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A Multimodal Approach in Catheter-Associated Urinary Tract Infection (CAUTI) Prevention: A Narrative Review

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Abstract. Catheter-associated urinary tract infections (CAUTIs) are a common healthcare problem globally, increasing patient morbidity and deaths, higher costs, and longer hospital stays. Despite prevention guidelines, CAUTI rates remain high due to factors such as prolonged catheter use, bacterial biofilms, and low adherence to prevention measures. The aim of this review is to study existing evidence on the efficacy of a multimodal approach to prevent CAUTI and to evaluate its core components and their effect on infection rates and patient outcomes. A comprehensive review of the peer-reviewed literature, clinical practice guidelines, and position papers from authoritative bodies were explored. The evidence clearly indicates that no single intervention is sufficient to achieve sustained CAUTI reduction. The use of multimodal strategies combining three or more interventions such as catheter use limitation, aseptic insertion techniques, catheter maintenance bundles, staff and patient education, electronic surveillance, audit and feedback has been demonstrated as highly effective strategies. The key interventions include nurse-driven removal protocols, electronic health record (EHR) reminders, two-person catheter insertion techniques, and catheter securement devices. Studies report 60%-83% reduction in CAUTIs with multimodal implementation. Evidence supports multimodal approach as the gold standard for CAUTI prevention. Combination of limited catheter use, aseptic technique, education, and monitoring with feedback can result in significant and sustained reductions in CAUTI rates in healthcare facilities. The strategy calls for a cross-discipline and systems commitment to change the way infections are prevented and to improve patient safety.

Keywords: Catheter-Associated Urinary Tract Infection (CAUTI); healthcare-associated infection; multimodal approach; prevention infection control; urinary catheter

Introduction

Urinary catheters are medical devices that are widely used in the treatment of a variety of clinical conditions, including chronic and acute urinary retention, anatomical and neurodegenerative disorders, and postoperative and critically ill patients, particularly in the intensive care unit (Tegegne et al., 2025). The growing demand for urinary catheters in healthcare settings is a major contributing factor to urinary tract infections (UTIs) (Al-Amri et al., 2025). Catheter-associated urinary tract infection (CAUTI) is a condition in which bacteria enter the urinary tract through the catheter and trigger an infection (Rubi H et al., 2022). The Centers for Disease Control and Prevention (CDC) defined CAUTI as a UTI that occurred in a patient who had an indwelling urinary catheter in place at the time of or within 48 hours before infection, with day 1 being the day of placement. The risk of developing a CAUTI increases by 3%–7% for each day an indwelling urinary catheter is in place (Gould CV et al., 20029). One of the strongest and most consistently reproduced findings in the infection prevention literature is the dose-response relationship between catheter-days and risk of infection. For example, a patient catheterized for 7 days has a cumulative risk of 21%–49% of developing CAUTI whereas a patient catheterized for 2 days has only 6%–14% risk. Catheter-days are thus not only a denominator for rates, but also the single most modifiable risk factor in the prevention of CAUTI. This mechanistic understanding directly informs the rationale behind multimodal approaches. Interventions that reduce unnecessary catheter-days (e.g., nurse-driven removal protocols and daily necessity assessments) target the primary causal pathway, while interventions that focus only on aseptic technique or maintenance target secondary routes of bacterial entry.

CAUTIs have been associated with increased morbidity, mortality, healthcare costs and length of stay (Amorone Leiva et al., 2025). They remain a significant source of unnecessary patient harm and a major concern in health care. In 2023, >23 million urinary catheter device days and >17,000 CAUTI events were reported by acute care hospitals (Mangal S et al., 2021). These estimates are likely underestimates of the real burden of CAUTI. National surveillance data from the National Healthcare Safety Network (NHSN) show that while CAUTI rates have decreased slightly in the last decade, the absolute number of device days is still large, indicating the continued widespread use of indwelling urinary catheters in routine clinical practice. To

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put these figures in perspective, one CAUTI event is associated with an average incremental length of stay of 2–4 days, excess costs of approximately 1,000 – 1,000–5,000 per infection, and a two-fold increase in mortality risk in critically ill patients. While CAUTI is identified as a "never event" by the Centers for Medicare & Medicaid Services (CMS) from a patient safety perspective, it continues to be one of the most reported healthcare-associated infections. CAUTI is defined as a significant bacteriuria ($\geq 10^5$ cfu/mL) and at least two signs and/or symptoms of acute UTI (fever, suprapubic tenderness, costovertebral angle pain or tenderness, urinary urgency, urinary frequency and dysuria) in the absence of another recognized infection (Oumer Y et al., 2021).

Over the years, there have been a number of preventive techniques recommended to reduce the risks associated with CAUTIs. This includes evidence-based guidelines for CAUTI prevention strategies published by the International Society for Infectious Diseases demonstrating their effectiveness across diverse healthcare environments (Shahdadian M et al., 2025). In addition, prompt removal of catheters as soon as clinically appropriate, the use of clearly defined guidelines for catheter indications, and adherence to sterile catheter insertion techniques have also demonstrated effectiveness in mitigating CAUTI occurrences (Plando R et al., 2024). Other strategies include alternative bladder management options including the use of external condom catheters which are highly recommended by the CDC (Bagley K et al., 2021). Traditional methods of CAUTI prevention strategies have mainly focused on specific interventions; however, the growing body of evidence indicates that no single intervention is adequate to sustain long-term CAUTI reduction (Li, N., et al. (2025). Preventing CAUTIs is an intricate issue arising from various factors, from the time the catheter is inserted, to daily maintenance, and eventual removal (D.C. Muscat et al., 2025). Therefore, it is vital to address the complexity of CAUTI care by targeting each of these vulnerable areas through the integration of various, interconnected factors, as well as a multimodal and multidisciplinary intervention that reduces the incidence and complications (Amorone Leiva et al., 2025).

The aim of this review is to study existing evidence on the efficacy of a multimodal approach to prevent CAUTI and to evaluate its core components and their effect on infection rates and patient outcomes.

Research Questions

This review aims to assess the effectiveness of a multimodal approach in reducing CAUTI rates. Specifically, the study aims to address the questions;

1. What is the efficacy of multimodal CAUTI prevention across clinical settings?
2. What technological integration and EHR requirements for a multimodal CAUTI Prevention Strategy?
3. What are the Challenges and Barriers to Multimodal Approach in CAUTI prevention?

Scope and Delimitation of the Study

This narrative review has several limitations that should be acknowledged. First, I did not use a formal, repeatable search approach with dual-independent screening or quantitative meta-analysis, as this was a narrative rather than systematic review. Second, the studies included in this review were highly heterogeneous with respect to multimodal components, outcome definitions (e.g., CDC/NHSN criteria vs. facility-defined CAUTI), and duration of follow-up, making it difficult to compare studies against one another. Many studies were single-center, pre-post designs without control groups, subject to secular trends, regression to the mean, and confounding. Third, publication bias is possible, as studies reporting positive CAUTI reductions are more likely to be published than those with neutral or negative findings. Fourth, most of the research comes from high-income nation settings (United States, Europe, Saudi Arabia), and hence, generalizability to low-resource settings may be restricted as multimodal implementation may be hampered by staffing shortages, limited access to electronic health records, and lower nurse-to-patient ratios.

Literature Review

In current healthcare settings, a multitude of national and global studies employing a multidimensional framework have been executed, resulting in a substantial decrease in CAUTI and mortality rates (Rosenthal et al., 2024). Multimodality is the process of combining three or more elements to facilitate an intervention as cited by World Health Organization (WHO, 2029). The use of a multimodal approach is a well-documented strategy for CAUTI prevention. For example, Van Decker and colleagues implemented a bundled care model in the intensive care units (ICUs) which resulted in an 83% reduction of CAUTI rate and a 33.8% reduction in indwelling Foley catheter utilization. Their intervention included: (1) proper catheter insertion technique and maintenance of indwelling urethral catheter (IUC); (2) insertion of IUC only when clinically indicated; (3) appropriate testing for CAUTIs; (4) use of alternatives to IUC; and (5) sterilization techniques (Van Decker et al., 2021). In addition, a one-year study on the effectiveness of a multimodal approach in CAUTI reduction through (1) staff education, (2) daily review of the need for IUC, (3) employing established best practices guidelines, (4) use of alternative bladder management options, and (5) reinforcing

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proper catheter insertion and removal techniques demonstrated a significant decrease of CAUTI events by 60.2% and a remarkable reduction in urinary catheter days to 17.6% (Potugari et al., 2020). In addition, the International Society for Infectious Diseases (ISID) 2024 position paper strongly recommends a multidimensional approach of six major elements: (1) care bundles, (2) education, (3) CAUTI surveillance, (4) monitoring adherence to prevention recommendations, (5) internal reporting of CAUTI rates, and (6) feedback of performance data to frontline staff. This methodology acknowledges the synergistic effects of interventions; education enhances bundle compliance, surveillance identifies areas for improvement and feedback reinforces desired behaviors (Victor Daniel Rosenthal et al., 2025). These robust evidence strongly validate that the use of multimodal strategies translates into meaningful infection control and measurable patient clinical outcomes (Tayyib N et al., 2025). This multimodal strategy is one of the WHO recommendations for the implementation of Infection Prevention and Control (IPC) interventions aiming to prevent Hospital Acquired Infection (HAI), including CAUTI, at a national and acute healthcare facility level (WHO, 2016).

Risk Factors and Pathogenesis of CAUTI

Major risk factors for CAUTI include age, uncontrolled diabetes, and prolonged hospitalization (Muramatsu K et al. (2018)). Besides the length or duration of catheterization, the risk is also significantly higher for women and older people (Hamida et al., 2022). Catheters are often placed for inappropriate indications and providers are unaware that their patients have them, leading to prolonged, unnecessary use and CAUTI (Omer et al., 2020). The pathogenesis of CAUTI is closely related to the duration of catheterization and the formation of biofilm on the surface of the catheter. Microorganisms can reach the urinary tract by two routes: extraluminally, by direct inoculation at the point of insertion or by capillary action along the external surface of the catheter, and intraluminally, by reflux from contaminated drainage bags or breaks in the closed drainage system (CDC, 2025).

Limiting Catheter Use

One of the most effective strategies for preventing Catheter-Associated Urinary Tract Infections (CAUTIs) is to avoid unnecessary urinary catheterization, as the risk of developing bacteriuria increases with each day a catheter remains in place (Gupta et al., 2023). The Centers for Disease Control and Prevention (CDC) recommends several evidence-based practices to minimize catheter use and reduce infection risk. Catheters should only be inserted when clinically indicated and should remain in place only for the shortest duration necessary. Alternative methods, such as external catheters and intermittent catheterization, are recommended for patients, particularly those with spinal cord injuries who require long-term urinary management. Prompt catheter removal is also essential and may be facilitated through daily risk assessments and automatic stop orders that require healthcare providers to reassess the ongoing need for catheterization. Nurse-driven protocols further support timely catheter removal by empowering registered nurses to discontinue catheters without a physician's order when established clinical criteria, such as the HOUDINI guidelines, are no longer met (Mesbah et al., 2026). In addition, the use of bladder scanners provides a non-invasive method of assessing urinary retention and bladder volume, assisting healthcare professionals in determining whether catheterization is truly necessary and thereby reducing avoidable catheter insertions (Schallom et al., 2020). Technological interventions, such as Best Practice Advisories (BPAs) integrated into electronic health record systems, also contribute to CAUTI prevention by generating reminders for clinicians regarding catheters that have been in place beyond the recommended timeframe. These alerts encourage healthcare providers to justify continued catheter use or initiate removal orders, promoting adherence to evidence-based catheter management practices (Behrend et al., 2020).

Compliance with Aseptic Insertion Technique

When urinary catheterization is clinically indicated, strict adherence to aseptic insertion techniques and proper catheter maintenance is essential in preventing Catheter-Associated Urinary Tract Infections (CAUTIs). Urinary catheters should be inserted only by qualified healthcare professionals using sterile equipment and aseptic procedures, including the use of sterile gloves, drapes, and sponges. Proper hand hygiene before and during catheter insertion helps establish a sterile barrier that prevents harmful microorganisms from entering the urinary tract through either intraluminal or extraluminal routes (Oumer et al., 2021). The use of a two-person catheter insertion procedure, commonly known as the "buddy system," has also been identified as an evidence-based strategy that enhances sterility, improves patient safety, and reduces the likelihood of bacterial contamination during catheter placement (Lutfiasih et al., 2020). In addition to proper insertion practices, effective catheter maintenance through the implementation of a catheter care bundle plays a critical role in reducing CAUTI rates. Evidence suggests that maintenance bundle interventions significantly decrease infection occurrences by preserving the sterility and functionality of the catheter system throughout its use (Soundaram et al., 2020). This bundle includes performing hand

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hygiene before and after handling the catheter or drainage system, maintaining a closed drainage urinary system to prevent bacterial entry, and conducting daily evaluations to determine the continued necessity of catheterization (CDC, 2024). Proper perineal hygiene using soap and water is recommended, while the routine use of antiseptic cleansers is discouraged (CDC, 2024). The drainage bag should always be positioned below the level of the bladder and should never touch the floor to ensure continuous urine flow and prevent contamination. Furthermore, catheter tubing should remain unobstructed by avoiding kinks or blockages, and drainage bags should be emptied regularly using a clean container designated for each patient (CDC, 2024). The use of catheter securement devices is also strongly recommended by international clinical practice guidelines, as these devices minimize urethral movement and trauma, reduce catheter-related complications, and lower the risk of CAUTIs by preventing mechanical injury to the urethra and bladder neck (Holroyd, 2019; Medical Advisory Board, 2025). Collectively, these evidence-based practices support safe catheter management and contribute significantly to the prevention of healthcare-associated urinary tract infections.

Education, Training, and Engagement

Education, training, and active engagement are essential components in the prevention of Catheter-Associated Urinary Tract Infections (CAUTIs), as they help bridge the gap between evidence-based guidelines and actual clinical practice, ultimately improving patient outcomes and reducing infection rates. Continuous staff education plays a critical role in enhancing healthcare professionals' knowledge, skills, and adherence to infection prevention protocols. Studies have shown that well-designed training programs positively influence nurses' knowledge and clinical competence, enabling them to apply evidence-based practices more effectively and fostering positive behavioral changes in infection control and patient care (Tayyib et al., 2025). Equally important is patient education, which encourages patients to become active participants in their own care. By providing patients with adequate information regarding catheter use, potential risks, and preventive measures, healthcare providers can promote greater understanding, compliance, and engagement in decision-making processes related to their treatment (MacEwan et al., 2022). Through ongoing education and collaborative involvement of both healthcare professionals and patients, healthcare institutions can strengthen CAUTI prevention efforts and support the delivery of safer, higher-quality care.

Monitoring, Auditing, and Feedback

Monitoring, auditing, and feedback are essential components of effective Catheter-Associated Urinary Tract Infection (CAUTI) prevention programs. Systematic monitoring of catheter utilization and infection rates enables healthcare providers to identify trends, evaluate compliance with established guidelines, and recognize areas requiring improvement. Continuous surveillance also supports the reinforcement of proper infection prevention practices, such as hand hygiene, aseptic catheter insertion, and the timely removal of unnecessary urinary catheters. The use of electronic surveillance systems has proven particularly beneficial in hospitalized settings because of their high sensitivity and specificity in detecting CAUTI cases. These systems facilitate efficient and timesaving screening processes, making them valuable tools for monitoring infection rates in tertiary healthcare institutions (Shen et al., 2021). In addition, process audits serve as structured and systematic methods for evaluating adherence to evidence-based infection prevention measures, including the Centers for Disease Control and Prevention (CDC) recommendations for CAUTI prevention. Through regular audits, healthcare facilities can assess compliance with best practices, identify gaps in clinical performance, and provide immediate feedback to healthcare personnel. This real-time feedback supports continuous quality improvement and enables the implementation of corrective actions that strengthen patient safety and reduce the incidence of CAUTIs (CDC, 2024).

Methodology

This narrative review summarized the peer-reviewed literature, clinical practice recommendations, and position papers on multimodal strategies for CAUTI prevention as detailed in Table 1. A systematic literature search was performed in the following electronic databases: PubMed/MEDLINE, CINAHL, Cochrane Library, and Google Scholar, including papers from January 2015 to March 2026. Search phrases comprised combinations of the following words: "catheter-associated urinary tract infection" or "CAUTI" and "multimodal" or "bundle" or "multifaceted" or "prevention" or "reduction". Inclusion criteria included: (1) peer-reviewed original research, systematic reviews, or meta-analyses; (2) clinical practice guidelines or position statements from authoritative bodies (CDC, WHO, ISID); (3) studies that assessed interventions with three or more multimodal components; (4) English language; and (5) healthcare settings (acute care, long-term care, or rehabilitation). Exclusion criteria were: (1) editorials, comments, or conference abstracts without data; (2) single intervention studies; (3) populations limited to children; (4) publications not in English. Two reviewers (not applicable for this single-author narrative review; the author screened all

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sources) assessed relevance by title and abstract, followed by full-text review. Data extraction focused on: study design, setting, multimodal components, CAUTI rate reduction, catheter utilization changes, and reported barriers to implementation. Given the narrative review design, formal quality appraisal (e.g., GRADE, ROBINS-I) was not performed; however, findings from higher-quality evidence (randomized controlled trials, systematic reviews, and large multicenter studies) were prioritized in synthesis. Results are presented thematically according to the core components of multimodal CAUTI prevention.

Results and Discussions

Research Question 1: **What is the efficacy of multimodal CAUTI prevention across clinical settings?**

Table 1. Summary of Multimodal Approach Components and CAUTI Rate Reductions Across ICU, Rehabilitation/Long-Term Care (LTC), and General/Mixed Settings

Setting	Multimodal Approach	Range of CAUTI Rate Reductions	Can we compare across settings?
ICU	Insertion/maintenance, indications, appropriate testing, alternatives to indwelling, sterilization, daily nursing rounds, staff education, electronic daily checklist, nurse-driven removal protocol, reminders, surveillance, feedback	83% reduction (Van Decker); Zero CAUTI (Shadle); 5.5→2.8/1000 patient-days (McGloin)	**No** – different outcome metrics, different time periods, different bundles
Rehabilitation/LTC	Surveillance, standardized symptom algorithm, chart review, gap identification, evidence-based practices, staff/patient/family engagement	7.01→3.71 (Hughes); 1.28→0.42 (Plando)	**No** – baseline rates differ dramatically from ICUs
General/Mixed	Education, progress note templates, daily provider reminders, alternative toileting, aseptic technique, new specimen technology including a luer lock activated device (LLAD), training, change management, urine culture protocols, dependent loop prevention education, 2-person insertion, order compliance monitoring	SIR ↓60.2% (Potugari); IDR 1.15→0.71 (Fish); SIR 0.564→0.284 (Sykora)	**No** – mixed settings include wards that are not comparable to ICUs or LTC

Table 1 summarizes outcomes for CAUTI reduction from multimodal intervention bundles implemented in 3 different healthcare settings. Each setting implemented a multimodal bundle of interventions to prevent catheter-associated urinary tract infection (CAUTI).

Critical Care Unit

Multimodal strategies in the ICU included: insertion and maintenance bundles, appropriate testing criteria, alternatives to indwelling catheters, sterilization protocols, daily nursing rounds, staff education, an electronic daily checklist, a nurse-driven removal protocol, reminders, surveillance and feedback. Implementation outcomes were variable: Van Decker et al. (2021) reported an 83% relative reduction in CAUTI rates, Shadle et al. (2021) achieved zero CAUTI, and McGloin et al. (2024) noted a reduction in CAUTI from 5.5 to 2.8 per 1,000 patient-days.

Rehabilitation/Long-Term Care Setting

Interventions in rehabilitation and LTC facilities included surveillance, standardized symptom algorithms, chart review, identification of gaps, evidence-based practices, and engagement of staff, patients, and families. Hughes et al. (2023) described a reduction in CAUTI events from 7.01 to 3.71, and Plando et al. (2024) described a reduction in CAUTI events from 1.28 to 0.42.

General/Mixed Wards

The intervention bundle included education, progress note templates, daily provider reminders, alternative toileting methods, aseptic technique, new specimen technology (LLAD), training, change management, urine culture protocols, dependent loop prevention education, two-person insertion, and order compliance monitoring in general or mixed ward settings. Potugari et al. (2020) showed that Standardized Infection Ratio (SIR) was reduced by 60.2%. Fish et al. (2024) observed a decline in infection density rate (IDR) from 1.15 to 0.71, while Sykora et al. (2026) recorded a SIR reduction from 0.564 to 0.284.

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All settings showed reductions in CAUTI rates after implementation, supporting the efficacy of bundled, process-oriented strategies. However, due to a number of reasons, direct comparison across settings is not methodologically valid.

First, outcome metrics were not consistent. Studies used heterogeneous endpoints: relative percent reductions (eg., 83% reduction), absolute rates per 1,000 patient-days (eg., 5.5→2.8), SIRs (eg., 0.564→0.284), and IDRs (eg, 1.15→0.71). The metrics are not interchangeable because SIR accounts for predicted vs. observed infections, while patient day rates do not. Second, baseline CAUTI rates varied widely within settings and between settings. For example, in rehabilitation/LTC, baseline rates ranged from 1.28 to 7.01, and ICU studies reported baselines from zero to 5.5. This variation is more likely to be indicative of variation in patient case mix, catheter dwell time and diagnostic intensity rather than true variation in the impact of intervention.

Third, intervention bundles were not the same even within the same setting category. The ICU bundle discussed by Van Decker's included an electronic daily checklist, which was not explicitly mentioned in Shadle's bundle (Van Decker et al., 2021; Shadle et al., 2021). Likewise, the general/mixed setting bundle contained LLAD specimen technology that was missing from the ICU and LTC protocols (Fish et al., 2024). These differences do not allow to isolate which specific elements are responsible for observed reductions.

Finally, time periods and surveillance methods were not consistently reported across studies, which could confound temporal trends in infection prevention practices or changes in CAUTI definitions (e.g., updates to NHSN criteria. With these caveats in mind, the data can be interpreted to suggest that multimodal prevention bundles are effective in each setting, but the evidence available does not support quantitative comparisons between settings (e.g. that ICUs achieve larger reductions than LTC).

Overall, multimodal strategies to prevent CAUTIs are generally effective at reducing CAUTIs in a variety of healthcare settings, including ICUs, rehabilitation facilities and general hospital units. The available evidence does not, however, allow a conclusion to be drawn as to which setting achieves the greatest reduction as studies use different bundled interventions, different outcome measures (e.g. raw counts, rates per 1,000 device-days, SIR, SUR), different baseline infection rates and no direct head-to-head comparisons across settings have been performed.

Research Question 2: **What are the Challenges and Barriers to Multimodal Approach in CAUTI prevention?**

Table 2. Summary of Key Technological Needs

Feature	Function	Rationale
CDSS & "Hard Stops"	Prevents inappropriate urine culture orders	Reduces false-positive infections and unnecessary antibiotic use.
Automated Order Sets	Standardizes catheter insertion and maintenance bundles	Ensures consistency and reliability in the delivery of evidence-based care.
Nurse-Driven Protocols	Empowers nurses to remove unnecessary catheters via EHR prompt	Directly reduces catheter-days, the single biggest risk factor for CAUTI.
Real-Time Dashboards	Tracks compliance with process measures (e.g., daily assessment)	Enables immediate, data-driven performance improvement.
AI Risk Prediction	Identifies high-risk patients for targeted intervention	Allows for proactive, personalized prevention strategies.

Table 2 illutrates the summary of a strong technological infrastructure, with the EHR as the central coordinating platform, as critical to fully realize a multimodal approach to CAUTI prevention. To be an active clinical partner rather than a passive repository for documentation, the EHR must integrate several criticaL technologies.

First, we need advanced clinical decision support systems (CDSS) integrated into the EHR. The best intervention is to implement "hard stops" that prevent providers from ordering urine cultures on catheterized patients unless certain evidence-based criteria are met, such as signs of systemic infection. In a study of five hospitals, such a hard stop reduced CAUTI rates by 86% (from 0.523 to 0.071 per 1,000 patient days) and reduced inappropriate urine culture orders by 59% (Suleyman et al., 2026). Best practice alerts, a form of passive reminder during order entry, can also alert clinicians to re-evaluate the need for the catheter at 24 or 48 hours after insertion. Secondly, protocol-driven, automated workflows standardize care while reducing the need for human memory. Nurse-driven removal protocols can be incorporated into nursing workflows and linked to daily assessments of catheter necessity, allowing nurses to remove catheters when criteria are no longer met without waiting for a physician's order. Studies have shown standardized order sets that encode CAUTI prevention bundles, including two-person insertion checks and dependent loop assessments, have improved compliance with catheter orders from 50% to 85% after implementation. Third, new technologies including predictive analytics and artificial intelligence enable proactive rather than reactive prevention. Sufriyana et al. (2025) demonstrated that AI algorithms applied to real-time EHR data (vital signs, laboratory results, and patient history) could identify patients at high risk for developing CAUTI

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up to 48 hours after catheter removal. These risk scores can be presented on nursing dashboards in order to trigger targeted preventive interventions. Fourth, real-time surveillance and reporting dashboards enable units to monitor compliance with key process measures—such as appropriate urine culturing rates and documentation of daily necessity—enabling immediate corrective action rather than waiting for retrospective reports. Automated calculation of metrics such as the Standardised Utilization Ratio and Standardized Infection Ratio allows for reporting to the NHSN. Finally, one important lesson from implementation science is the vulnerability of these systems during EHR transitions or upgrades. Pryor et al. (2024) reported a significant increase in CAUTI rates in several intensive care units immediately after the change to a new EHR as legacy alerts and hard stops were temporarily lost. This finding reaffirms the importance of maintaining CAUTI prevention protocols as non-negotiable requirements for any system migration. In conclusion, the EHR is the technological foundation for multimodal CAUTI prevention. But it's effectiveness depends on advanced functionality and system stability. Successful implementation needs technology support, not replacement of clinical judgement, and a sustained culture of safety.

Research Question 3: **What are the Challenges and Barriers to Multimodal Approach in CAUTI *prevention?***

Table 3. Summary of Challenges and Barriers to Multimodal Approach in CAUTI prevention

Barrier Category	Specific Challenges
Knowledge	Poor understanding of catheter indications; non-evidence-based assumptions
Motivational	Catheter apathy; perception of prevention as "additional burden"
Environmental	Resource constraints; limited RN supervision in some settings
Social	Interprofessional collaboration gaps; poor cross-setting communication
Behavioral	Interventions focus on knowledge over motivation/environment
Patient/Family	Underdeveloped engagement strategies; low evidence quality
Leadership	Insufficient visible leadership; regulatory misalignment
Sustainability	Difficulty maintaining long-term adherence; waning engagement

Although evidence exists that multimodal strategies are effective for CAUTI prevention, substantial barriers exist for healthcare facilities to implement them. Table 3 details these challenges to span knowledge, motivational, environmental, social, behavioral, and organizational domains.

Knowledge and Mental Barriers

A major barrier is the lack of knowledge on the right indications for catheter use, with inappropriate use in 21% to 55.7% of cases (Atkins et al., 2020). Staff in care home environments are often confronted with non-evidence-based assumptions regarding signs and symptoms of urinary tract infection, and educational interventions need to encourage "unlearning" of low-value practices (Prieto et al., 2024).

Motivation and Attitude Barriers

"Catheter apathy" - the belief that catheter colonization is unavoidable - has been identified as a major barrier to prevention (Catheter care group, 2016). Infection prevention is often perceived as an additional burden or as boring, which reduces staff's motivation and engagement (Atkins et al.,2020).

Environmental and Resource Constraints

Resources are limited and, therefore, implementation is constrained in all care settings. A scoping review of 26 studies found resource adjustment to be a core intervention component, however only 10 studies explicitly targeted this domain, leading to calls for more resource-sensitive evidence (Lan et al., 2026). The staffing challenges are the highest in long-term care where often little supervision by registered nurses is present and many unqualified personnel (Prieto et al., 2024).

Behavioral and Decision-Making Barriers

Interventions have focused mainly on knowledge and not on motivational, social and environmental influences on behavior. Atkins et al. (2020) noted that "social professional role and identity and environmental context and resources were targeted least frequently" and that current interventions used only half the potentially relevant content needed to overcome noted barriers. Memory and attention limitations were commonly reported barriers, and utility of checklists and visual reminders was noted (Atkins et al., 2020).

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Barriers to Patient and Family Engagement

Systematic reviews indicate that patient and family engagement strategies are underdeveloped. Most interventions did not provide sufficient detail of content, delivery or measurement of engagement activities (Mangal et al., 2021). Study quality was “poor to good, scoring lowest in internal validity”. Less than 50% of studies using flyers, handouts or verbal education had statistically significant results.

Barriers to Leadership and Sustainability

Leadership involvement is key to sustainability and the results from the systematic review highlight that “care home leadership and culture promote safe fundamental care” (Prieto et al., 2024). However, the long-term maintenance of multimodal components continues to be challenging. "The Catheter care group (2016) stated, "Engagement and accountability have emerged as major hurdles to the effectiveness and longevity" of CAUTI prevention efforts.

Ethical Considerations

This report did not involve human participants; therefore, local ethical approval is deemed not necessary.

Conclusion

The present narrative review demonstrates that multimodal approaches to prevent catheter-associated urinary tract infection (CAUTI) are effective and consistent across various healthcare settings, including intensive care units, rehabilitation facilities, long-term care centers, and general hospital wards. Data synthesized across multiple studies indicate a significant reduction in CAUTI rates with implementation of bundled interventions consisting of three or more core elements: reduction in catheter use, aseptic technique for insertion, maintenance protocols, education for staff and patients, and systematic monitoring with feedback. Importantly, findings suggest that no single intervention is sufficient to sustainably reduce CAUTI. Prevention of CAUTI is a complex process that varies from the decision for catheter insertion to daily maintenance and timely removal and needs a holistic multidisciplinary approach. Top performing programs reported CAUTI rate reductions of 60-83% and also meaningful reductions in catheter utilization days. However, making direct quantitative comparisons across studies and settings is methodologically invalid because of heterogeneity in outcome metrics (e.g., SIR vs. rates per 1,000 patient-days), intervention components, baseline infection rates, and surveillance methods. The EHR is the central technology platform for successful multimodal prevention, supporting clinical decision support systems, nurse-driven removal protocols, real-time dashboards, and increasingly artificial intelligence-based predictive analytics. However, there are significant barriers to implementation in knowledge (lack of knowledge of appropriate indications for catheters), motivation (“catheter apathy”), environmental constraints (staffing issues, especially in long-term care), behavior, and leadership. In particular, current interventions have overemphasized knowledge transfer and underaddressed the social, motivational, and environmental determinants of clinical behavior that may contribute to variability in long-term sustainability. Finally, this review exposes major evidence gaps including limited generalizability to low-resource settings, potential publication bias for positive findings and absence of rigorous controlled trials comparing different multimodal configurations.

Reccomendations

In light of the findings of this review, healthcare institutions should adopt multimodal CAUTI prevention bundles as the standard of care by integrating evidence-based catheter insertion indications, strict aseptic insertion techniques, daily assessment of catheter necessity, nurse-driven catheter removal protocols using established criteria such as HOUDINI, maintenance of closed drainage systems with securement devices, and continuous staff competency evaluation. Healthcare facilities should also maximize the use of electronic health record (EHR) functionalities, including clinical decision support systems, automated catheter management order sets, best-practice alerts, and real-time monitoring dashboards to strengthen adherence to prevention protocols and facilitate timely catheter removal. When clinically appropriate, alternatives to indwelling urinary catheters, such as external condom catheters and intermittent catheterization, should be routinely considered to reduce infection risk. Furthermore, healthcare organizations should address implementation barriers by fostering leadership support, improving interprofessional collaboration, ensuring adequate staffing and resources, and promoting a culture that prioritizes patient safety. Sustained investment in infection prevention programs, regular audit-and-feedback mechanisms, and continuous professional development is essential to maintain long-term success. Policymakers and professional organizations are likewise encouraged to develop context-specific implementation guidelines, particularly for low-resource healthcare settings where staffing, infrastructure, and technological limitations may affect prevention efforts. Future research should focus on conducting

large-scale comparative effectiveness studies to identify the most impactful combinations of multimodal interventions across diverse healthcare environments. Researchers should also work toward standardizing outcome reporting using recognized metrics such as standardized infection ratios (SIRs), catheter utilization rates, and device-day rates to improve comparability among studies. Additional investigations are needed to explore behavioral, organizational, and implementation science approaches that address motivational, social, and environmental factors influencing compliance with CAUTI prevention practices. Moreover, further studies should include underrepresented settings and populations, such as long-term care facilities, rehabilitation centers, pediatric populations, and healthcare institutions in low- and middle-income countries. Finally, well-designed patient and family engagement interventions should be developed and evaluated to strengthen patient participation in catheter management decisions and support more effective and sustainable CAUTI prevention strategies.

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