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# RECURRENT URINARY TRACT INFECTIONS IN OLDER ADULTS WITH LONG-TERM INDWELLING URETHRAL CATHETERS: AN INTEGRATIVE REVIEW

*Integrative Review*

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## ABSTRACT

**Background:** Long term indwelling urethral (foley) catheterisation is often used in older adults who are frail, have neurogenic bladder, chronic urinary retention, non-healing sacral wounds or for end of life comfort. It is the single most important risk factor for recurrent catheter associated urinary tract infections (CAUTI) in this patient group.

**Outcomes:** To synthesize up-to-date, evidence-based information regarding the epidemiology, pathophysiology, diagnosis, treatment and most importantly, prevention of recurrent CAUTI in older adults with an indwelling permanent catheter, and to provide a clinical framework for clinicians, nurses and LTC teams.

**Methods:** An integrative review was conducted, which included evidence from randomised trials, systematic reviews, large cohort of older adults with an indwelling urinary catheter (IUC), and society guidance from 2020 to 2026 from PubMed, The Cochrane Library, and targeted searches within PubMed and selected journals for catheter-associated urinary tract infection (CA-UTI), indwelling catheter, older adults, asymptomatic bacteriuria (ABU), biofilm, encrustation, and methenamine.

**Results:** Most patients with a permanent catheter will develop “bacteriuria” within a few weeks and the central clinical question is whether they have asymptomatic bacteriuria (which should not be treated) or true symptomatic infection (which in cognitively impaired or non-verbal older adults may be presented by failure to have dysuria or fever, but rather by sudden delirium, new incontinence, or sudden loss of function). Crystalline biofilms formed by Proteus mirabilis, catheter encrustation and blockage are important factors that contribute to recurrent infection, in addition to antibiotic failure. Resistance risk should be considered when using antibiotic prophylaxis in continuous use; the latter is used as a last resort in selected patients; non-antibiotic prophylaxis, e.g. methenamine hippurate, should be used in lieu of antibiotic use, and structured catheter-care bundles, individualised (not fixed-interval) catheter change schedules, and diagnostic stewardship (to avoid unnecessary antibiotic exposure for asymptomatic bacteriuria) should be used for prevention.

**Conclusion:** Recurrent CAUTI in the permanently catheterised older adult should be treated as a chronic problem involving the biofilm related to the device, not a string of individual infections. Stewardship, not necessarily a multidisciplinary approach focused on prevention, decreases the amount of unnecessary antibiotic use and ensures patients are kept safe from true complications of blockage, pyelonephritis, and urosepsis.

**Keywords:** Catheter-Associated Urinary Tract Infection; Indwelling Urinary Catheter; Older Adults; Asymptomatic Bacteriuria; Biofilm; Methenamine Hippurate; Antimicrobial Stewardship; Geriatrics; Integrative Review

## INTRODUCTION

Indwelling urethral catheters are still widely used in older adults who are frail and multimorbid, for chronic urinary retention, neurogenic bladder dysfunction, use for end-of-life care for comfort or to treat stage 3-4 pressure injuries in the sacral region. After weeks to months of a catheter it is almost inevitable that all patients will develop bacteriuria, and the challenge now is to prevent it causing clinical infection, blockage, and the associated complications of pyelonephritis, bacteraemia and urosepsis. CAUTI is consistently detected as one of the most common HAIs in older, catheterised patients and has a disproportionately high rate of morbidity, hospitalisation and antibiotic usage in this age group [1, 3]. In hospitalised elderly cohorts, older age, male gender, longer catheter dwell time, diabetes mellitus, malnutrition and decreased functional independence have all been found to be independent risk factors for CAUTI [1,2]. The nature of the treatment of recurrent CAUTI is different from that of recurrence of UTI in ambulatory, non-catheterised women, which have been the basis of most modern studies of recurrent UTI and trials of UTI prophylaxis. The focus of this review is specific to the practical, evidence-based management of older adults with a permanently (long-term) indwelling urethral catheter, with particular attention to recent updates on the guidelines, trial evidence and mechanisms of catheter biofilm and encrustation, to help bridge the evidence base to a practical clinical framework.

## METHODS

This integrative review was conducted using the popular five-step method for integrative reviews (problem identification, literature search, data evaluation, data analysis, and presentation) that allows for the integration of experimental and non-experimental data (randomised trials, cohort studies, systematic reviews, mechanistic laboratory studies, and society guidelines) to provide a comprehensive, clinically applicable overview of a topic. Medline/PubMed and the Cochrane Library were searched with the following combinations: “catheter-associated urinary tract infection” and “indwelling urinary catheter” or “long-term catheter”, “older adults”, “nursing home”, “asymptomatic bacteriuria”, “biofilm”, “encrustation”, and “methenamine”. The literature search was limited to literature published from 2020–2026, as a means of including current, contemporary literature, rather than historical literature. The following types of studies were prioritised for inclusion: society guidance, randomised controlled trials, systematic reviews and meta-analyses, and large observational cohort studies; case reports, non-peer-reviewed sources, and studies that only included populations without indwelling catheters were included if they provided evidence that could be directly applied to older adults with an indwelling catheter (e.g. trials of non-antibiotic prophylaxis in women without indwelling catheters). Each of the identified sources was reviewed for relevance to older adults with long-term indwelling urethral catheter, methodological quality, and recency; and classified thematically into epidemiology and burden, pathophysiology, diagnosis, microbiology, acute management, and prevention. The results were then compiled narratively together across these themes to create the practical clinical framework below.

## RESULTS

Clinical burden and epidemiology: The high prevalence of CAUTI in older people with an indwelling urinary catheter (IUUC) was demonstrated in a large case-control study of 7295 older people (aged ≥60 years) hospitalised with an IUUC; risk factors for CAUTI were indwelling urinary catheter duration of ≥10 days, hospitalisation of ≥14 days, moderate-to-severe dependence in self-care, age ≥74 years, male sex, diabetes and malnutrition, with the prevalence of CAUTI being 3.4 per 1000 catheter-days [1]. The most common clinical clues included fever, procalcitonin abnormalities and positivity for urinary nitrite, while the most common pathogens isolated were gram-negative organisms, followed by gram-positive organisms and fungi [1]. Similarly, a population-based cohort study of non-hospitalised older adults revealed that there was a high risk of treatment failure with either antibiotic for a CAI, which showed that CAI is more likely to recur in this population due to the underlying device rather than because of any particular antibiotic choice [2]. Worldwide, urological infections, with CAUTI being among the most prevalent, continue to be a significant and growing problem for health care systems and are particularly prevalent in older people [3]. The risk of developing a UTI increases with the length of time a catheter is left in place so that in patients with a permanent catheter for months to years, a UTI is not the abnormal finding—it is the normal one and the question to be answered is whether the deterioration is in fact due to the UTI or the urinary tract. [4].

Pathophysiolog: Biofilm formation, encrustation and host factors. An indwelling catheter immediately acquires a film of host proteins that can be colonized by bacteria which are protected against antibiotics, urine flow, and host immunity by a biofilm. Crystalline biofilm formation is a unique problem associated with Proteus mirabilis use among long-term catheter users. The urease activity of this organism converts urea to ammonia which alkalizes the urine and promotes the supersaturation and precipitation of struvite and apatite crystals into the biofilm matrix, thus gradually blocking the catheter lumen [5]. This encrustation and blockage leads to stagnation of infected urine, reflux of urine to the upper tract and increases the risk of infected urine continuing to ascend to the upper tract, causing pyelonephritis, bacteraemia and septic shock if it is not detected [5-7]. When treating a catheter blockage as an infectious disease alone, rather than also a mechanical and biofilm problem, the blockage is likely to recur because the bacteria in the crystalline biofilm are very resistant to systemic antibiotic treatment. There is a lot of current research into disrupting the bio film process itself, not just on antimicrobial therapy, like the work done on infection responsive and theranostic catheter coatings and on indole impregnated silicone catheters to inhibit the formation of crystalline bio film [6,7]. This large, UK randomised trial of an antimicrobial-impregnated long-term catheter further confirms that blockage rather than infection is the predominant clinical issue and problem that leads to unplanned care in this group of patients [8].

The mechanical susceptibility of older people is further complicated by host factors: as people get older, their bladder mucosal defences decrease, the bladder fails to empty completely, the presence of comorbid diabetes, malnutrition, immobility and poor hand hygiene or catheter care in those who are dependent all contribute to the increase in colonisation density and the risk of developing symptomatic infection [1,2]. The diagnostic conundrum – true infection vs true colonization. Current guidelines do not recommend screening and treating for and preventing ASB in older people, even in nursing homes, because treatment to eradicate the bacteria is temporary and does not benefit the person and may increase resistance and adverse effects from antibiotics [11]. A positive urine culture, even if the quantity of bacteria is heavy, and the urine is cloudy or foul smelling, does not necessarily indicate that the patient is infected and should be treated in a chronically catheterised patient [11].

However, in practice, many older people who have a permanent catheter cannot give a reliable history of the typical urinary symptoms (such as dysuria, urgency and suprapubic pain) of UTIs associated with a catheter. Many older patients with a urinary infection that is complicated by bacteraemia do not have a typical urinary symptom at presentation, but have other more non-specific signs, such as delirium, functional deterioration, rigors or unexplained fever [9]. Diagnostic algorithms for long-term-care residents have been developed which require that a patient with a catheter have at least one of the following urinary symptoms: fever, new costovertebral angle tenderness, rigors or new onset delirium; urine culture should not be ordered in older patients unless there are clinical symptoms, and should not be used as a screening tool [12,26]. In the real world this translates into a fever in an older person with no other obvious cause, new or worsening delirium, rigors, hypotension, or flank pain should be considered to be evidence of CAUTI, and cloudy or malodorous urine, sediment, or a positive culture (albeit incidental) of an otherwise healthy person should not [11,12,26]. These are good criteria that can be consistently applied, and, when used to structure order sets and electronic reminders, can be one of the most effective antimicrobial stewardship interventions in the care of long term catheter users [11].

Microbiology and resistance to antibiotics. In older, catheterised patients with CAUTI, gram-positive bacteria (Enterococcus species) and fungi play a smaller but still significant role, while gram-negative bacteria, including Escherichia coli, Klebsiella pneumoniae, Proteus mirabilis and Pseudomonas aeruginosa, account for the bulk of the microbiology [1]. Bacteriuria in long-term catheter users is usually polymicrobial and this further complicates the interpretation of the culture results, justifying the use of culture positivity as an indication for treatment [1]. As more and more courses of antibiotics are repeated, and often empirically, for suspected recurrent CAUTI, increasingly multi-drug resistant organisms are selected, thus reducing the number of options available for future treatment, which is one of the main criticisms in the literature for the lack of diagnostic stewardship and is a reason to look for non-antibiotic prevention measures outlined below [2,11]. There are limited but generally positive trends reported for external collection methods (male external catheter), with less UTI and asymptomatic bacteriuria rates than indwelling catheter use where external collection is a clinically appropriate alternative, while the principle of avoiding or minimising the dwell time of a catheter is the most effective resistance-sparing intervention [19].

Principles of managing an acute symptomatic episode. If a catheterized older adult is clinically considered to have probable CAUTI, the first step should be to obtain a new urine sample after the removal of the catheter (not from the old catheter or urine bag, as this would be contaminated with the film or biofilm), to evaluate for catheter obstruction or encrustation as a potential cause, and to provide empirical antimicrobial treatment based on local resistance data and previous culture results, followed by targeted therapy when susceptibility results become available [2,16]. If there is any evidence of involvement of the upper tract of the urinary tract, haemodynamic instability or signs of sepsis, the treatment should be escalated to hospital level and more broad-spectrum antibiotics used until cultures are available. Changes of the catheter at the time of or just before antibiotic initiation is often recommended because treatment of a biofilm is less likely to lead to successful clearance [2,16]. High incidence of treatment failure was identified in the different antibiotic classes and durations of treatment for CAI in non-hospitalised older adults in a recent population-based cohort study, supporting the notion that the device is more likely to be the most important factor than the specific antibiotic used [2]. Measures to prevent reoccurrence. Multicomponent “bladder bundles”” that involve hand hygiene before contact with the catheter, secure catheter fixation to prevent urethral trauma, maintain a closed sterile drainage system and daily reassessment of the continued need for a catheter have been the cornerstone of successful CAUTI prevention programmes, and will continue to be recommended as first-line practice in acute and longer term care, according to updated national strategy statements [16]. Such quality improvement bundles have been evaluated economically and demonstrate clinically significant decreases in infection rates if they are sustained, and they are cost-effective with them [17]. Another more comprehensive systematic review of interventions to reduce CAUTI identified that each of the following interventions resulted in significant decreases in CAUTI - antiseptic solution, catheter specific materials, structured education, reminder systems for timely removal, and standardised maintenance procedures - with the quality of the evidence for each intervention varying [18]. The lesson for those who are not able to have their catheter removed is to be mindful of unnecessary interruptions to a closed system, and to simplify maintenance of the closed system, not to seek catheter removal.

In long-term users, an antimicrobial impregnated catheter was compared to usual care in a large, randomised controlled trial in the UK for 1 year, which looked at CAUTI, catheter blockages, unscheduled catheter changes, quality of life and cost-effectiveness [8]. The coating of novel infection-responsive and theranostic materials that are able to detect the pH increase by urease-producing bacteria could be used to locally delay or resist the formation of crystalline biofilms, which has been demonstrated in a laboratory and early clinical-translation studies as a beneficial effect in delaying encrustation and blockage; however, larger-scale clinical evidence, specifically in older adults with permanent catheterisation, is still limited [5, 6, 7]. Non-antibiotic prophylaxis with methenamine hippurate shows the most trial evidence in ambulatory women with recurrent UTI as

compared to catheterised patients. The multicentre non-inferiority trial ALTAR has shown that methenamine hippurate is as effective as continuous low dose antibiotic prophylaxis, and has a favourable cost-effectiveness ratio [21,22] and a randomized trial compared methenamine hippurate with trimethoprim and found similar effectiveness [20]. The more recent ImpresU trial in older women was triple blind and placebo-controlled and found a slight decrease in UTI episodes when women were being treated with antibiotics compared to placebo; there was no difference in the follow-up period [23]. A recently published systematic review, meta-analysis and trial sequential analysis across all RCTs supports methenamine hippurate as a safe, effective and generally non-inferior prophylactic in adult women, but suggests a need for additional trials to determine the sustainability of this benefit [24]. Majority of patients prescribed methenamine hippurate for recurrent UTIs from a UK teaching hospital were symptomatically improved with no significant difference in outcome between those who had a catheter and those who did not [25]. Together, this evidence base is strongest for non-catheterised older women, with efficacy in patients with a permanent indwelling catheter less well established, dependent on maintaining acidic urine and should be considered an adjunct, discussed on a case-by-case basis with the specialist, rather than a routine prophylactic measure [20,21,23–25].

Near universal bacteriuria in patients with permanent catheters makes continuous low dose antibiotic prophylaxis an ineffective way to prevent the underlying process of recurrent UTI, and is generally not recommended for these patients, although it is occasionally employed in non-catheterised patients with recurrent UTI [11,16]. Current guidance instead focuses on diagnostic stewardship to ensure antibiotics are only used during episodes that are diagnosed to have met validated symptomatic criteria to help minimise true recurrence and unnecessary antibiotic pressure [11,12,26]. The use of alternatives to catheterisation is the single most effective way to remove the risk of catheter associated infection and the original indication should be reviewed regularly in all patients with long-term catheters. The use of intermittent catheterisation, external collection devices (which may result in reduced urethral complications but do not remove the risk of CAUTI), or a suprapubic catheter (which may lead to fewer urethral complications, but not reduce the risk of CAUTI) can change or reduce the infection profile where possible and feasible, and a recent systematic review of external collection devices in men and a meta-analysis reported a non-significant trend towards a lower rate of UTI and asymptomatic bacteriuria than with indwelling collection devices, with the authors emphasising the need for better standardisation of the reporting of outcomes in this literature [19]. However, in many very fragile, cognitively impaired or bed bound older people a permanent indwelling catheter is the only viable choice, and this is the population in which the above prevention strategies are most applicable. The Asia Pacific Society for Infection Control guide also provides regional guidance on the key, generalisable components of any CAUTI prevention programme: catheter necessity review, insertion and maintenance bundles, and surveillance [14] and nursing-led bundles to reduce catheter dwell time and infection rates have been demonstrated to independently reduce dwell time and infection rates in hospitalised older and adult populations [15]. Table 1 provides an overview of the key prevention domains, illustrative interventions, and evidence to support them.

**Table 1. Overview of evidence-based strategies to reduce recurrent catheter-associated urinary tract infection in long-term indwelling catheter users, with representative sources.**

| Prevention domain | Representative interventions | Key evidence / source | Practical note for permanent-catheter users |
|---|---|---|---|
| Catheter necessity & care bundles | Daily review of indication; closed, sterile drainage; aseptic insertion; hand hygiene; securement to prevent traction | McCleskey et al., 2022 [17]; Patel et al., 2023 [16] | For permanent catheters the goal shifts from removal to minimising manipulation and breaks in the closed system |
| Catheter material / coating | Silicone vs latex; antimicrobial-impregnated or novel infection-responsive coatings | Bayston et al., 2025 [8]; Li et al., 2025 [18] | No catheter type reliably prevents CAUTI in long-term use; coated catheters mainly aim to delay blockage, not just infection |
| Encrustation / biofilm control | Regular catheter change schedule individualised to blocking pattern; infection-responsive and theranostic coatings under study | Wasfi et al., 2020 [5]; Slate et al., 2023 [6]; Amer et al., 2022 [7] | Proteus mirabilis urease drives struvite encrustation; "blockers" need planned, not emergency, changes |
| Non-antibiotic prophylaxis | Methenamine hippurate | Botros et al., 2022 [20]; Harding et al., 2022 [21]; Chadwick et al., 2024 [22]; Heltveit-Olsen et al., 2025 [23]; Hobaica et al., 2025 | Evidence base is strongest in non-catheterised older women; efficacy in catheterised patients remains |

| | | | |
|---|---|---|---|
| | | [24]; Abolanle et al., 2025 [25] | less certain and urine pH-dependent |
| Antibiotic prophylaxis | Continuous low-dose antibiotics | Krzyzaniak et al., 2022 [11]; Patel et al., 2023 [16] | Generally discouraged for catheter-associated recurrence given resistance risk; reserved for selected, refractory cases after specialist review |
| Diagnostic stewardship | Avoid urine dipstick/culture for screening; apply symptom-based criteria before treating | Llor et al., 2024 [12]; Krzyzaniak et al., 2022 [11]; CDC/NHSN, 2024 [26] | Asymptomatic bacteriuria is near-universal with permanent catheters and should not trigger antibiotics |
| Catheter alternatives | Intermittent catheterisation, suprapubic catheter, external/male external collection devices where feasible | Mercado et al., 2025 [19] | Not always feasible in frail, cognitively impaired, or immobile patients but should be revisited periodically |

## DISCUSSION

The evidence gathered here points to one over-arching explanation for the recurrent CAUTI in the permanently catheterised older person – the CAUTI is a biofilm process that is more chronic than a series of separate infective events and is device-related. Once a catheter has been in place for a few weeks, it is a normal condition to have bacteria in the urine and the diagnostic challenge is not to detect bacteria, but to determine which changes in the urine are from the urinary tract. The role of antibiotic failure as a cause of recurrent blockage and breakthrough infection is not as significant as that of crystalline biofilm and encrustation by Proteus mirabilis, and this is why interventions aimed at the device itself (individualised catheter-change schedules, new coatings or catheter free alternatives in cases where possible) are featured as prominently in the literature as are antimicrobial interventions. There is also a mechanistic reason for this: diagnostic stewardship is consistently the most effective intervention, because treating ASB will not eradicate the underlying biofilm, and will promote resistance without clinical benefit. Renal function tends to decrease as people age and many antimicrobials used to treat CAUTI require dose adjustment; nitrofurantoin is a good example of this, as it is best avoided when the estimated glomerular filtration rate is very low and is not recommended for treating an upper tract or systemic infection. When a new agent is started, the risk of drug interactions with any other agent is elevated in the presence of polypharmacy, and this should be addressed at every course of antibiotics. In this population, caregivers and nursing staff might be the only ones to present with delirium, falls, or functional decline as the only symptoms, making it important for them to receive structured education about what changes require urgent clinical assessment based on validated criteria for symptoms of infection, not just appearance of urine or its odour [9,12,26]. Finally, when patients are receiving palliative/end-of-life treatment, consideration of further diagnostic testing and/or antibiotic treatment for possible CAUTI should be re-evaluated in the context of an overall goal of care discussion with the patient (where feasible), family, and multi-disciplinary team, rather than routinely.

Many of the best data on the benefits of prophylaxis (such as the large methenamine hippurate trials) have been obtained in ambulatory women with recurrent UTI, and there remains doubt about its magnitude, optimal dosing, and safety in this patient population [20–25]. Most permanent catheter users are in a nursing-home or home-care setting, and there is a need for pragmatic, adequately powered trials in these settings, which are more representative of where they live in practice, in order to progress antimicrobial and infection-responsive catheter coatings to early clinical-trial stage [5–8]. The diagnostic criteria for surveillance and antibiotic initiation in long-term care were developed in a main aim to standardise the criteria, and are still being analysed for accuracy against actual infection in catheterised residents, showing a need for improved point-of-care diagnostics that will be able to differentiate between colonisation and infection, without relying on clinical judgement alone [12,26].

The conclusions of this review have several limitations that need to be taken into account in drawing the conclusions to the review. Study selection and synthesis were systematic, but involved some aspects of narrative judgement; a formal risk of bias or GRADE-type appraisal of the individual sources was not conducted, as this was not considered a systematic review. The literature search was intentionally limited to publications since 2020 to ensure that the most recent literature, reflecting current practice, was reviewed, which resulted in some earlier foundational literature on the pathophysiology of CAUTI and catheter biofilm not being reviewed. Many of the best trials evidence, especially for methenamine hippurate, comes from ambulatory women, and not from women with permanent catheters; hence these trials do not directly apply to the women this review addresses. The sources searched were in English language only, and may not have included all relevant regional or non-English sources. They are not

specific to this review, but are reflective of the current state of the field, and strengthen the argument of this review for dedicated trials in older adults who have permanent catheters. The clinical message to clinicians, nurses and long term care teams is that recurrent CAUTI in this population should be addressed proactively, as an ongoing, device-care related issue, not reactively, as a series of unrelated infections that need to be treated with antibiotics. The combination of using validated symptom-based diagnostic criteria for orders and pathways, individualising instead of standardising catheter-change intervals and only providing non-antibiotic and antibiotic prophylaxis for patients that are carefully selected is a cohesive and evidence-based approach to this biofilm linked problem. In addition to these technical measures, periodic reassessment of the indication for the catheter and of the goals of care in frail / palliative patients is an integral part.

## CONCLUSION

In the older adult with a permanent indwelling catheter, recurrent UTI is a chronic problem of biofilm and device as opposed to a sequence of UTIs. The ubiquitous presence of bacteriuria and its inability to be avoided makes the ability to make clinical judgments based on proper and validated criteria to distinguish true UTI (usually associated with delirium, fever, rigors) from asymptomatic bacteriuria the pivotal skill in clinical practice. The best strategy to minimize the true number of catheter-related UTIs and unnecessary antibiotic use or exposure among this vulnerable group of patients is to layer on structured bundles of catheter care, individualize the schedule for changing catheters, use non-antibiotic catheter prevention strategies (like methenamine hippurate) judiciously in carefully selected patients, and periodically reassess the necessity of the catheter itself.

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**AUTHOR's CONTRIBUTION:**

| Author | Contribution |
|---|---|
| Aleem Ejaz | Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Validation, Supervision |
| Ali Hamza Arshad | Methodology, Investigation, Data Curation, Writing - Review & Editing |