PREVENTION OF CATHETER-ASSOCIATED URINARY TRACT INFECTIONS: A SYSTEMATIC REVIEW

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ABSTRACT:
Catheter-Associated Urinary Tract Infections (CAUTI) represent a significant global public health challenge. **Objective:** to analyze the available evidence on the prevention of urinary catheter-associated infections to reduce the risk of infection. **Methods:** we conducted a systematic review that included 21 articles published in high impact databases. **Results and discussion**: the prevalence of UTI varies between 15 and 48% of cases of total healthcare-associated infections (HCAI), the main risk factors include catheter length of stay, inadequate management and comorbidities. Its main prevention measures are: hand hygiene, continuous education, restricted use, antisepsis of the insertion site, use of checklists**. Conclusion:** Reduction of prolonged catheter use, hand hygiene, and training are key strategies for its prevention, thus improving patient safety.

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INTRODUCTION

Healthcare-associated Infections (HAI) represent a significant public health problem worldwide and are associated with high rates of decreased quality of life, increased costs to the state, illness and death [(1)]. According to the World Health Organization (WHO) bulletin, in developed countries, 7 out of every 100 patients will contract a nosocomial infection; however, this figure doubles in developing countries to a ratio of 15 per-100 patients [(2)]. In European countries, Healthcare-associated infections correspond to a total of 4.1 million patients per year; 37,000 of these patients die, mostly because HAI are caused by multiresistant microorganisms [(1)]. In North America (Canada), it is estimated that around 8,000 deaths are caused by HAIs. According to the Pan American Health Organization, there are not many statistical data in several Latin American countries, despite the fact that these are one of the main causes of in-hospital morbidity and mortality [(1)]. In Ecuador, the Ministry of Public Health conducted a retrospective study on HAIs from 2018 to 2021 through the Integrated Epidemiological Surveillance System, and for the year 2021 a total of 5420 cases of Healthcare-associated infections were reported [(3)].

Within HCAI, the four common infections related to invasive or surgical procedures are: catheter-associated urinary tract infections, ventilator-associated pneumonias, surgical site infections, and catheter-associated bloodstream infection [(4)]

Urinary tract infections associated to vesical catheter are defined as the presence of two or more microorganisms at concentration greater than 100,000 CFU (colony forming units) /ml in urine culture, 48 hours after placing a urinary catheter or 48 hours after removing the catheter, accompanied by inflammatory response and fever higher than 38°C [(5) (6)]

Eighty percent of hospital-acquired urinary tract infections are related to the presence of a urinary catheter. It is estimated that 15 to 25% of patients who are admitted to hospital require the placement of a urinary catheter, this share increases to about 85% in critical units [(7)]. The staff working in hospital areas plays an essential role in the prevention of urinary tract infections associated with the presence of bladder catheters. In this context, the aim of this study is to analyze the available evidence on the prevention of urinary catheter-associated infections by means of a systematic review, identifying effective measures to reduce the risk of infection in hospitalized patients.

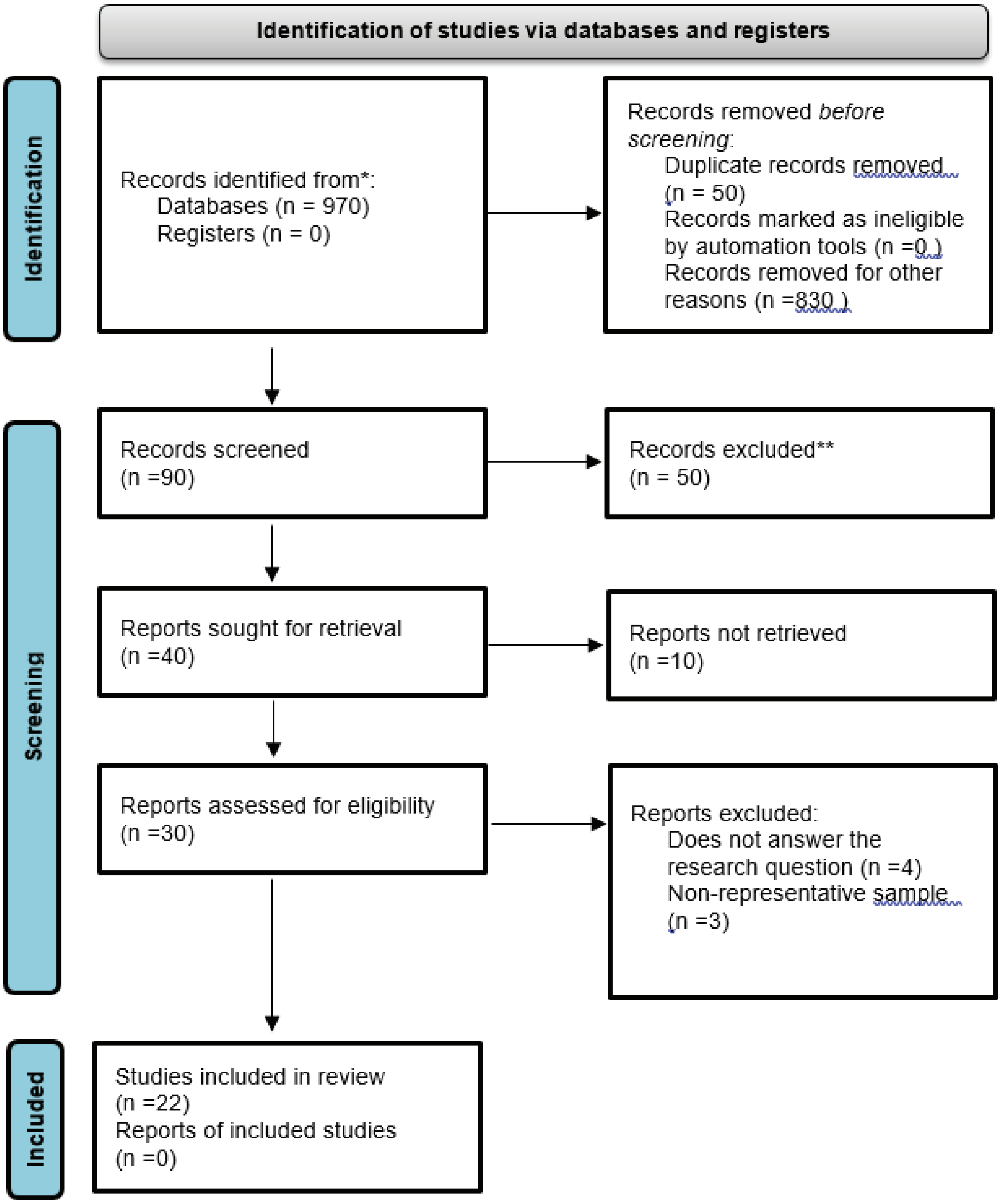

Figure 1. PRISMA Flowchart. Source: Own elaboration

METHODS

This study used a qualitative approach by means of a systematic review of the literature available in with high-impact scientific-technical information databases as Scielo, Scopus, PubMed, Dialnet, Elsevier. The search strategy was based on the use of descriptors (DESH and MESH), Boléan operators and truncators to elaborate the search equation. The inclusion criteria were: types of sources such as original articles, observational, intervention, systematic reviews and meta-analyses on the prevention of infections associated with urinary catheter placement; English, Spanish and Portuguese language, and a publication date within 13 years. The tool used for the systematic review was the prism diagram (Fig. 1). Chat GPT (OpenIA) was used as a support tool in the writing and editing of the manuscript, following the recommendations of the WAME. Final validation was performed by the authors.

RESULTS

Through initial identification using search equations and the application of inclusion criteria, 970 articles were found. After a quick review of titles and abstracts, as well as the elimination of duplicates, the selection was reduced to 90 articles. Subsequently, a rigorous critical analysis was carried out, from which 21 articles were

Table 1. Incidence of catheter-associated urinary tract infections.

Category	Main results	References
Incidence	Between 2005 and 2010, the incidence of urethral catheter-associated urinary tract infections in the intensive care unit decreased from 6.69 to 4.18 episodes per-1000 catheter days. Still, 2.95% of urinary catheter wearers developed at least one catheter-associated infection. Common etiologic agents persist, but with an increase in multidrug-resistant strains.	F Alvarez, F., Et al. 2013
Incidence	CAUTIs represent one of the most frequent infections in the intensive care unit, with an incidence of 40.5% in the study. The most frequent etiological agents were *E. coli* and *Klebsiella pneumoniae* with an incidence of 29.8% each.	Hidalgo I., 2015
Incidence	Healthcare associated infections (HAIs) acquired in the PICU had an incidence of 16%, of which 69.2% were due to catheter associated urinary tract infection (CAUTI).	Coelho N., Cunha M., 2020
Incidence	This systematic review including 25 articles, showed that CAUTIs were the most frequent type of nosocomial infection, accounting for 48% of all invasive device-related infections. It was followed in prevalence by ventilator-associated pneumonia (VAP) with 36% and central venous catheter (CVC)-associated bloodstream infections - 8%. These findings reinforce the need to strengthen prevention strategies aimed especially at the use and management of bladder catheters in critical settings.	Espinosa M., et al. 2023

Source: Own elaboration

selected directly related to the topic in question. These are shown in the following tables 1,2, and 3.

DISCUSSION

Prevalence and incidence: UTI associated with the presence of urethral catheters represent a significant problem within HAI. Several studies have reported a high incidence of this infection in the nosocomial setting.

According to the National Surveillance Study of Nosocomial Infections Acquired in Intensive Care Units (ENVIN ICU) of the Spanish Society of Critical Intensive Care Medicine and Coronary Units (SEMICYUC), 2.95 % of the 2329 patients studied developed CAUTI [8]. This study also revealed that, in 2023, the rate of HAI in ICU was 7.85 per 100 admitted patients. The main causes of infections in this context were: pneumonias associated with mechanical ventilation (36.15%), catheter-associated urinary tract infections (29.59%) and bacteremias of primary origin (21.18%) [9].

In Spain, according to a report including 116 post-surgical cardiac surgery patients with urethral catheter installation, 40.7% developed urinary catheter-associated infections [10]. A similar report in Portugal stated that infections due to mechanical ventilation were the most prevalent (69.2%), followed by infections related to central tract or urinary catheter, both with 15.4% [11].

In Germany, 21.6% of nosocomial infections were related to UTI, of which 60% were caused by the presence of a bladder catheter [9]. In Colombia, a study of HAI in post-surgical patients found that UTI CA were the most frequent (48%), followed by pneumonia due to mechanical ventilation (36%) [13].

In Ecuador, a study including 377 patients with UTI reported that 23.61% of the cases were related to the presence of urethral catheterization [14]. The incidence of CAUTI varies according to the context, but is regularly among the top 3 causes of HAI, with an average prevalence of 28.3%. These statistical data show the need to strengthen prevention and monitoring strategies for invasive device-associated infections in the hospital setting.

E. coli is the microorganism most commonly associated with those infections, with a frequency between 42.2% and 49.9%, followed by *K. pneumoniae* (23.4% and 26.9%) and *P. aeruginosa* (9%) [15] [16].

Risk factors:

Duration of catheterization:

The duration of urethral catheter use is a determining factor in the development of CAUTI. Studies show that the risk of infection increases as the time of catheter use increases.

In Colombia, it was reported that the risk was 4.5 times higher when catheterization exceeded 10 days (Odds Ratio (OR) = 4.502, (95% CI = 0.952 to 7.683) (15). In Chile, the risk of infection was found to increase 2.6 times on the seventh day of use (OR 2.6 CI 1.4-4.9, p = 0.004). At 15 days, the risk increased 7.8 times (OR 7.8 CI 2.9-20.9 p = 0.000)) [17]

The duration of catheterization as a risk factor is closely related to the formation of microbial biofilms, which play a key role in the pathogenesis of some infections.

Table 2. Risk factors in catheter-associated urinary tract infections.

Category	Main results	References
Incidence and Risk Factors	This systematic review identified the duration of urinary catheter use as a determining factor in the occurrence of urinary tract infections associated with urinary tract infections (UTI), showing that the longer the device remains in place, the greater the risk of bacterial colonisation and subsequent infection. Likewise, the use of antibiotic prophylaxis in selected patients has been shown to have a protective effect, reducing the incidence of CAUTI, especially when combined with rigorous aseptic and controlled catheter management practices.	Kranz J., et al., 2020
Incidence and risk factors Prevention measures	The incidence of CAUTI was 21.24%, with a higher frequency observed in patients with immunomodulatory or chronic comorbidities such as diabetes mellitus, systemic lupus erythematosus and rheumatoid arthritis. These conditions predispose patients to an increased risk of infection due to altered immune response and increased susceptibility to bacterial colonisation of the urinary tract.	Proaño C., 2021
Incidence and risk factors Prevention measures	It was found that the urethral catheter stay of more than 10 days and antibiotic therapy were associated with the occurrence of CAUTI, the first - as a risk factor and the other - as a protective factor, while age and gender made no significant difference .	Ortiz L., et al., 2021
Incidence and Risk Factors	Of 269 episodes of CAUTI analysed, 69.1% occurred in patients with indwelling bladder catheters, confirming their role as a key risk factor. In this study, the most frequent micro-organisms were *E. coli* with 42.2% and *Klebsiella pneumoniae* with 23.4%. Complications included bacteraemia (9.2%) and septic shock (0.8%), reflecting the severity that this infection caould reach if not properly managed.	Arias A., et al., 2012
Risk factors	In this study, which included 125 cases, an incidence of 25 CAUTI/1000 days of catheter stay was reported. This shows a significant frequency of this complication in exposed patients, underlining the need for rigorous evaluation of its indication and duration.	Hernández M., et al., 2022
Risk factors	Biofilm formation was identified in 37.7 of the urinary catheters, with *Proteus mirabilis* being the predominant micro-organism.	Sousa M., et al 2022
Risk factors	Urinary catheters promote the formation of biofilms and encrustations, increasing the risk of UTIs, and requiring innovative strategies the theto prevent them..	Rajaramon S., et al.2023
Risk factors Preventive measures	A UTI prevention programme, with surveillance and use of bundles, implemented with a continuous improvement approach and a multidisciplinary team is recommended.	Lin Ling M., et al., 2023

Source: Own elaboration

Biofilm is defined as a collection of microorganisms that grow indiscriminately on a surface of exopolysaccharides that are attached to inert material or living tissue. Prolonged use of catheters increases the likelihood of bacterial adhesion and colonization on their surface, leading to the development of microbial biofilms. These biofilms not only protect microorganisms from the host's immune response, but also confer resistance to antimicrobial treatments, significantly hindering treatment outcomes. There is evidence linking microorganisms such as *E. coli, P. aeruginosa*, and biofilm formation, and the same microorganisms are very commonly found in UTIs [(18)] These findings reinforce the evidence that the long duration of catheterization is directly associated with a higher infection risk. Therefore, it is essential to constantly evaluate the need to maintain the urethral catheter and apply measures that can shorten its use, thus reducing the likelihood of complications.

Immune status of the patient:

The patient's immune status plays a fundamental role in the development of CA UTI. Immunocompromised or chronically ill patients are at a higher risk. A study by Ramirez et al [(15)] found that diabetes and chronic kidney disease increased the risk of CAUTI by 1.3 and 1.4 times respectively (OR= 1.349, 95% CI= 0.615-2.676), (OR=1.470, 95% CI= 0.243-2.070). [(15)] However, other studies such as that of Véliz and Vergara [(17)] and Proaño [(19)] presented less conclusive results, highlighting that comorbidities are not always significantly associated with CAUTI (OR= 0.71 and OR=0.27, respectively), which requires further research [(14)(17) (19) (20) (21).]

Sex

Female sex seems to be related to a higher frequency of CAUTI. In a study with 377 patients, 63.92% of infections occurred in women, compared to only 36.08% in men. [(14)] A further analysis with 269 episodes of CAUTI reported a frequency of 55.3% in women. [(21)] However, both studies are based on descriptive statistics, so they do not establish a causal relationship between sex and predisposition to CAUTI. [(14) (22)]

Table 3. measures to prevent catheter-associated urinary tract infections

Category	Main results	References
Preventive measures	Management policies influence the incidence of infections such as COVID 19 cases with variations by quintile, while handwashing and hand disinfection reduce the incidence of this infection, highlighting the essential role of handwashing in reducing the risk of health-care-associated infections.	Dzator J., et al., 2022
Preventive measures	In the analysis of 441 cases of urinary catheter maintenance and management, recurrent deficiencies in the proper fixation of the device, correct management of the closed drainage system and compliance with hand hygiene were evident. Those are key factors that determine the occurrence of UTIs.	Campos M., y Oliveira A., 2019
Preventive measures	This study evidenced a relationship between urethral catheter and the development of urinary tract infection. Highlighting the device as a relevant risk factor in the acquisition of UTI.	Ramírez Y., y Fernández, A., 2019
Preventive measures	The Argentine Society of Infectious Diseases (SADI) and the Argentine Society of Intensive Care (SATI) suggested the rational use of antibiotics and improved practices to reduce costs and risks associated with the presence of urinary catheters.	COR-NISTEIN W., et al., 2018.
Preventive measures	This study showed that the systematic application of scales and checklists resulted in reduced rates of urinary tract infection associated with CAUTI, highlighting the importance of these tools as effective strategies to improve patients' safety and standardize care.	Sameer K., et al. 2018.
Preventive measures	The review included 12 studies on catheter care education involving patients and family members for prevention of CAUTI. Among the interventions, leaflets stood out with 83.3% and verbal education with 58.3%. Although all reported improved knowledge and management, only in 41.7% the improvement reached statistical significance. The methodological quality was variable, with limitations in internal validity and poor description of the interventions.	Manga S., et al., 2021
Preventive measures	The study focused on nurse, family and patient model which reduced the incidence of permanent UTI. However, the effect was not statistically significant which limits the strength of the evidence and suggests the need for more robust and better evaluated interventions.	Chen Lee K. et al., 2014
Preventive measures	The use of antiseptics for genital cleansing and antisepsis may reduce the incidence of CAUTI, although more evidence and strength of studies are needed to confirm their effectiveness.	Mitchell B., et al., 2020
Preventive measures	A study comparing genital cleansing and antiseptic measures prior to urinary catheter insertion found a lower incidence in those patients who used chlorhexidine gluconate. Although the results were promising, researchers were urged to strengthen this evidence with further confirmatory studies.	Düzkaya D., et al., 2017
Preventive measures	Chlorhexidine was proposed as an antiseptic effective against bacteria, fungi and viruses, used to prevent catheter-associated urinary tract infections. Research was recommended to confirm its efficacy**.**	Vallejo J y Molero M., 2019

Source: Own elaboration

Prevention measures

Hand hygiene

Hand washing and hand disinfection are two of the most important self-care and prevention measures against nosocomial infections. [23] According to statistical data from the United Nations, between 7% and 15% of hospitalized patients acquire a nosocomial infection, and of those, 10% die due to complications. [24] The World Health Organization (WHO) indicates that hand hygiene reduces the risk of nosocomial infection by 70%. [24]

Several studies have confirmed that hand hygiene reduces the incidence and transmissibility of infections. In an investigation carried out with data from 176 countries on government policies and their impact on the incidence of COVID 19, it was found that hand washing and hand disinfection have a positive effect on the reduction of confirmed cases. [25] However, studies such as the one conducted in Brazil show that, although 94.2% of health personnel performed hand hygiene before inserting the bladder catheter, only 66.5% did so afterwards. [26] Education and awareness of this habit are still essential to reduce the incidence of infections. [27]

Restricted use

The use of a bladder catheter should be limited to the strictly necessary situations [28], since its prolonged stay increases the risk of CAUTI. Once placed, it is essential to evaluate its necessity on a daily basis to avoid its unnecessary use. [15] [17] A study by the Critical Infectious Diseases Committee of the Argentine Society of Intensive Care (SATI) indicates that bacterial colonization of urine in patients with catheters increases with 3% to 7% per day, reaching 100% after 30 days. [29]

Antibiotic use

The SATI does not recommend the regular use of antibiotics to prevent CAUTI [29]. The study by Ramirez et al [15] showed that previous antibiotic therapy in patients with urethral catheters can act as a protective factor against CAUTI (OR= 0.06; 95%CI=0.036 and 0.103). However, several clinical practice guidelines worldwide do not recommend the use of antibiotics to prevent this type of infection, due to the imminent risk of resistance. [15]

Non-pharmacological measures

Effective prevention of CAUTIs relies on non-antibiotic strategies, primarily through combined approaches. These approaches integrate multiple evidence-based practices, including aseptic catheter insertion, maintenance of a closed drainage system, timely catheter removal, routine inspection of urine appearance, immediate laboratory testing when urine becomes cloudy or symptoms appear, and emptying of drainage bags separately into clean containers. The implementation of those combined approaches has been shown to significantly reduce CAUTI rates and improve patient outcomes.

Checklists

Checklists have proven to be an effective tool to strengthen the application of preventive measures in the use of invasive devices. A study in an ICU showed that the implementation of these checklists reduced the rate of urinary catheter-associated infection from 8 -17 to 8 – 10 cases per 1000 days of stay. [30]

Education

Patient, family and caregiver education is essential to reduce CAUTI, especially in patients with long-duration catheters and home management. [31] A study published in the International Journal of Nursing Practice noted that active involvement of caregivers in indwelling urinary catheter management decreased the incidence of CAUTI from 38.8% in the control group to 20% in the educated group. [32]

Cleaning and antisepsis of the insertion site

Cleaning and antisepsis of the urinary meatus and surrounding areas are effective measures to reduce the risk of infection associated with urinary catheter use. A review of 18 studies indicated that the use of antiseptics such as chlorhexidine and iodopovidone act as a protective factor (OR=0.84, 95%CI 0.69-1.02) compared to saline, soap and antimicrobial wipes (OR= 0.65, 95%CI 0.42-0.99). [33] Among all interventions, chlorhexidine has been shown to be the most effective option, although further studies are required to obtain conclusive results. A study in 122 pediatric patients compared three solutions: 0.05% chlorhexidine gluconate, 10% iodopovidone and sterile water. The UTI rates were 4.8%, 15% and 7.5%, respectively. However, this study concluded that the results were not statistically significant (P>0.05). [34]

According to Vaez and Pardo [35], chlorhexidine is effective against various microorganisms, with no adverse effects reported. However, further research was recommended to confirm or rule out the protective effect of this antiseptic in the prevention of CAUTI. [35]

CONCLUSION

CAUTI represent a significant problem within HAI, with an incidence ranging from 15% to 48%. The systematic review shows that the duration of catheterization is a determining factor in the development of CAUTI, with an increase of risk with increasing the time of use of the device. Likewise, the presence of comorbidities such as diabetes mellitus, chronic renal disease, or immune deficiency may increase susceptibility to infection, although some studies show inconclusive results in this regard.

The main etiological agent of CAUTI is *E. coli,* followed by *K. pneumoniae* and *P. aeruginosa*, which highlights the need for rigorous microbiological control and rational use of antibiotics to prevent microbial resistance. Given the impact of CAUTI on global public health, it is essential to implement prevention strategies based on the reduction of catheterization time, infection monitoring, strict compliance with aseptic measures in the placement and management of urinary catheters, as well as continuous education of healthcare personnel and caregivers. Despite the advances in prevention, the evidence reviewed suggests the need for more studies with robust methodological designs to clarify the relationship between risk factors and the development of CAUTI, which will allow the establishment of more effective and personalized strategies in clinical practice.

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