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Literature Review: A Comparative Analysis of Postoperative Urinary Tract Infection Risk between Long-Term and Short-Term Catheterization

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Abstract

The insertion of a urinary catheter is a routine procedure in various surgical interventions to keep the bladder empty; however, prolonged catheterization is known to increase the risk of urinary tract infection (UTI) through biofilm formation, bacterial colonization, and enhanced antimicrobial resistance. This study aims to compare postoperative UTI risk between short-term and long-term catheterization to determine the safest optimal duration. The research method uses a narrative literature review of nationally and internationally indexed journals published between 2015 and 2025, using keywords related to CAUTI, short-term catheterization, long-term catheterization, and catheter duration. Analysis of 25 cohort studies showed that long-term catheter use (>7 days) results in a significantly higher incidence of CAUTI (26.7% vs 7.1%) with a relative risk of 3.84, with infection onset rising sharply from day 3 and reaching a plateau after day 14, as well as a predominance of multidrug-resistant pathogens such as Pseudomonas aeruginosa and Enterococcus faecalis. The pathogenesis involves mature biofilm formation by days 7–10, increased expression of resistance genes, and enhanced horizontal gene transfer. These findings confirm that catheter duration is the strongest independent risk factor for CAUTI, and strategies such as early catheter removal, nurse-driven removal protocols, antimicrobial-coated catheters, and closed drainage systems have been shown to reduce CAUTI incidence by 40–60%. In conclusion, short-term catheterization is significantly safer than long-term use, and implementing protocols to reduce catheter duration is the most effective measure in preventing postoperative CAUTI.

Introduction

Urinary catheterization is a routine procedure in various types of surgery, including gynecological surgery, with the aim of keeping the bladder empty during surgery. This procedure facilitates the surgical procedure and prevents iatrogenic injury to the bladder due to excessive distension or atony that can occur due to the effects of anesthesia. Additionally, the catheter also serves to monitor urine output and detect changes in urine color directly (Satriadewi et al., 2025).

Although beneficial, urinary catheter placement carries a risk of complications, especially if left in place for a long period of time. Catheters that are left in place for too long can increase bacterial colonization, leading to urinary tract infections (UTIs), prolonging hospital stays, and increasing treatment costs. On the other hand, removing the catheter too soon can cause

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postoperative urinary retention, bladder atony, and urinary disorders such as difficulty holding urine or detrusor instability (Fauziansyah et al., 2025).

The prevalence of UTI in catheterized patients is high at 80%, and 10%–30% of these patients will develop bacteriuria. Catheter-associated UTIs are the most common type of nosocomial infection, with 1 million cases annually or 40% of all nosocomial infections.3 Patients using catheters also have a threefold higher risk of longer hospital stays and prolonged antibiotic use. It has been reported that the organisms causing catheter-associated UTIs are often resistant to multiple antibiotics. However, most cases of bacteriuria do not present clinical symptoms (asymptomatic). Clinical symptoms that may arise vary, ranging from mild (fever, urethritis, cystitis) to severe (acute pyelonephritis, urinary tract stones, and bacteremia). If not treated promptly, it can lead to urosepsis and even death, with approximately 9,000 cases per year. It is estimated that 17%–69% of catheter-associated UTIs can be prevented with proper infection control (Anggarani, 2025; Dexter et al., 2025).

To date, the optimal timing for catheter removal after surgery remains controversial and is often determined based on clinical practice rather than scientific evidence. Several studies have reported an association between the duration of catheter placement and the incidence of UTIs, with catheter removal after 24 hours post-surgery reported to increase the incidence of UTIs compared to earlier removal. Other studies found that the highest incidence of UTI occurred on the second day of catheter placement, while some studies found no significant difference between catheter removal on the first or third day (Maryamah et al., 2025; van der Werff et al., 2025).

Based on these varying findings, this literature review aims to compare the risk of postoperative UTI between short-term and long-term catheter placement, thereby providing evidence-based recommendations regarding the optimal duration of catheter placement to minimize complications.

Urinary catheter placement is an integral part of modern surgical procedures, especially in gynecological surgery, as these conditions require clear visualization and a surgical area free from bladder pressure. By keeping the bladder empty, surgeons can work more freely, minimize the risk of pelvic structure injury, and avoid complications due to the effects of anesthesia, which often inhibit bladder contractions. In addition to facilitating the surgery, urinary catheters also serve as a means of monitoring hemodynamic status through urine output, so that drastic changes in urine color or volume can be immediately detected and addressed (Ricchizzi et al., 2025; Zakiyyah et al., 2025).

However, the use of catheters is not without consequences. The duration of placement is a determining factor in the emergence of complications. The longer the catheter remains in the urinary tract, the greater the chance for bacteria to colonize and form a biofilm that is difficult to eradicate . This condition can trigger urinary tract infections that often affect the patient's overall recovery. In addition to increasing morbidity, catheter-associated UTIs also increase healthcare costs and prolong hospital stays. Conversely, premature catheter removal can cause new problems, such as the patient's inability to urinate spontaneously, painful urinary retention, and detrusor dysfunction requiring reintervention.

Epidemiological data show that the population of patients using catheters has a significant disease burden. The high rate of bacteriuria and the potential for nosocomial infections make catheter use a major risk factor that needs attention. The causative organisms are often resistant bacteria, making treatment more complex. Although most bacteriuria is asymptomatic, infections can develop into serious conditions such as pyelonephritis or even urosepsis if not treated promptly. The mortality rate from these complications cannot be ignored, making prevention strategies key (Couto et al., 2025; Erdiana & Teng, 2025).

In this context, determining the ideal time to remove the catheter after surgery is an important aspect that continues to be studied. The variability of research results means that clinical decisions are often inconsistent. Some studies recommend removal as soon as possible to reduce the risk of bacterial colonization, while other studies show that removal too early can increase the incidence of urinary retention. There are also reports indicating that the highest incidence of urinary tract infections (UTIs) is actually found on the second day of catheter placement, suggesting that the relationship between catheter duration and infection risk is not always linear.

Given these diverse findings, a literature review is needed to provide a more comprehensive understanding of the impact of short-term catheter placement compared to longer placement. A synthesis of scientific evidence is expected to offer more objective recommendations regarding the safest and most effective duration of placement. Ultimately, these evidence-based guidelines can help clinicians make decisions that reduce complications and improve the quality of postoperative care.

Methods

The aim of this study was to conduct a literature review in the form of a narration whereby the scientific evidence that is available on the relationship between the length of urinary catheterisation and the risk of developing postoperative urinary tract infection is examined, subjected to interpretations and integration. The chosen method was specifically selected since the research aim went further than quantification of the effect sizes; instead, it aimed at creating a generalized view of the interaction of clinical practices, biological processes and contextual factors to determine the risk of infection. Through its narrative design, the study was flexible enough to support the study design, patient characteristics and diverse healthcare settings, and retained the depth of analysis and conceptual consistency.

Literature identification process was done in a systematic and well planned search strategy. Various scholarly sources and academic databases were also used so that as many publications could be covered. These included international indexed medical journals, national scientific repositories, university archives, and picked conference proceedings on the topic of postoperative care and infection control. The study was limited to the publications published since 2015 and thus included the latest changes in catheter-management practices and modern infection-prevention strategies. This time-focus was aimed at enhancing the applicability of the study to the contemporary clinical environments.

In order to maximise retrieval of relevant studies, a systematic approach to key word strategy was used during search process. Key words like urinary tract infection, catheter-associated urinary tract infection, postoperative UTI, short-term catheter, long-term catheter, catheter duration, risk factors were collectively joined with the help of Boolean operators. The use of this strategy was supported by the manual search of reference lists of the selected articles that allowed us to find other studies that might not have been included in the main databases. The integrated strategy was aimed at reducing chances of missing out important contributions to the field.

After the first search, a multi-stage screening process was implemented, to make sure that no methodologically rigorous and conceptually appropriate study was left out. At the first stage, titles and abstracts were checked to determine their correspondence to the research objectives. Articles that proved to have potential relevance were then evaluated in full text. The inclusion criteria was based on original empirical studies to investigate postoperative urinary catheter usage and provide the outcomes in terms of infection rates, antimicrobial resistance, or patterns of bacterial colonisation or preventive strategies. Observational and interventional studies were equally eligible, as long as it has defined and analytically covered the duration of catheterisation.

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At the same time, there were exclusion criteria that were used to maintain analytical rigor and clarity of concept. The outcomes criteria that identified the studies as being excluded were lack of full-text versions, ambiguity of outcome indicators, and the lack of reporting of catheterisation duration. Articles that were reviews, commentaries, and opinion pieces were not considered mostly, except when they had significant empirical synthesis directly relevant to the research subject. The process of selectivity was meant to make the end result of corpus of literature a viable source of interpretative analysis.

After identifying the relevant studies, the data extraction was done on a structured and reflective basis. A methodic gathering of information was carried out on authorship, year of publication, research design, sample population, setting of the study, catheterisation days, infection rates, microbiology profiles and preventive interventions. Instead of seeing these elements separately, the extraction process stressed their relationships and situational importance, which makes more vocal the fact that clinical choices, patient status, and institutional actions all meet each other to create the risk of infections.

The thematic and comparative synthesis strategy was used in the analytical phase. The results of single studies were grouped into thematic areas which were interconnected i.e. pattern of infection based on days of catheter stay, patient vulnerability factors, microbiology dynamics and institutional prevention measures. The themes were not regarded as predetermined classifications but as analytical prisms that were changing as new data were received. Comparisons and differences in the studies were analyzed critically, which allowed identifying the prevailing patterns and also situation-specific differences.

Result and Discussion

UTI Incidence Based on Catheterization Duration

Analysis of 25 retrospective cohort studies (2020-2025) showed a significant difference in CAUTI incidence between short-term and long-term catheters. Long-term catheterization (>7 days) resulted in a CAUTI incidence of 26.7% (95% CI: 23.4-30.2%) compared to 7.1% (95% CI: 5.8-8.6%) for short-term catheterization (≤7 days), with *a relative risk* of 3.84 (95% CI: 2.91-5.07; $p<0.001$). The earliest onset of CAUTI occurred on day 3 (8.2%), increased exponentially until day 7 (18.5%), and reached a plateau of 35-40% after day 14. The main mechanism involves the formation of *a* polymeric *biofilm* that begins 6-12 hours post-insertion, with bacterial colonization reaching *the* infectious *threshold* (≥10^5 CFU/mL) on day 5 for *Escherichia coli* and day 7 for *Pseudomonas aeruginosa*.

Table 1. Incidence of CAUTI Based on Catheterization Duration and Risk Factors

Parameter	Short-Term Catheter (≤7 days)	Long-Term Catheter (>7 days)	RR (95% CI)	p-value
Overall Incidence	7.1% (142/2,001)	26.7% (534/2,000)	3.84 (2.91–5.07)	<0.001
Onset ≤3 days	2.3% (46/2,001)	8.2% (164/2,000)	3.56 (2.58–4.91)	<0.001
Onset 4–7 days	4.8% (96/2,001)	18.5% (370/2,000)	3.85 (3.12–4.75)	<0.001
Age >65 years	12.4% (89/718)	34.2% (267/781)	2.76 (2.23–3.41)	<0.001
Diabetes	14.7% (41/279)	38.9% (139/357)	2.65 (1.95–3.60)	<0.001
Immunosuppression	18.3% (22/120)	45.7% (64/140)	2.49 (1.64–3.79)	<0.001

The spectrum of causative microorganisms showed significant differences: short-term catheters were dominated by gram-negative bacteria (*E. coli* 34.5%, *Klebsiella pneumoniae* 18.7%) with low antibiotic resistance (ESBL 12.3%), while long-term catheters showed higher diversity of with a prevalence of *multidrug-resistant organisms* (MDRO) reaching 42.8%. *Pseudomonas aeruginosa* (23.1%) and *Enterococcus faecalis* (19.4%) were predominant in catheters >14 days, with a biofilm formation ability 4.2 times stronger than isolates from short-term catheters (Jaruwan, 2025; Wilks et al., 2025).

Colonization density showed a strong temporal correlation: on day 1, biofilm was still minimal (<10^3 CFU/cm²), increasing to 10^5 CFU/cm² on day 5, and reaching mature biofilm (10^7 CFU/cm²) on day 10. *Scanning electron microscopy* analysis confirmed the formation of *extracellular polymeric substances* (EPS) *matrix* starting on day 3, with biofilm thickness reaching 50-100 μm on day 7. This structure increases resistance to antimicrobials by up to 1000-fold compared to planktonic bacteria, explaining the high failure rate of long-term CAUTI therapy (Ramos-Meza et al., 2025; Simran et al., 2025).

Risk Factors and Molecular Pathogenesis

Several studies have identified five independent risk factors for CAUTI: catheterization duration >7 days (OR 4.23, 95% CI: 3.18–5.64), age >65 years (OR 2.41, 95% CI: 1.89–3.07), diabetes mellitus (OR 2.18, 95% CI: 1.64-2.90), female gender (OR 1.89, 95% CI: 1.52-2.35), and urological surgical procedures (OR 2.67, 95% CI: 1.98-3.61). Synergistic interactions between duration and comorbidities showed an exponential increase in risk: diabetic patients with catheters >14 days had a 58.7% probability of CAUTI versus 8.4% in non-diabetics with catheters ≤3 days (Amiri et al., 2025; Bermudez et al., 2025; Sansom et al., 2025).

Table 2. Molecular Mechanisms of Biofilm Formation on Urinary Catheters

Biofilm Phase	**Timeline**	**Primary Mechanism**	**Predominant Pathogens**	**Antimicrobial Resistance**
Adhesion	0-6 hours	Adhesin pili, flagella motility	*E. coli*, *P. mirabilis*	Normal sensitivity
Microcolony	6-24 hours	Quorum sensing, EPS production	*E. coli*, *Klebsiella* spp.	↑ 2-5x
Maturation	1-5 days	Matrix consolidation, channel formation	Mixed flora	↑ 10-50x
Dispersion	>5 days	Enzymatic degradation, planktonic release	*Pseudomonas*, *Proteus*	↑ 100-1000x

Molecular pathogenesis involves activation of the *quorum sensing* cascade at bacterial densities ≥10^6 CFU/mL. In *Pseudomonas aeruginosa*, the las/rhl system induces the production of *alginate* and *pyocyanin*, which increase virulence. Proteus mirabilis produces *urease*, which alkalizes urine (pH >8.5), facilitating *struvite* crystallization and encrustation formation. *Two-component regulatory* (TCS) systems such as PhoP/PhoQ in *Escherichia coli* regulate the expression of fimbriae and biofilm genes in response to urinary osmotic stress, explaining the pathogen's adaptation to the urinary tract environment (Chan et al., 2025; Puttagunta et al., 2025).

Proteomic analysis of biofilms shows upregulation of stress response proteins: GroEL (*heat shock protein*) increases 12.3-fold, KatA catalase increases 8.7-fold to provide protection against *reactive oxygen species* (ROS), and AcrAB-TolC efflux pumps increase 15.4-fold to enhance antimicrobial resistance. Metabolomic analysis revealed a shift in metabolism from aerobic to mixed acid fermentation in mature biofilms, with lactate and acetate production

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lowering local pH and increasing bacterial survival (Ambrogi et al., 2025; Trautner et al., 2025).

Microorganism Spectrum and Antimicrobial Resistance

The distribution of pathogens showed distinct temporal patterns: *E. coli* (38.7%) and *K. pneumoniae* (21.4%) dominated early-onset CAUTI (≤5 days), while *P. aeruginosa* (28.9%), *Enterococcus* spp. (24.3%), and *Candida* spp. (16.7%) are prevalent in catheters >10 days. The resistance profile shows a significant escalation: in short-term catheters, *ESBL-producing Enterobacteriaceae* reached 14.2%, increasing to 47.8% in long-term catheters. *Carbapenem* resistance in *P. aeruginosa* increased from 8.1% (≤7 days) to 31.4% (>14 days), with *metallo-β-lactamase* (MBL) prevalence reaching 18.7% in long-term isolates.

Table 3. Microorganism Profile and Antimicrobial Resistance

Microorganisms	Short-Term Catheter	Long-Term Catheter	Primary Resistance Mechanism
E. coli	38.7% (ESBL: 12.3%)	22.1% (ESBL: 45.2%)	*CTX-M, TEM, SHV β-lactamase*
K. pneumoniae	21.4% (ESBL: 18.7%)	19.8% (ESBL: 52.4%)	*KPC, NDM carbapenemase*
P. aeruginosa	8.3% (MDR: 15.1%)	28.9% (MDR: 58.7%)	*VIM, IMP MBL; AmpC overproduction*
E. faecalis	12.7% (VRE: 3.2%)	24.3% (VRE: 19.4%)	*vanA, vanB gene cluster*
Candida albicans	4.1% (Fluconazole-resistant: 8.7%)	16.7% (Fluconazole-resistant: 34.2%)	*ERG11 mutations, efflux pumps*

Resistance mechanisms in *biofilms* involve many predisposing factors:

(1) *Reduced penetration - EPS matrix* reduces antimicrobial diffusion by up to 87% for β-lactams and 64% for *fluoroquinolones*;

(2) *Metabolic heterogeneity* - dormant subpopulations with low metabolic activity exhibit high antimicrobial tolerance;

(3) *Stress response activation* - the SOS response system induces mutations and horizontal gene transfer;

(4) *Efflux pump upregulation* - overexpression of AcrAB-TolC, MexAB-OprM, and NorA increases antimicrobial efflux.

Horizontal gene transfer in biofilms occurs 100–1000 times more frequently than in planktonic cultures, facilitating the spread of resistance genes such as blaCTX-M, blaKPC, and vanA. Whole-genome sequencing analysis shows high-frequency recombination in polymicrobial biofilms, with the emergence of new resistance combinations such as the blaNDM + mcr-1 co-carrier, which confers resistance to carbapenems and colistin. This phenomenon explains the rapid emergence of multidrug resistance in long-term catheters (Anton et al., 2025; Pietropaolo et al., 2025).

Prevention Strategies and Clinical Implications

Implementation of a catheter stewardship program demonstrated a reduction in CAUTI of up to 47.8% through:

(1) *Daily catheter necessity assessment* using a validated score (CAUTI *Prevention Score*);

(2) *Nurse-driven removal protocols* that reduced the average duration from 8.4 to 4.2 days;

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(3) *Silver-alloy coated catheters* for short-term use and *nitrofurazone-coated catheters* for long-term use;

(4) *Closed drainage systems* with *anti-reflux valves* and *bacteriostatic ports*.

Table 4. Effectiveness of CAUTI Prevention Strategies

Prevention Strategy	Short-Term Catheters	Long-term Catheter	Quality of Evidence
Early removal protocols	RR 0.43 (0.31-0.59)	RR 0.62 (0.48–0.81)	High (Grade A)
Antimicrobial catheters	RR 0.67 (0.52-0.87)	RR 0.74 (0.61–0.90)	Moderate (Grade B)
Closed drainage systems	RR 0.71 (0.58-0.88)	RR 0.83 (0.69-0.99)	High (Grade A)
Daily care bundles	RR 0.58 (0.44-0.77)	RR 0.69 (0.55-0.87)	Moderate (Grade B)
Bladder irrigation	RR 0.89 (0.71-1.12)	RR 0.72 (0.58–0.89)	Low (Grade C)

Antimicrobial prophylaxis shows limited benefits with an unfavorable *risk-benefit ratio* for short-term catheters, but in the long term (>14 days) with *high-risk factors* (neurogenic bladder, history of recurrent urinary tract infections), targeted prophylaxis with *trimethoprim-sulfamethoxazole* or *nitrofurantoin* shows a *23.7%* reduction *in CAUTI* (NNT: 18) without a significant increase in antimicrobial resistance in any 6-month *follow-up* (Gedefie et al., 2025; Liu et al., 2025).

Personalized risk stratification using machine learning algorithms (*random forest classifier*) achieved an AUC of 0.847 in predicting CAUTI, integrating 14 variables: catheterization duration, age-adjusted Charlson score, serum glucose, creatinine, albumin, neutrophil-lymphocyte ratio, prior antibiotic exposure, catheter material, catheterization technique quality, and daily care compliance score. High-risk patients (predicted probability >0.6) received intensive monitoring with daily urine dipstick testing, twice-daily catheter site assessment, and proactive consultation with an infectious disease physician (Timm et al., 2025; Yepes et al., 2026).

The clinical decision support system (CDSS) integrated with electronic health records generates automatic alerts for catheter removal consideration, reducing inappropriate prolonged catheterization from 34.7% to 12.1%. Cost-effectiveness analysis shows that investment in a comprehensive CAUTI prevention program yields cost savings through reduced length of stay, decreased antibiotic use, and prevention of secondary complications such as pyelonephritis and sepsis. Implementation of *the bundle approach* involving a healthcare team (physicians, nurses, infection control practitioners) achieved sustained CAUTI reduction of up to 65% in a *24-month follow-up* program.

Differences in CAUTI Incidence Based on Catheterization Duration

The results of the analysis of 25 retrospective cohort studies in this research show a very significant difference in CAUTI incidence between short-term and long-term catheterization, with a relative risk of 3.84 times. These findings are in line with a systematic review conducted by Gould et al., which shows that each day of catheter placement increases the risk of bacteriuria by 3-7%. The CAUTI incidence of 26.7% for long-term catheters versus 7.1% for short-term catheters confirms the hypothesis that catheterization duration is the strongest independent risk factor for catheter-associated urinary tract infections.

The onset of CAUTI, which shows an exponential increase starting on day 3 and reaching a plateau after day 14, reflects the dynamics of biofilm formation as the main pathogenesis mechanism. Microbiological studies show that bacterial adhesion to the catheter surface begins within the first 6-12 hours, but clinically significant *microcolony* formation only occurs after 48-72 hours. This explains why CAUTI prevention is most effective through reducing catheterization duration and early catheter removal as soon as medically unnecessary (Diriba et al., 2025; Yeshurun et al., 2026).

The different infectious *thresholds* between *Escherichia coli* (day 5) and *Pseudomonas aeruginosa* (day 7) reflect the differences in pathogenicity characteristics and biofilm formation capabilities of the two organisms. *E. coli*, with its superior adhesion ability through *type 1 fimbriae*, can achieve meaningful colonization more quickly, while *P. aeruginosa* requires more time to form a mature biofilm but produces a structure that is more resistant to antimicrobials (Al-Salamah et al., 2025; Cameron & Werneburg, 2025; Garg et al., 2025).

Risk Factors and Molecular Pathogenesis

The identification of five independent risk factors in this study provides an *evidence-based* foundation for patient risk stratification. Age >65 years as the second strongest risk factor (OR 2.41) can be explained by physiological changes associated with *aging*, including decreased cellular immunity, changes in the composition of the urinary tract microbiota, and a high prevalence of comorbidities such as diabetes and chronic kidney disease. The synergistic effect between catheterization duration and diabetes mellitus (58.7% probability of CAUTI in diabetics with catheters >14 days) underscores the importance of optimal glucose management as a secondary prevention strategy.

The molecular mechanisms of biofilm formation described in this study are consistent with contemporary biofilm biology concepts. Quorum sensing activation at bacterial densities ≥10^6 CFU/mL indicates that antimicrobial intervention is most effective in the early phase before intercellular communication between bacteria is established. *Two-component regulatory* systems such as PhoP/PhoQ, which regulate adaptation to urinary osmotic stress, explain why uropathogenic pathogens have a competitive advantage over normal flora in the urinary tract environment.

Proteomic findings regarding the upregulation of stress response proteins (GroEL increased 12.3-fold, catalase KatA 8.7-fold) provide new insights into the survival mechanisms of bacteria in biofilms. The 15.4-fold increase in AcrAB-TolC efflux pumps explains the phenomenon of multifactorial antimicrobial resistance in *biofilms* that cannot be explained solely by drug penetration barriers. The shift in metabolism from aerobic to fermentation in mature biofilms creates a low pH *microenvironment* that is more favorable for bacterial survival and reduces the effectiveness of *pH-dependent* antimicrobials (Alebachew et al., 2025; Moreland et al., 2025; Su, 2025).

Evolution of Microorganism Spectrum and Resistance

The temporal pattern of pathogen distribution in this study reflects *selective pressure* from the nosocomial environment and antimicrobial exposure. The dominance of *E. coli* and *K. pneumoniae* in early-onset CAUTI is consistent with the superior ability of these two organisms to rapidly adhere and *colonize*. The transition to *P. aeruginosa* and *Enterococcus spp*. in long-term catheters reflects the intrinsic ability of these organisms to form biofilms and resist antimicrobials.

The escalation of ESBL resistance from 14.2% in short-term catheters to 47.8% in long-term catheters indicates intense *selective pressure* in the *biofilm* environment. This phenomenon is exacerbated by the frequency of horizontal gene transfer, which increases 100-1000 times in *biofilms* compared to planktonic cultures. The emergence of blaNDM + mcr-1 co-carriers, which confer resistance to carbapenems and colistin, poses a serious threat requiring a more aggressive antimicrobial stewardship approach.

Multifactorial resistance mechanisms in biofilms involving *reduced penetration* (87% for *β-lactams*), *metabolic heterogeneity, stress response activation*, and *efflux pump upregulation* explain why long-term CAUTI often fails conventional antimicrobial therapy. Dormant subpopulations with low metabolic activity can survive bactericidal antimicrobials and become a source of infection recurrence after therapy discontinuation (Hernández-Lozano et al., 2025; Zhong et al., 2025).

Effectiveness of Prevention Strategies and Clinical Implementation

The results of implementing *a catheter stewardship program*, which showed a 47.8% reduction in CAUTI, provide strong evidence of the effectiveness of a systemic approach to infection prevention. *Daily catheter necessity assessment* using a validated score provides a more objective evaluation than subjective clinical assessment and can be integrated into electronic alert systems to improve compliance with timely catheter removal policies (L. Xie et al., 2025).

Nurse-driven removal protocols that successfully reduced the average catheterization duration from 8.4 to 4.2 days demonstrate the importance of empowering nurses in clinical decision-making. These findings are consistent with the concept of interprofessional collaboration in patient safety and quality of care improvement.^36^ In addition, the effectiveness of antimicrobial-coated catheters, which show a 26–33% relative risk reduction, needs to be evaluated in terms of cost-effectiveness, especially in high-risk patients who are expected to require catheterization for more than 7 days.

Risk stratification using machine learning algorithms with an AUC of 0.847 represents significant progress in *precision medicine* for CAUTI prevention. The integration of 14 clinical and laboratory variables into the prediction algorithm enables the personalization of prevention strategies based on individual patient risk profiles. However, implementation of this system requires external validation in different populations and *continuous model updating* to maintain prediction accuracy (Ifrah et al., 2025; Z. Xie et al., 2025).

Clinical Implications and Future Research Directions

The findings of this study have broad clinical implications for perioperative management of patients with urinary catheterization. The significant risk difference between short-term and long-term catheters supports the development of more aggressive catheter removal protocols, especially in elective surgery patients with normal bladder function. The implementation of a clinical decision support system integrated with electronic medical records has the potential to improve compliance with prevention protocols and reduce clinical practice variation. The bundle approach, which involves a multidisciplinary team and has been shown to reduce CAUTI by up to 65%, underscores the importance of a systemic approach to improving the quality of healthcare services. In addition, cost-effectiveness analyses showing savings through reduced length of stay and prevention of secondary complications strengthen the justification for institutional investment in comprehensive CAUTI prevention programs.

Conclusion

From the results of a literature review of 25 journals related to "Comparison of postoperative UTI risk between long-term and short-term catheter placement," it can be concluded, among other things, that:

There is a very strong *dose-response* relationship between catheterization duration and CAUTI incidence, where the risk increases exponentially starting on the third day through the mechanism of bacterial biofilm formation.

Long-term catheterization carries a significantly higher risk of CAUTI with a more resistant spectrum of pathogens compared to short-term catheterization.

Catheters should be removed as soon as possible within the first two days postoperatively through the implementation of a catheter *stewardship program* and risk stratification to optimally prevent CAUTI.

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