathogens. Antimicrob Agents Chemother. 2014, 58:2089-97. 10.1128/AAC.02552-13

69. Tamibay PA, Oon J: Catheter-associated urinary tract infection. Curr Opin Infect Dis. 2012, 25:565-70. 10.1097/QCO.0b013e3283556e5r

70. Warren W, Tenney BH, Hooper M, Muncie HL, Anthony WC: A prospective microbiologic study of bacteriuria in patients with chronic indwelling urethral catheters. J Infect Dis. 1982, 142:719-25. 10.1093/infdis/142.6.719

71. Zimlichman E, Henderson D, Tamir O, et al.: Health-care-associated infections: a meta-analysis of costs and financial impact on the US health care system. JAMA Intern Med. 2013, 173:2039-46. 10.1001/jamainternmed.2013.9763

72. Lo E, Nisolle LE, Goffin BM, et al.: Strategies to prevent catheter-associated urinary tract infections in acute care hospitals: 2014 update. Infect Control Hosp Epidemiol. 2014, 35:464-79. 10.1086/675178

73. Nicolle LE: Urinary catheter-associated infections. Infect Dis Clin North Am. 2012, 26:65-77. 10.1016/j.cinc.2011.10.003

74. Trittou JC, Poston D: Prevalence of catheter-associated urinary tract infections among patients in a neurological intensive care unit: a single institution’s success. J Neurosci Nurs. 2012, 44:111-20. 10.3171/2011.11.NNS11974

75. Lohde LW, Stennos S, Sanchez JA: Hospital-acquired infections. Surg Clin North Am. 2012, 92:65-77. 10.1016/j.suc.2011.11.003

76. Gray M: Reducing catheter-associated urinary tract infection in the critical care unit. AACN Adv Crit Care. 2010, 21:247-257. 10.1097/nuc.0b013e3181d1b5cb

77. R. Douglas Scott II: The Direct Medical Costs of Healthcare-Associated Infections in U.S. Hospitals and the Benefits of Prevention. Daniel A. Pollock, Patricia W. Stone (ed): Centers for Disease Control and Prevention, 2009.

78. Saint S, Wise J, Amory JK, et al.: Are physicians aware of which of their patients have an indwelling urinary catheter? Am J Med. 2000, 476-480. 10.1016/s0002-9345(00)00231-3

79. Hutton DW, Krein SL, Saint S, et al.: Economic evaluation of a catheter-associated urinary tract infection (CAUTI) intervention: a decision-analysis study. J Hosp Med. 2017, 12:356-68. 10.12788/jhm.2724

80. Gonneau LW, Yeoh NS, MacDonald RW, Cadieux PA, Burton JP, Razvi H, Reid G: Selective target inactivation rather than global metabolic dormancy causes antibiotic tolerance in uropathogens. Antimicrob Agents Chemother. 2014, 58:2089-97. 10.1128/AAC.02552-13

81. Fasugba O, Roemer J, Mitchell BG, Gardner A: Meal cleaning with antibiotics for the prevention of catheter-associated urinary tract infections: A discussion paper. Infect Dis Health. 2017, 22:135-6. 10.1016/j.idh.2017.08.004

82. Russo PL, Cheng AC, Richards M, Graves N, Hall L: Variation in health care-associated infection surveillance practices in Australia. Am J Infect Control. 2015, 43:773-9. 10.1016/j.ajic.2015.02.035

83. Mitchell BG, Hall L, Halton K, et al.: Time spent by infection control professionals undertaking healthcare associated infection surveillance: a multi-centred cross-sectional study. Infect, Disease & Health. 2016, 21:56-60. 10.1016/j.idh.2016.03.005

84. Saint S, Kowalski GP, Kaufman SB, et al.: Preventing hospital-acquired urinary tract infection in the United
