Risk Management and Healthcare Policy

Dovepress
Taylor & Francis Group

Open Access Full Text Article

REVIEW

Best Evidence for Preventing Urinary Tract Infections and Optimizing Care in Adults with Indwelling Urinary Catheters

Jiayan Tang[1,2], Yanhong Fan[3], Jiayun Lu[3], Yongfang Zhang[1,3]

[1]Graduate School, Shanghai University of Traditional Chinese Medicine, Shanghai, 201203, People's Republic of China; [2]School of Nursing and Health Management, Shanghai University of Medicine & Health Sciences, Shanghai, 201318, People's Republic of China; [3]Nursing Department, Shanghai University of Medicine & Health Sciences Affiliated Zhoupu Hospital, Shanghai, 201318, People's Republic of China

Correspondence: Yongfang Zhang, Email 93118415@qq.com

Background: Catheter-associated urinary tract infection (CAUTI) is the most frequent hospital-acquired infection and remains a major challenge for nursing quality and infection control. Existing studies are fragmented, and high-quality evidence syntheses are lacking.

Objective: This study aimed to systematically search for relevant evidence on the prevention and care of catheter-associated urinary tract infections. The evidence was evaluated and integrated to provide reference for clinical practice.

Design: This study was conducted as a systematic evidence summary, following a systematic review methodology to identify, appraise, and synthesize best available evidence on the prevention and care of catheter-associated urinary tract infections.

Methods: Identify the evidence-based questions, based on the "6S" evidence pyramid model, evidence related to the prevention and care of urinary tract infections in patients with indwelling urinary catheters were systematically searched from relevant databases and relevant websites for clinical decisions, guidelines, evidence summaries, systematic reviews and expert consensuses. The study was initiated in December 2024, and the search period covered from database inception to January 2025. Three researchers who had completed their professional training and assessment at the Evidence-based Nursing Center conducted literature screening, quality evaluation, and evidence synthesis. The study population was global, not restricted to a specific region.

Results: Fourteen studies were included: two clinical decision-making articles, eight guideline articles, two systematic review articles and two expert consensus articles. A total of 32 pieces of evidence were formed in five aspects: pre-catheterization criteria, catheterization techniques and requirements, daily care and maintenance of urinary catheters, catheter removal, and diagnosis and treatment of CAUTI.

Conclusion: This study summarizes the best available evidence on the prevention and care of urinary tract infections in patients with indwelling urinary catheters. The findings provide an evidence base for clinical nursing practice, enhance nurses' awareness of CAUTI prevention and care, and support the development of evidence-informed protocols for clinical settings.

Trial Registration: This study was registered at the Center for Evidence-Based Nursing of Fudan University (registration number ES20257362).

Keywords: patients with catheter retention, urinary tract infection, preventive nursing, evidence summary, evidence-based nursing

Introduction

Catheter-associated urinary tract infection (CAUTI) refers to a urinary tract infection that occurs during catheterization or within 48 hours after catheter removal.[1] It is the most common hospital-acquired infection worldwide.[2] According to the US Centers for Disease Control and Prevention, 70–80% of all urinary tract infections are related to indwelling catheters.[3] CAUTI is associated with significant morbidity and mortality. A large multicenter survey reported that CAUTI contributes to an average increase of 18.5% in patient mortality, although 65–70% of cases are preventable.[4–6] In urology wards, urinary catheterization is highly prevalent, with studies reporting that up to 72% of hospitalized

Received: 1 August 2025
Accepted: 25 October 2025
Published: 11 November 2025

patients require catheterization during their stay.[7] Catheter-associated urinary tract infections (CAUTIs) represent a major healthcare burden, accounting for approximately 40% of all hospital-acquired infections.[1] A recent matched case–control study in an intensive care unit reported a catheter-associated urinary tract infection incidence of 3.7 per 1000 catheter-days, and identified several patient- and device-related risk factors.[8,9] Once CAUTI develops, it worsens the patient's condition, prolongs hospitalization, increases medical costs, and may even be life-threatening.[8–10]

Reducing the incidence of CAUTI has therefore become a key priority in infection control and nursing quality management. However, existing research on CAUTI prevention and care is limited, with most studies focusing on univariate analysis and lacking systematic, high-quality evidence. To address this gap, we systematically reviewed domestic and international evidence on the prevention and care of CAUTI, with the aim of synthesizing best evidence to guide clinical decision-making and improve nursing practice.

Information and Methodology

Development of Evidence-Based Issues

In this study, we follow the PIPOST tool proposed by Fudan University's Evidence-Based Nursing Centre to identify and define an evidence-based problem, which was then structured as a PIPOST component:[10] P(Target Population for Evidence Application): All patients with indwelling urinary catheters in the hospital; I(Intervention methods): A series of evidence related to preventive care measures for urinary tract infections, mainly including preventive measures, intervention strategies, and related nursing care; P(people applying evidence): Clinical-related nursing staff with extensive experience in evidence handling; O(Outcome indicators): Incidence of urinary tract infections associated with indwelling urinary catheters, etc. S(Application areas): Hospitals, communities, etc; T(Types of evidence): Clinical decision-making, guidelines, expert consensus, systematic reviews, and evidence summaries, etc.

Retrieval Strategy

We performed a systematic search across guideline repositories, evidence-summary databases, and bibliographic databases, using the 6S pyramid approach (BMJ Best Practice, UpToDate, EAU, NICE, JBI, PubMed, Cochrane, CNKI, Wanfang, and others). A combination of subject headings and free-text terms related to "catheter", "catheter-associated urinary tract infection", "prevention", and "nursing care" was used. Full search strings for each source are provided in Appendix 1. Searches were conducted through 31 January 2025. In addition to the databases listed, no supplementary backward or forward citation tracking and no grey literature search were conducted.

Inclusion and Exclusion Criteria for the Literature

Inclusion Criteria

(i) The research content focuses on studies related to the prevention and management of CAUTI.
(ii) The research types include clinical decision-making, guidelines, evidence summaries, systematic reviews, and expert consensus statements.
(iii) The languages of the published literature are Chinese and English.

Exclusion Criteria

(i) Incomplete information, inability to obtain the full text.
(ii) Duplicate publications or drafts published domestically and internationally.
(iii) Literature that does not meet quality evaluation standards.

Literature Quality Evaluation Criteria

① Clinical guidelines: Quality evaluation was conducted using the Appraisal of Guidelines for Research and Evaluation (AGREE II).[11] The evidence appraisal tool encompasses six core dimensions comprising 23 secondary indicators, along with a dual global assessment module. Evaluation is conducted using a seven-point rating scale established through the Delphi method, where a score of 1 indicates complete deviation from the standard requirements and a score of 7 represents full compliance with the guideline specifications. The standardized value for each dimension is calculated as

a percentage to reflect its relative position within the possible score range, by subtracting the minimum possible score from the actual score, dividing the result by the difference between the maximum and minimum possible scores, and multiplying by 100%. Under the guideline quality grading framework, Grade A is assigned when standardized scores for all dimensions are ≥60%. Grade B applies when three or more dimensions fall within the 30–59% range, whereas Grade C is defined by three or more dimensions scoring <30%. Grade A guidelines are considered suitable for direct clinical implementation, Grade B guidelines should undergo expert appraisal and modification prior to implementation, and Grade C guidelines are not recommended for clinical implementation. ②Expert consensus: The evaluation was conducted using the evaluation criteria corresponding to the JBI Australian Centre for Evidence-Based Health Care (2016 edition), and the evaluation tool included 6 items, each item was rated as "yes", "no", "unclear" and "not applicable".[12] ③Systematic review: The methodological quality of the systematic review was evaluated using JBI standards. The evaluation tool consists of 11 items, each of item was rated as "yes", "no", "unclear" and "uncertain".[13] ④Literature from authoritative institutions such as UpToDate was directly included.

Literature Quality Evaluation Process

The included guidelines were evaluated by two researchers trained in evidence-based care systems (1st and 2nd authors) using a paper-based scale, and the intra-group correlation coefficient was used to test the consistency of the results. The included clinical decisions, guidelines, expert consensus, and systematic reviews were also independently completed by the two investigators and cross-checked. In case of disagreement, the evidence-based care experts of the research team are consulted for assessment.

Evidence Extraction and Consolidation

Two researchers who had completed training in evidence-based nursing were responsible for reviewing the included literature one by one and organising the evidence content and its sources item by item according to the established criteria, which were then checked and revised by a third evidence-based nursing expert. The following principles of evidence integration were followed in this process:[10] (i) when the evidence content was expressed in the same way, it was merged; (ii) when the evidence content was complementary, it was merged according to the logical order of the language; and (iii) when there was conflict between different sources of evidence, we applied a structured GRADE-style evidence-to-decision approach, taking into account the certainty of evidence, balance of benefits and harms, patient values, feasibility, and resource implications. For instance, the BAUS/BAUN consensus24 for long-term indwelling catheters states in its patient information leaflet that "The catheter should be changed at least every 3 months". In contrast, the 2014 SHEA/IDSA practice 28 recommendations explicitly advise "No routine change in catheter". To reconcile this, we prioritized higher-quality evidence and adopted a clinically indicated replacement strategy rather than routine time-based changes.This approach reflects international standards for guideline development, ensuring that recommendations are both evidence-based and feasible in practice. The JBI evidence pre-grading and recommendation system (2014) was used to grade and evaluate the extracted evidence.[14] The evidence system was divided into five levels according to the differences in the types of study designs: level 1 evidence covers randomised controlled trials and related experimental studies; level 2 corresponds to class experimental studies with partially controlled conditions; level 3 involves analytical designs in observational studies; level 4 contains descriptive designs in observational studies; and level 5 refers to expert consensus or foundational research results. The evidence recommendations were formed by referring to the level of evidence recommendation in the JBI evidence pre-classification and evidence recommendation level system (2014 version), according to this framework, the strength of recommendation is divided into two levels: Grade A (Strong recommendation): The evidence is of high quality and consistency, with clear applicability to clinical practice. The balance of benefits and risks strongly supports adoption, and the recommendation can generally be implemented across most clinical contexts. Grade B (Weak recommendation): The evidence is of lower quality, inconsistent, or limited in applicability. Implementation may depend on contextual factors such as resources, patient preferences, or institutional priorities. These recommendations should be adopted conditionally and adapted to the specific clinical setting. In this study, evidence derived primarily from clinical guidelines and systematic reviews was generally graded as A, whereas recommendations informed mainly by expert consensus or limited evidence were graded as B.[14] It should be noted that

the compilation team of this evidence summary has completed standardized evidence-based medical system training, and strictly followed the principle of academic independence during the implementation of the project, without accepting any funding or guidance from any catheter product manufacturers.

Result

The Results of the Literature Search and the General Characteristics of the Included Literature

In this study, 2629 articles were preliminarily searched, 1582 articles were obtained after excluding duplicate literature, 1459 articles were excluded from reading titles and abstracts, and the remaining 123 articles were re-screened. A total of 109 articles that did not meet the requirements were excluded, including 87 studies with inconsistent study types, 12 with inconsistent outcome indicators, 4 with incomplete information, and 6 review articles. Finally, 14 articles were included,[15–28] comprising 2 clinical decisions,[27,28] 2 expert consensuses[17,21] and 2 systematic reviews.[19,20] The literature screening process is shown in Figure 1. The general characteristics of the included studies are shown in Table 1.

Quality Evaluation Results of the Included Literature

Results of the Evaluation of the Quality of Clinical Decision-Making

A total of 2 clinical decisions were included in this study, both from Up To Date, and the original literature was mainly from randomized controlled trials, with high quality of evidence.[27,28]

Results of the Evaluation of the Quality of the Guideine

Eight guidelines were included in this study, and the quality evaluation results are shown in Table 2.[15,16,18,22–26]

Results of the Qualitative Evaluation of Expert Consensus

Two expert consensus articles were included in this study. The evaluation results of 6 items in 2 articles were "yes", and the quality evaluation results are shown in Table 3.[17,21]

Results of the Quality Evaluation of Systematic Evaluations

Two systematic reviews were included in this study, and the quality evaluation results are shown in Table 4.[19,20]

Summary of Evidence

Through the discussion, analysis and integration of the evidence on the prevention and care of urinary tract infection in patients with indwelling urinary catheters, 32 pieces of evidence were finally summarized from five aspects: pre-catheter guidelines, catheter technology and requirements, daily care and maintenance of urinary catheters, urinary catheter removal, and diagnosis and treatment of CAVI, as shown in Table 5.

Discussion

Implementing Multi-Angle Pre-Catheterisation Guidelines and Clarifying the Key to Preventing Catheter Complications

Placing catheters only when indicated is key to preventing catheter complications, and daily assessment of the need for ongoing indwelling catheters is essential to minimise complications.[28] Indwelling catheters should only be inserted when the indications for their retention are met, and it is recommended that alternatives to indwelling catheterisation be used depending on the patient's individual care needs.[29] Evidence 1–5 includes the content of the pre-catheterisation guidelines in 3 areas: indications for catheterisation, choice of catheter, and requirements of the person placing the catheter. It has been reported that avoiding indwelling catheters is the most effective way to prevent catheter-related urinary tract infections.[23] When the use of indwelling catheters is unavoidable, their duration of use should be minimised.[16,20,23,25,28] At present, various CAUTI-related guidelines do not give clear recommendations on the choice of catheter material, and the common catheter materials in China are natural latex, silicone, and polyvinyl chloride,[29,30] and there is no evidence that silver-coated catheters or antibiotic-coated catheters have any effect on the prevention of urinary tract infections

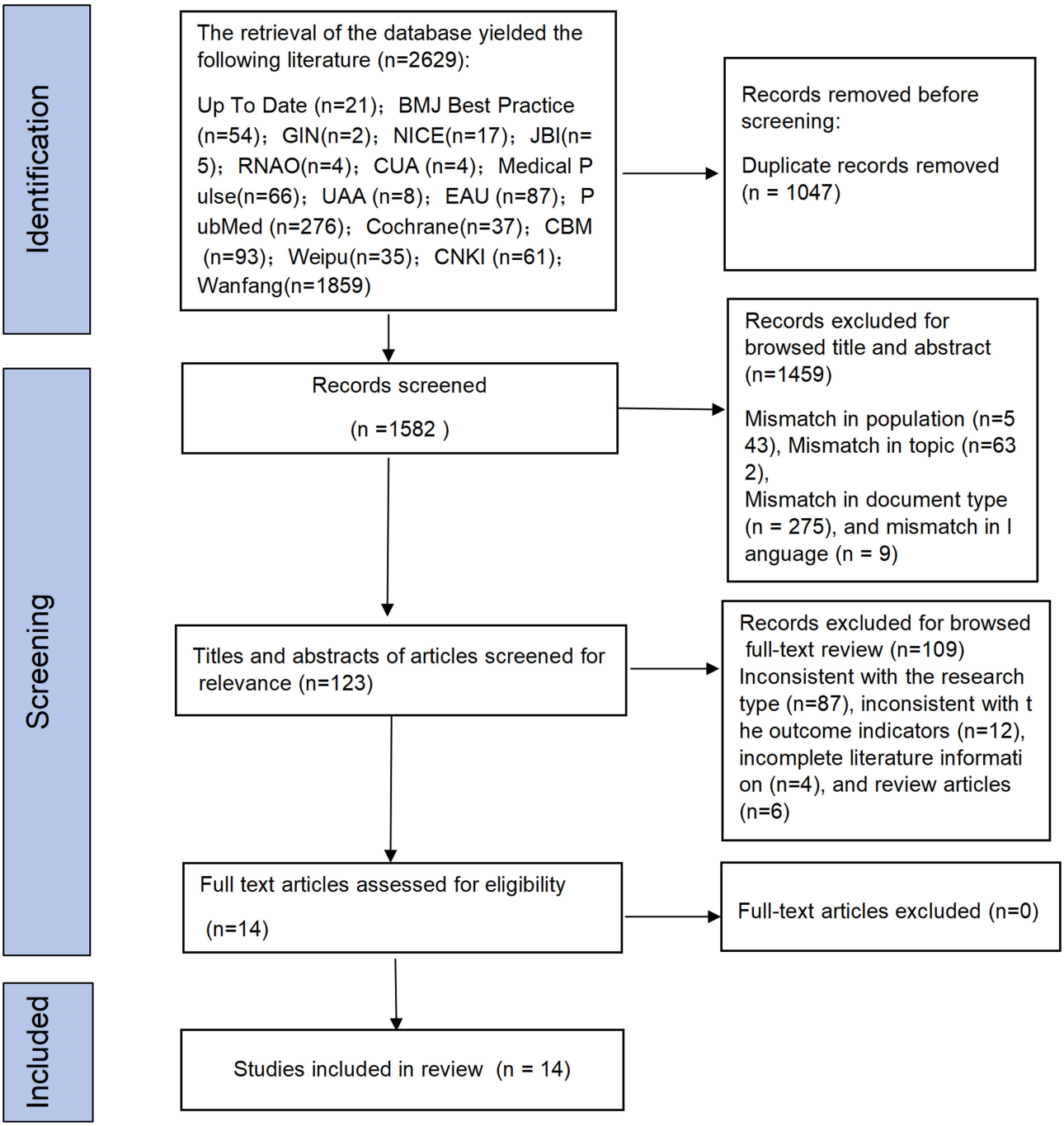

Figure 1 Flow chart of literature screening.
Abbreviations: GIN, Guidelines International Network; NICE, National Institute for Health and Care Excellence; JBI, the Australian Joanna Briggs Institute Evidence-Based Healthcare Centre database; RNAO, Registered Nurses Association of Ontario; NGC, the National Guideline Clearinghouse; CUA, Chinese Urological Association; AUA, the American Urological Association; UAA, the Asian Urological Association; EAU, the European Association of Urology; CBM, China Biology Medicine disc.

(UTI) and therefore routine use of such catheters is not recommended. It has been suggested[15,18,25] that the smallest possible catheter made of hydrophilic material may be preferred, and that the standard Foley catheter (ie, a double-lumen latex catheter) is suitable for the majority of adults requiring urethral intubation.[28] Thus, pre-catheterisation assessment of the patient's needs such as the presence of latex allergy; catheter length (standard, female, paediatric); type of sterile drainage bag and sampling holes, catheter valves; comfort and dignity is necessary.[16] At present, more disposable catheterisation kits are used in clinical practice, and catheters are routinely configured in the kits. The purchasing

Table 1 General Characteristics of the Included Literature (n=14).

Inclusion of Literature	Publication Year	Literature Sources	Literature Theme	Literature Type
Barbara et al[27]	2024	Up to date	Clinical features, diagnosis, treatment, and prevention of catheter-associated urinary tract infections	Clinical decision
Anthony et al[28]	2024	Up to date	Use and management of urinary catheters	Clinical decision
Bonkat et al[25]	2024	EAU	Diagnosis, treatment, and prevention of urinary tract infections	Guideline
Zacharyet al[26]	2024	SEIMC	Diagnosis, prevention, and treatment of urinary tract infections and associated genitourinary infections	Guideline
Moi et al[24]	2023	APSIC	Prevention and management of CAUTI in patients with indwelling urinary catheters	Guideline
Chuang et al[22]	2021	Pubmed	Recommendations for the management and prevention of CAUTI	Guideline
Satoshi et al[23]	2021	JUA	Urological infection control and urinary tract management	Guideline
Marina et al[18]	2016	Medical Pulse	Etiology, microbiology, prevention, diagnosis, and treatment of various urinary tract infections	Guideline
Evelyn et al[15]	2014	Medical Pulse	Catheter-associated urinary tract infection prevention strategies	Guideline
Loveday et al[16]	2014	Medical Pulse	Comprehensive recommendations for the prevention of healthcare-associated infections	Guideline
Reid et al[21]	2021	Pubmed	Suggested checklist and troubleshooting strategies for the management of complications of long-term indwelling urinary catheters	Expert consensus
Zheng et al[17]	2015	CNKI	Diagnosis and treatment of complicated urinary tract infections	Expert consensus
Mangal et al[20]	2021	Pubmed	The content, format, and outcomes of interventions for patient or family involvement in CAUTI prevention	System evaluation
Gad et al[19]	2021	Pubmed	To summarize current strategies and interventions to reduce urinary catheter-associated urinary tract infections	System evaluation

Table 2 Methodological Quality Evaluation Results of the Guidelines (n=8).

Included Literature	Percentage of Field Standardisation (%)						≥ 60% Field Number (n)	≥ 30% Field Number (n)	Recom Mendation Level
	Scopes and Objects	Participant	Rigour of the Guide Lines	Clarity of Guidelines	Application of Guidelines	Independence of the Guide			
Bonkat et al[25]	80.95	81.87	91.07	97.62	94.23	92.96	6	0	A
Zachary et al[26]	71.43	76.19	70.54	80.96	61.53	85.71	6	0	A
Moi et al[24]	54.76	71.43	74.11	73.81	71.15	89.29	5	1	A
Chuang et al[22]	66.67	59.52	83.93	83.33	82.69	88.27	5	1	A
Satoshi et al[23]	85.71	65.67	72.32	85.71	71.15	92.86	6	0	A
Marina et al[18]	69.05	66.67	72.32	88.10	73.08	96.43	6	0	A
Evelyn et al[15]	71.47	72.94	62.50	83.41	69.23	85.71	6	0	A
Loveday et al[16]	92.86	88.10	87.50	90.48	89.38	89.28	6	0	A

Notes: AGREE-II: Appraisal of Guidelines for Research & Evaluation II. Domain scores shown are standardized (0–100%). Two independent reviewers scored each guideline; intra-class correlation coefficient (ICC) for domain scoring were 0.99 (95% CI 0.96–0.99), 0.97 (95% CI 0.96–0.99), 0.96 (95% CI 0.96–0.99), 0.89 (95% CI 0.43–0.98), 0.89 (95% CI 0.41–0.98), 0.98 (95% CI 0.90–0.99), 0.93 (95% CI 0.60–0.99), 0.98 (95% CI 0.90–0.99).

Table 3 JBI (2016) Critical Appraisal Checklist for Expert Consensus (n=2).

Study	Q1: Clinical Question Stated	Q2: Systematic Method for Evidence	Q3: Experts Composition Reported	Q4: Consensus Method Described	Q5: Evidence & Opinion Synthesis	Q6: Recommendation Process Explained
Reid et al[21]	Yes	Yes	Yes	Yes	Yes	Yes
Zheng et al[17]	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Provides a systematic approach to evidence-based healthcare, including evidence classification, grading, and recommendation development.
Abbreviation: JBI: Joanna Briggs Institute.

department tends to have a single specification for the procurement of disposable catheterisation kits, which restricts the medical staff's choice of catheter models, and communication with the relevant departments should be strengthened to increase the number of models of different catheters available for the choice of the medical staff.

Strictly Grasp the Requirements in Catheterisation and Comprehensively Standardise the Catheter Care Process

The principles of asepsis must be strictly adhered to throughout the indwelling urinary catheter.[31] Studies have shown that careful hand washing, wearing sterile gloves, and strict enforcement of hand hygiene can significantly reduce the incidence of CAUTI.[32] Evidence 6–11 suggests the importance of following aseptic handling practices and using sterile equipment for insertion and placement of catheters. Repeated picking up of items during catheterisation, crossing sterile areas, and disruption of the sterile environment can also increase the incidence of infection.[29] The following points must be considered when placing a urinary catheter:[23] ① Hand hygiene must be performed immediately before and after insertion. ② Aseptic treatment must be carried out and clean instruments must be used. ③ It is best to use a closed urine collection system, which can effectively reduce the invasion pathway of external pathogens. However, it should be noted that sterilising lubricants cannot be routinely used to prevent CAUTI.[21,33] Clinical nursing staff must properly fix the catheter and drainage device, catheter fixation technology can be divided into two major dimensions, the internal anchoring technology is the catheter proximal 5cm balloon injected with sterilised water for injection of 10–15mL, to maintain the intra-balloon pressure of 15–20mmHg. For external stabilisation technology, there is no uniform implementation of the standard. The JBI Evidence Based Nursing System 2023 report shows that 32 different fixation methods coexist. The composite fixation solutions often used in clinical practice include medical catheter fixation devices, hydrocolloid dressing interface cushioning technology, and so on. Nursing staff should properly adjust the position of the urine collection bag to reduce urinary tract injury caused by catheter pulling and avoid complications such as catheter dislodgement, skin indentation, urethral injury, and unplanned extubation, thus reducing the incidence of CAUTI.[29] After indwelling a urinary catheter the appropriate person should record the following information: indication for catheter insertion, date and time of catheter insertion, operator's information, and expected date and time of catheter removal.[21]

Optimising Routine Catheter Management and Maintenance Strategies for Multidimensional Prevention of Complications

Reducing the risk of CAUTIs through a comprehensive strategy of routine catheter management and maintenance is clinically important. Evidence 12–26 describes five aspects of catheter and drainage device management, cleaning, bacteriuria screening, catheter replacement, and education and training. In daily management, it is vital to keep the catheter and drainage system closed and patent,[28] which prevents infections such as those caused by urine reflux. The drainage bag should always be kept below the level of the bladder to avoid urine reflux or contact with the floor. Also, regular assessment of the need for indwelling urinary catheters and prompt removal when conditions permit can be effective in minimising complications.[17] Washing around the catheter (around the urethra, suprapubic area) with soap and water is sufficient for daily bathing, avoiding the use of urethral antiseptics or antimicrobial urethral lubricants, which not only do not prevent infections, but may lead to the emergence of drug-resistant organisms in the urethra.[27] Healthcare workers must wear gloves to operate the catheter or drainage system, and the drainage plug should not touch the urine

Table 4 JBI Critical Appraisal Checklist for Systematic Reviews (n=2).

Study	Q1: Review Question Stated	Q2: Inclusion Criteria Appropriate	Q3: Comprehensive Search	Q4: Quality of Studies Assessed	Q5: Standardized Data Extraction	Q6: Appropriate Synthesis Methods	Q7: Publication Bias Assessed	Q8: Heterogeneity Assessed	Q9: Results Clearly Presented	Q10: Conclusions Based on Evidence	Q11: Conflicts of Interest Reported
Mangal et al[20]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Gad et al[19]	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes

Note: JBI: Joanna Briggs Institute. Provides a systematic approach to evidence-based healthcare, including evidence classification, grading, and recommendation development.

https://doi.org/10.2147/RMHP.S557548

Table 5 Summary of the Best Evidence for the Prevention and Care of Urinary Tract Infections in Patients with Indwelling Urinary Catheters.

Categories		Content of Evidence	Level of Evidence (Grade)	Level of Recommendation (Grade)
Pre-catheterization guidelines	Indications for indwelling catheterization	1.Strictly grasp the indications for indwelling catheterization, evaluate the necessity of indwelling catheterization daily, consider other treatment methods, such as urine condom, intermittent catheterization, etc., according to the patient's condition and condition needs, and minimize the use time when the indwelling catheter is unavoidable.[16,19,23,25,28]	Level I (Guidelines, System evaluation, Clinical decision)	A
		2.The single most important factor for preventing urinary catheter-related complications is limiting their use to appropriate indications.Urinary catheters are indicated in the following clinical situations: (1) Treat urinary retention with or without bladder outlet obstruction. (2) Dealing with urinary incontinence patients who have failed conservative treatment, behavioral therapy, drug therapy and surgical treatment. (3) Treating open wounds in the sacral or perineal area of incontinence patients. (4) Measure the hourly urine output of critically ill patients. (5) Measurement of daily urine output for fluid management or diagnostic testing. (6) Intraoperative assessment of fluid status and prevention of over-distended bladder (which can occur during long operation or large infusions). (7) during and after certain surgeries of the genitourinary tract or adjacent structures (ie, urological, gynaecological, and colorectal surgery). (8) Treatment of hematuria with blood clots. (9) Intravesical drug therapy (such as bladder cancer, etc). (10) Improve the comfort of terminally ill patients. (11) Management of immobile patients (eg, stroke, pelvic fracture). (12) Management of patients with neurogenic bladder due to spinal cord injury.[25,28]	Level 5(Clinical decision)	B
	Choice of urinary catheter	3.It is recommended to choose a catheter of appropriate material and length according to the patient's age, gender, urethral condition, etc., and it is recommended to use a urinary catheter with the smallest possible model and match it with a drainage bag to minimize the incidence of urethral injury and urinary tract infection.[15,16,18,21,25,27,28]	Level I(Guidelines, System evaluation, Clinical decision)	A
		4.Routine use of antimicrobial catheters is not recommended.[21–23]	Level I(Guidelines, Expert consensus)	A
	Requirements for the person who placed the catheter	5.An indwelling urinary catheter is a sterile procedure that should be placed by a trained and competent health care provider.[20,21,24]	Level I (Guidelines, Expert consensus, System evaluation)	A
Techniques and requirements for catheter placement	Aseptic technique is strictly enforced	6.Hand hygiene must be performed before and after insertion to ensure that all necessary instruments for sterile catheterization are available and easily accessible.[15,21–24]	Level I (Guidelines, Expert consensus)	A
		7.When inserting a urinary catheter, it should be strictly aseptic, properly lay sterile towels, maintain the maximum sterile barrier, use cotton balls, sterile lubricant in single-dose packaging, and wear sterile gloves during intubation.[16,23,27,28]	Level I (Guidelines, Clinical decision)	A
		8.Before the catheter is implanted, a standardized mucosal disinfection process should be carried out: povidone-iodine solution with an effective iodine concentration of 1000–2000mg/L should be used to infiltrate the disinfection cotton ball, and the disinfection operation should be carried out step by step according to the three-zone mucosal disinfection method (urethral orifice→perineum→ perianal area). The operation specification requires strict adherence to the principle of one-way wiping, and each sterilized cotton ball is limited to a single one-way disinfection, and repeated contact with contaminated parts is prohibited.[16,21,23,27,28]	Level I (Guidelines, Clinical decision, Expert consensus)	A
	Catheters are difficult to place	9.If the catheter is advanced to the interface and there is still no urine outflow, the suprapubic area can be gently pressed on the patient in an attempt to get urine to flow out by compressing the bladder. Women should recheck whether the catheter is inserted into the vagina and, if so, remove the catheter and replace it with a new sterile catheter and insert it into the urethra. If the patient complains of pain during catheter insertion, the catheter should be removed. Blood at the urethral opening or at the tip of the catheter should be terminated and a urologist should be consulted.[28]	Level 5 (Clinical decision)	B

(*Continued*)

https://doi.org/10.2147/RMHP.S557548

Table 5 (Continued).

Categories		Content of Evidence	Level of Evidence (Grade)	Level of Recommendation (Grade)
	Fixation and documentation of urinary catheters and drainage devices	10.Properly fix the urinary catheter and drainage device, and randomly adjust the position of the urine collection bag to reduce the occurrence of complications such as urethral prolapse, skin indentation, urethral injury, and unplanned extubation.[23,27]	Level I (Guideline, Clinical decision)	B
		11.A multi-dimensional electronic record system should be established for catheter indwelling management, clearly indicating the indication for insertion, operation time (accurate to minutes) and catheter specifications, lumen structure (single/double/triple lumen) and surface treatment technology (hydrophilic coating/antibacterial coating); Establish a dynamic assessment mechanism for the retention cycle, and simultaneously mark the planned maintenance time window and the risk early warning threshold date.[16,21,22,25]	Level I (Guidelines, Expert consensus)	A
Daily care and maintenance of urinary catheters	Management of urinary catheters and drainage devices	12.Maintain the airtightness of the indwelling urinary catheterization drainage device.[15,16,21–23,27,28]	Level I (Guidelines, Clinical decision, Expert consensus)	A
		13.During indwelling catheterization, urine drainage should be kept unobstructed, distortion of the catheter and drainage tube should be avoided, and the urine collection bag should always be lower than the level of the bladder, avoiding touching the ground or placing it directly on the ground.[15,22,23,28]	Level I (Guidelines, Clinical decision)	A
	Clean	14.Topical antiseptics or antibiotics are not recommended in the catheter, urethra, or urethral meatus; It is recommended to wash the area around the urethral opening and the surface of the urinary catheter daily with water/0.9% NaCl/soapy water to maintain local cleanliness.[16,20,23,24,27,28]	Level I (Guidelines, System evaluation, Clinical decision)	A
		15.When cleaning, the principle of scrubbing from the perineum to the rectum should be followed, care should be taken to protect the catheter and avoid immersing the catheter in water.[21]	Level 5 (Expert consensus)	B
		16.Patients with defecation incontinence started cleaning intervention in time after defecation, and pH-balanced skin cleanser (5.5–6.5) combined with one-way wiping technology was used to remove pollutants, and povidone-iodine gradient disinfection system (effective iodine concentration 1000–2000mg/L) was used to carry out zonal and hierarchical disinfection according to the three-zone disinfection method (perineal triangle area→urethral orifice→ perianal radiation belt), and the external catheter segment was simultaneously disinfected by annular wiping (wiping radius ≥5cm). After disinfection and drying, zinc-containing protective paste should be applied to form a physical barrier, focusing on covering the catheter-skin interface area.[19]	Level I (System evaluation)	B
		17.When emptying the bag, the drain should not touch the collection container, and each patient should use a personal collection container.[16,28]	Level I (Guideline, Clinical decision)	A
		18.Before transporting the patient, the urine in the urine collection bag should be emptied and the urine in the bag should not exceed 3/4 of its capacity.[16,28]	Level I (Guideline, Clinical decision)	B
		19.It is not recommended to add antibacterial or antimicrobial solutions to the urine pouch.[16]	Level I (Guideline)	A
		20.Routine bladder irrigation is not required during an indwelling urinary catheter; When bladder irrigation is required for treatment, it should be strictly aseptic and the drainage system should be kept closed.[16,23,27,28]	Level I (Guideline, Clinical decision)	A
	Bacteriuria screening	21.Routine asymptomatic bacteriuria screening in patients with urinary catheters is not recommended.[17,21–24,27,28]	Level I (Guidelines, Clinical decision, Expert consensus)	A

		22.Urine is sent for analysis and culture only if the patient has signs or symptoms that may be attributable to CAUTI.[22]	Level I (Guideline)	A
	Replace the urinary catheter	23.Routine replacement of an indwelling urinary catheter should be avoided and should not be replaced when the urine stream is adequate.[20,28]	Level I (Guideline, System evaluation)	A
		24.In case of mechanical problems such as poor drainage and scaling, the catheter needs to be replaced; Urine leakage occurs around the catheter or mature suprapubic catheter (which has been placed for more than 6 weeks) and a new catheter should be replaced.[28]	Level 5 (Clinical decision)	B
	Education & Training	25.Health education and hygiene education on the maintenance and management of urinary catheters are recommended for patients and families.[15,21,24]	Level I (Guidelines, Expert consensus)	A
		26.Education and regular training of staff on insertion and removal techniques, maintenance procedures, complications, infection prevention, and alternatives to urinary catheters is recommended.[15,21,24]	Level I (Guidelines, Expert consensus)	A
Removal of urinary catheters	Daily assessments	27.The reason for the continued indwelling catheter is assessed and documented daily, and the prompt withdrawal is not clinically indicated to minimize the time of indwelling and reduce the risk of CAUTI.[16–18,20,22,27,28]	Level I (Guideline, Clinical decision)	A
	Accidental extubation or injury	28.If an indwelling catheter is accidentally withdrawn (usually by the patient), it can be gently reinserted as long as there is no blood at the urethral opening. If there is blood at the urethral meatus, or if there is resistance to reinsertion of the catheter, insertion should be stopped and urologist consultation should be sought.[28]	Level 5 (Clinical decision)	B
Diagnosis and treatment of CAUTI		29.Routine antibiotic prophylaxis is not recommended for patients with indwelling urinary catheters, and antibiotic therapy should only be started if there is clear evidence of symptomatic infection.[22,23,25,28]	Level I (Guideline, Clinical decision)	A
		30.Diagnostic criteria for CAUTI: (1) the catheter has been indwelled >for 2 consecutive days, and the catheter has been removed at any stage of CAUTI development or the day before it is started (2) the symptoms meet at least one of the following requirements: fever > 38°C; suprapubic tenderness; Costovertebral angle pain or tenderness (3) Microbiological criteria: positive urine culture with no more than 2 microorganisms identified (excluding Candida species, yeasts, molds, dimorphic fungi, and parasites), at least one of which ≥ 105 CFU/mL.[21]	Level 5 (Expert consensus)	B
		31.Patients with confirmed CAUTI are advised to remove the catheter or replace the catheter that has been in place for more than 7 days prior to antimicrobial therapy, followed by urine and blood culture testing.[23]	Level I (Guideline)	B
		32.Antimicrobial therapy for CAUTI should be started as soon as possible after diagnosis and treated empirically depending on the degree of complications of the UTI, with 7 days recommended for 7 days if symptoms are predominantly confined to the lower urinary tract and 14 days for fever, bacteremia, organ damage, or sepsis.[21,25]	Level I (Guideline, Expert consensus)	B

https://doi.org/10.2147/RMHP.S557548

collection container when emptying the collection bag[16] and each patient should use a personalised collection container.[28] Patients should have their urine collection bag emptied prior to transfer and should not allow the bag to contain more than 3/4 of its capacity, and there is no evidence to suggest that the addition of antimicrobial or antimicrobial solutions to the bag reduces the likelihood of CAUTI.[29] In addition, regular replacement of urinary catheter appendages, such as urine collection bags, is one of the most important measures to maintain the cleanliness of the urinary system and reduce the incidence of infection.[34] Research has demonstrated[23] routine bladder flushing is not recommended unless catheter blockage is anticipated, and antibiotic bladder flushing does not appear to prevent or delay UTIs, but may increase the risk of infection.[28] Urine is sent for analysis and culture only when patients present with signs or symptoms that may be attributable to catheter-related UTI, with the aim of confirming purulent and bacteriuria and identifying the causative organisms to adjust antimicrobial therapy.[27] It has been shown that indwelling urinary catheters should not be routinely replaced; replacement is required when mechanical problems such as poor drainage and scaling occur.[28] Multidimensional prevention strategies should also include education of patients and their families as well as education and regular training of staff on insertion and removal techniques, maintenance procedures, complications, infection prevention, and catheter replacement options.[15,20,24] Not only does it improve the knowledge and skills of nursing staff, but patients are also better able to participate in self-management, such as observing changes in urine, keeping the urethral opening clean, and correctly disposing of the drainage device. Meanwhile, in patient health education, patients are encouraged to maintain adequate fluid intake to ensure sufficient urine output. Increased urine flow may help flush out potential pathogenic bacteria from the urinary tract, thereby reducing the risk of catheter-associated urinary tract infection.[21,25] Recent evidence suggests that in hospitalised elderly patients, interventions that promote hydration correlate with lower incidence of CAUTI and better clinical outcomes.[35]

Enhancement of Pre-Catheter Removal Assessment to Clarify the Diagnosis and Treatment of CAUTIs

Urinary tract infections are less frequent when catheters are removed early, the shorter the duration, the better the overall outcome.[30] Getting the timing of catheter removal right is then critical. Evidence 27–28 summarises the relevant aspects of catheter removal. Evidence 29–32 then clarifies the diagnosis and treatment of CAUTI. It is recommended to evaluate and document daily the rationale for maintaining indwelling catheters, with electronic or other reminder systems potentially aiding compliance. Examples of monitoring continuous catheterization needs include: automated stop commands requiring status updates; reminders for standardized catheterization documentation; and daily ward rounds by clinical staff to assess all catheterized patients and determine their continued necessity. Whether as a process or outcome, such monitoring procedures will help track urinary tract infection (UTI) incidence rates. Facilities may develop risk-based systems to analyze and report data on catheter use and adverse events, including stratification by risk factors such as gender, age, ward, and duration of catheterization.[24] When there is no clinical indication, the catheter should be removed in time to minimize the length of stay and reduce the risk of CAUTI.[27,28] Clinical evaluations typically encompass multiple dimensions, including patients' psychological state, physiological condition, and postoperative recovery progress, providing robust support for clinical decision-making. However, the current clinical practice still lacks standardized assessment tools, particularly across different departments and patient populations where the indications and timing for catheter removal often depend on healthcare professionals' experience. Therefore, future efforts should focus on refining evaluation tool development and validation, expanding sample sizes through multicenter studies to enhance their universality and accuracy. When the catheter is removed, the administration of antibacterial drugs should be limited to necessary cases and routine administration is not recommended.[22,23,25,28] In addition, the diagnostic criteria for CAUTI need to be clarified. Research has demonstrated that patients have a catheter in place for more than 2 consecutive days and it is removed at any stage of the development of the CAUTI or one day prior to the onset of the CAUTI.[22] The symptoms meet at least one of the following requirements: (1) fever >38 degrees Celsius, (2) suprapubic pressure, (3) costal angular pain or tenderness; and the microbiological criteria meet the criteria of a positive urine culture, which identifies no more than two microorganisms (excluding Candida spp., yeasts, moulds, dimorphic fungi and parasites), at least one of which is $\geq 10^5$ CFU/mL. Importantly, in older adults, CAUTI may present with atypical

manifestations such as delirium, acute confusion, unexplained falls, or sudden functional decline, even in the absence of typical fever or suprapubic pain. These atypical presentations are increasingly recognised as clinically relevant indicators of infection in elderly populations and should be given equal attention in clinical assessment.[36,37] Once the diagnosis of CAUTI is confirmed, antimicrobial therapy is the most appropriate treatment.[23] Complete removal of the catheter system is preferred when the catheter is not essential, and if there is an indication for continued retention, complete catheter system replacement (including a urine collection device) is performed for long-term catheters that have been left in place for more than 7 days, with a delayed collection of quantitative urine samples for culture of 2 hours after placement of the new catheter. The optimal duration of treatment has not been systematically studied, but it is recommended that treatment be continued for 7 days if symptoms are mainly confined to the lower urinary tract, and for 14 days in cases of fever, bacteraemia, organ damage or sepsis.[17,18] A study suggests that CAUTI management should be dynamically optimised using a continuous quality improvement approach.[38] This includes regular monitoring and analysis of a range of relevant indicators such as CAUTI incidence, urinary catheter utilisation rate, urine specimen delivery rate, etc., so that potential problems can be identified in a timely manner. After problems are identified, improvement measures can be formulated and implemented in a targeted manner, such as strengthening training in specific areas and optimising operational procedures, thereby effectively reducing the incidence of CAUTIs, improving the implementation rate of catheter-related care measures, and ensuring the continued effectiveness of CAUTI management.

Implementation Considerations in Different Resource Settings

Although most of the 14 included guidelines and consensus statements emphasize universal principles such as aseptic insertion, maintaining a closed drainage system, and timely catheter removal, their feasibility varies across healthcare settings. In high-resource hospitals, recommendations such as the use of single-use catheterization kits, antimicrobial-coated catheters, and electronic reminder systems are realistic; however, evidence from recent studies highlights that low-resource hospitals may struggle to afford these interventions due to supply chain limitations, financial constraints, or inadequate IT infrastructure.[39–41] To improve applicability, we propose a tiered approach that accounts for varying levels of healthcare resources. In well-resourced hospitals, an ideal strategy would include the adoption of single-use catheterization kits, the use of closed drainage systems, electronic reminder systems to promote timely catheter removal, and structured staff training supported by regular audit and feedback. In moderately resourced settings, the focus should be on ensuring aseptic insertion technique, maintaining a closed drainage system, implementing paper-based insertion checklists, and conducting periodic audits. In low-resource hospitals, where advanced supplies or IT systems may not be feasible, priority should be given to strict hand hygiene, restricting catheterization to clear clinical indications, keeping drainage bags consistently below bladder level, and preserving the integrity of the closed system. To evaluate the effectiveness of implementation across different settings, suggested pilot indicators include the catheter utilization rate, the incidence of CAUTI per 1,000 catheter-days, the number of catheter-days per 100 patient-days, and the compliance rate with insertion checklists.This tiered framework aligns with international guideline standards while acknowledging resource constraints, enabling institutions to tailor CAUTI prevention strategies to their local context.

Limitations

This evidence summary synthesised mainly secondary sources (guidelines, expert consensus, and systematic reviews), and we did not conduct formal appraisal of primary studies. Although this approach is appropriate for guidelineoriented practice guidance, it may miss some recent primary-study data. Additionally, variation in guideline methodology and reporting across included sources introduced heterogeneity in recommendations; where guidance conflicted, we prioritized more recent, higher-quality guidelines and explicitly documented our rationale.The search was restricted to studies published in Chinese and English, which may have introduced language bias. Despite efforts to conduct a comprehensive search across multiple databases and guideline repositories, the possibility of missing relevant evidence cannot be ruled out. Finally, although inter-rater reliability was assessed during literature screening and appraisal, the evidence synthesis process may still have been influenced by subjective judgment.

Conclusion

This study summarises the best available evidence on the prevention and care of catheter-associated urinary tract infections across five domains: pre-catheterisation guidelines, catheterisation techniques and requirements, routine catheter care and maintenance, catheter removal, and the diagnosis and treatment of CAUTIs. Most recommendations were supported by high-level evidence (evidence-based guidelines and systematic reviews), while some were derived from expert consensus with lower certainty. Based on this, a knowledge translation system for CAUTI prevention—comprising evidence-based decision support and a localised implementation pathway—can be established, tailored to the clinical context, with further research warranted in areas where evidence remains limited.

Acknowledgments

All persons who have made substantial contributions to the work reported in the manuscript (eg, technical help, writing and editing assistance, general support), but who do not meet the criteria for authorship, are named in the Acknowledgements and have given us their written permission to be named. If we have not included an Acknowledgements, then that indicates that we have not received substantial contributions from non-authors.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This study was funded by Health Science and Technology Project of Shanghai Pudong New District Health Commission (PW2023A-71) and Hospital Management Research Fund of Shanghai Hospital Association (X2025112).

Disclosure

The authors reports no conflicts of interest in this work.

References

1. Venkataraman R, Yadav U. Catheter-associated urinary tract infection: an overview. *J Basic Clin Physiol Pharmacol*. 2023;34(1):5–10. doi:10.1515/jbcpp-2022-0152
2. Mong I, Ramoo V, Ponnampalavanar S, Chong MC, Wan NW. Knowledge, attitude and practice in relation to catheter-associated urinary tract infection (CAUTI) prevention: a cross-sectional study. *J Clin Nurs*. 2022;31(1–2):209–219. doi:10.1111/jocn.15899
3. Scruggs-Wodkowski E, Kidder I, Meddings J, Patel PK. Urinary catheter-associated infections. *Infect Dis Clin North Am*. 2024;38(4):713–729. doi:10.1016/j.idc.2024.07.006
4. Zhang Y, Zhong ZF, Chen SX, et al. Prevalence of healthcare-associated infections and antimicrobial use in China: results from the 2018 point prevalence survey in 189 hospitals in Guangdong Province. *Int J Infect Dis*. 2019;89:179–184. doi:10.1016/j.ijid.2019.09.021
5. Van Decker SG, Bosch N, Murphy J. Catheter-associated urinary tract infection reduction in critical care units: a bundled care model. *BMJ Open Qual*. 2021;10(4):e001534. doi:10.1136/bmjoq-2021-001534
6. Rosenthal VD, Yin R, Jin Z, et al. Examining the impact of a 9-component bundle and the INICC multidimensional approach on catheter-associated urinary tract infection rates in 32 countries across Asia, Eastern Europe, Latin America, and the Middle East. *Am J Infect Control*. 2024;52(8):906–914. doi:10.1016/j.ajic.2024.02.017
7. Medina-Polo J, Naber KG, Bjerklund JT. Healthcare-associated urinary tract infections in urology. *GMS Infect Dis*. 2021;9:Doc5.
8. Yajun L, Xuan Z, Juan T, et al. Risk factors for catheter-associated urinary tract infection in an intensive care unit: a matched case-control study. *BMC Infect Dis*. 2025;25(1):617. doi:10.1186/s12879-025-10839-0
9. Ruan C, Shi S, Shen Z, Guo L, Gong L. Effect of precision management scheme based on the best evidence summary on reducing catheter-associated urinary tract infection. *Zhong Nan Da Xue Xue Bao Yi Xue Ban*. 2023;48(9):1333–1342. doi:10.11817/j.issn.1672-7347.2023.230173
10. Kelly T, Ai C, Jung M, Yu K. Catheter-associated urinary tract infections (CAUTIs) and non-CAUTI hospital-onset urinary tract infections: relative burden, cost, outcomes and related hospital-onset bacteremia and fungemia infections. *Infect Control Hosp Epidemiol*. 2024;45(7):864–871. doi:10.1017/ice.2024.26
11. Brouwers MC, Kerkvliet K, Spithoff K. The AGREE reporting checklist: a tool to improve reporting of clinical practice guidelines. *BMJ*. 2016;352(i1152). doi:10.1136/bmj.i1152

12. Brouwers MC, Kho ME, Browman GP, et al. AGREE II: advancing guideline development, reporting and evaluation in health care. *CMAJ*. 2010;182(18):E839–E842. doi:10.1503/cmaj.090449
13. Aromataris E, Fernandez R, Godfrey CM, Holly C, Khalil H, Tungpunkom P. Summarizing systematic reviews: methodological development, conduct and reporting of an umbrella review approach. *Int J Evid Based Healthc*. 2015;13(3):132–140. doi:10.1097/XEB.0000000000000055
14. Wang C Q, Hu Y. JBI evidence pre-grading and evidence recommendation level system (2014 edition). *J Nurs Continuing Educ*. 2015.
15. Evelyn L, Lindsay EN, Susan EC, Carolyn G. Strategies to prevent catheter-associated urinary tract infections in acute care hospitals: 2014 update. *Infect Control Hosp Epidemiol*. 2014;35(Suppl 2):S32–S47.
16. Loveday HP, Wilson JA, Pratt RJ, et al. epic3: national evidence-based guidelines for preventing healthcare-associated infections in NHS hospitals in England. *J Hosp Infect*. 2014;86(Suppl 1):S1–S70.
17. Zheng B, Tang W, Chen M, et al. Chinese Expert Consensus Working Group on Diagnosis and Treatment of Urinary Tract Infections.Chinese Expert Consensus on Diagnosis and Treatment of Urinary Tract Infections (2015 Edition). *Chin J Urol*. 2015;36(4):241–244.
18. Marina De C, Luis A, Andres C, Ibai L. Executive summary of the diagnosis and treatment of urinary tract infection: guidelines of the Spanish Society of Clinical Microbiology and Infectious Diseases (SEIMC). *Enferm Infecc Microbiol Clin*. 2017;35(5):314–320. doi:10.1016/j.eimc.2016.11.005
19. Gad MH, AbdelAziz HH. Catheter-associated urinary tract infections in the adult patient group: a qualitative systematic review on the adopted preventative and interventional protocols from the literature. *Cureus*. 2021;13(7):e16284. doi:10.7759/cureus.16284
20. Mangal S, Pho A, Arcia A, Carter E. Patient and family engagement in Catheter-Associated Urinary Tract Infection (CAUTI) prevention: a systematic review. *Jt Comm J Qual Patient Saf*. 2021;47(9):591–603. doi:10.1016/j.jcjq.2021.05.009
21. Reid S, Brocksom J, Hamid R, et al. British Association of Urological Surgeons (BAUS) and Nurses (BAUN) consensus document: management of the complications of long-term indwelling catheters. *BJU Int*. 2021;128(6):667–677. doi:10.1111/bju.15406
22. Chuang L, Tambyah PA. Catheter-associated urinary tract infection. *J Infect Chemother*. 2021;27(10):1400–1406. doi:10.1016/j.jiac.2021.07.022
23. Satoshi T, Soichi A, Kiyohito I, Jun M. Guidelines for infection control in the urological field, including urinary tract management (revised second edition). *Int J Urol*. 2021;28(12):1198–1211. doi:10.1111/iju.14684
24. Moi L, Ching P, Apisarnthanarak A, Jaggi N, Harrington G, Fong SM. APSIC guide for prevention of catheter associated urinary tract infections (CAUTIs). *Antimicrob Resist Infect Control*. 2023;1(12):52.
25. Bonkat G, Bartoletti R, Bruyère F, et al. EAU guidelines on urological infections. *Eur Urol*. 2024;2024.
26. Zachary N, Abdullah Tarik A, Nathan P, Michelle B, Matthew C. Guidelines for the prevention, diagnosis, and management of urinary tract infections in pediatrics and adults. *JAMA Network Open*. 2024;7(11):e2444495. doi:10.1001/jamanetworkopen.2024.44495
27. Barbara WT, Kalpana G. Catheter-associated urinary tract infection in adults. In: *Up to date, Stephen B Calderwood, Khalil G Ghanem (ED), Wolters*. 2024.
28. Anthony JS, Coerdt K, Taylor JS, Hsieh F, Anthony JS. Placement and management of urinary catheters in adults. In:up to date, Jerome P Richie (ED),Wolters. 2024;35(6):674–675. doi:10.1089/derm.2023.0249
29. Peng F. Best practices for preventing and controlling catheter-associated urinary tract infections—series interpretation of the "Expert consensus on best nursing practices for preventing and controlling catheter-associated infections" (Part one). *Shanghai Nurs*. 2019;19(06):1–4.
30. Gambrill B, Pertusati F, Hughes SF, Shergill I, Prokopovich P. Materials-based incidence of urinary catheter associated urinary tract infections and the causative micro-organisms: systematic review and meta-analysis. *BMC Urol*. 2024;24(1):186. doi:10.1186/s12894-024-01565-x
31. Hooton TM, Bradley SF, Cardenas DD, et al. Diagnosis, prevention, and treatment of catheter-associated urinary tract infection in adults: 2009 international clinical practice guidelines from the infectious diseases society of America. *Clin Infect Dis*. 2010;50(5):625–663. doi:10.1086/650482
32. Gupta P, Thomas M, Mathews L, et al. Reducing catheter-associated urinary tract infections in the cardiac intensive care unit with a coordinated strategy and nursing staff empowerment. *BMJ Open Qual*. 2023;12(2):e002214. doi:10.1136/bmjoq-2022-002214
33. Mitchell B, Curryer C, Holliday E, Rickard CM, Fasugba O. Effectiveness of meatal cleaning in the prevention of catheter-associated urinary tract infections and bacteriuria: an updated systematic review and meta-analysis. *BMJ Open*. 2021;11(6):e46817. doi:10.1136/bmjopen-2020-046817
34. Miranda M, Rosa MR, Castro M, Fontes C, Bocchi S. Nursing protocols to reduce urinary tract infection caused by indwelling catheters: an integrative review. *Rev Bras Enferm*. 2023;76(2):e20220067. doi:10.1590/0034-7167-2022-0067
35. Shen L, Fu T, Huang L, et al. 7295 elderly hospitalized patients with catheter-associated urinary tract infection: a case-control study. *BMC Infect Dis*. 2023;23(1):825. doi:10.1186/s12879-023-08711-0
36. Dutta C, Pasha K, Paul S, et al. Urinary tract infection induced delirium in elderly patients: a systematic review. *Cureus*. 2022;14(12):e32321. doi:10.7759/cureus.32321
37. Nicolle LE. Catheter associated urinary tract infections. *Antimicrob Resist Infect Control*. 2014;3(1):23. doi:10.1186/2047-2994-3-23
38. Plando R, Obaid L, Al BA, et al. Prevention and Control of Catheter-Associated Urinary Tract Infection (CAUTI): a patient safety and quality improvement project. *Cureus*. 2024;16(10):e72105.
39. Menegueti MG, Ciol MA, Bellissimo-Rodrigues F, et al. Long-term prevention of catheter-associated urinary tract infections among critically ill patients through the implementation of an educational program and a daily checklist for maintenance of indwelling urinary catheters: a quasi-experimental study. *Medicine*. 2019;98(8):e14417. doi:10.1097/MD.0000000000014417
40. Werneburg GT. Catheter-associated urinary tract infections: current challenges and future prospects. *Res Rep Urol*. 2022;14:109–133.
41. McCleskey SG, Shek L, Grein J, et al. Economic evaluation of quality improvement interventions to prevent catheter-associated urinary tract infections in the hospital setting: a systematic review. *BMJ Qual Saf*. 2022;31(4):308–321. doi:10.1136/bmjqs-2021-013839