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Community vs. Hospital-Acquired MDR UTIs in Goa: Challenges in Pathogen Control and Treatment: A Review

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ABSTRACT

Urinary tract infections (UTIs) are among the most prevalent bacterial infections, classified primarily as Community-Acquired UTIs (CA-UTIs) and Hospital-Acquired UTIs (HA-UTIs). This study provides a comprehensive analysis of these two categories, examining their causative pathogens, risk factors, clinical presentations, and associated virulence mechanisms. CA-UTIs are commonly caused by Escherichia coli and affect otherwise healthy individuals. In contrast, HA-UTIs, often linked to prolonged catheterization or hospitalization, involve multidrug-resistant organisms such as Pseudomonas aeruginosa and Klebsiella pneumonia. Antibiotic resistance presents significant challenges in both contexts, with multidrug-resistant pathogens complicating treatment and leading to poorer patient outcomes. This review also explores the efficacy of antimicrobial agents, resistance patterns, and the implications for therapeutic strategies. By comparing the distinct and overlapping aspects of CA-UTIs and HA-UTIs, this study underscores the urgent need for targeted prevention measures and the judicious use of antibiotics to mitigate the growing resistance crisis.

Keywords: *Urinary tract infections (UTIs), Community-Acquired UTIs (CA-UTIs), Hospital-Acquired UTIs (HA-UTIs), MDR.*

INTRODUCTION

1. URINARY TRACT INFECTION

Urinary Tract Infections (UTIs) are a significant public health issue in India, affecting millions of individuals annually [2]. Women are particularly vulnerable, with studies indicating that nearly 50-60% of Indian women experience at least one UTI in their lifetime [1]. The prevalence is higher in rural areas due to poor sanitation, lack of clean water, and inadequate healthcare facilities [3]. The common causative agents of UTIs in India include *Escherichia coli, Klebsiella pneumonia*, and *Proteus mirabilis* [4]. Goa is located on the southwestern coast of India, bordered by the Arabian Sea to the west, the North Goa district to the north, and the state of Karnataka to the south and east [5]. The state's geography includes diverse landscapes ranging from beaches to dense forests [6]. South Goa District, covering the southern part of the state, spans a geographical area of 1,966 square kilometers, with its coordinates ranging between latitudinal parallels of 15° 29′ 32″ N and 14° 53′ 57″ N, and longitudinal parallels of 73° 46′ 21″ E and 74° 20′ 11″ E [7]. The Royal Hospital Laboratory, located at coordinates 15.2708° N and 73.9721° E, serves as a critical facility for diagnosing and managing UTIs in the region [8]. The laboratory's data on antibiotic resistance patterns provide valuable insights into the local epidemiology of UTIs and inform treatment protocols [9]. The surveillance and research are essential to adapt to the evolving resistance patterns and ensure effective management of UTIs in Goa [10].

a) INDIA with GOA ***c) SOUTH GOA DISTRICT***

Fig- 1.1: Study area maps (a, b & c) Google maps

In India, the management of UTIs is often complicated by the widespread use of antibiotics, leading to high levels of antimicrobial resistance (AMR) [11]. A study conducted in various regions of India found that over 60% of UTI-causing E. coli strains were resistant to commonly used antibiotics like ciprofloxacin and trimethoprim-sulfamethoxazole [12]. This resistance makes it challenging to treat infections effectively and increases the risk of complications [13]. Globally, UTIs are among the most common infections, affecting millions yearly [14].

In developed countries, such as the United States and Europe, the prevalence of UTIs is also high, with women again being the most affected group. According to the Centers for Disease Control and Prevention (CDC), nearly 50% of women in the U.S. will experience a UTI in their lifetime (CDC, 2020). The primary causative agents are similar to those found in India, with *E. coli* being the most common pathogen [15]. UTIs can be classified based on the location of acquisition into community-acquired UTIs (CA-UTIs) and hospital-acquired UTIs (HA-UTIs) [16]. The pathogens causing these infections and their antibiotic resistance patterns can vary significantly based on geographic location and healthcare practices [17]. This review focuses on the uropathogenic responsible for UTIs in Goa, a coastal state in India, and compares the antibiogram patterns between CA-UTIs and HA-UTIs.Also studies virulence factors in UTIs and the growing trend of Klebsiella species as compared to *E.coli*. [18].

Klebsiella pneumonia has become an increasingly common cause of urinary tract infections (UTIs), challenging the dominance of *Escherichia coli* (*E. coli*) as the primary uropathogen [19]. Recent studies have indicated a significant rise in the incidence of Klebsiella-related UTIs, particularly in hospital-acquired settings [20]. This increase can be attributed to the pathogen's ability to develop and spread antibiotic resistance, making infections more difficult to treat [21]. *E. coli* remains the most frequent cause of UTIs globally, but the gap between the prevalence of E. coli and Klebsiella pneumonia is narrowing [22]. Factors contributing to the rise in *Klebsiella* infections include its capacity to form biofilms and evade the host immune response, traits that are less prominent in *E. coli* [23]. Furthermore, the extensive use of antibiotics in healthcare settings has been selected for multidrug-resistant Klebsiella strains, exacerbating the issue [24].

Public health initiatives in India focus on improving sanitation, promoting hygiene, and increasing awareness about UTIs [25]. The government has launched several programs to improve access to clean water and sanitation facilities, particularly in rural and underserved areas [26], efforts are being made to regulate the use of antibiotics to combat the rising issue of AMR [27]. Prevention strategies in developed countries focus on public education about hygiene practices, proper hydration, and the importance of seeking medical advice for symptoms of UTIs [27]. There is also a significant emphasis on research and development to better understand the epidemiology of UTIs and develop more effective treatment and prevention strategies [29]. Surveillance data from hospitals have shown a marked increase in Klebsiella cases over the past decade [30]. This trend is particularly evident in regions with high antibiotic usage and inadequate infection control practices [31]. In contrast, *E. coli*, although still prevalent, has not shown the same rate of increase, possibly due to differences in resistance mechanisms and transmission dynamics [32].

2. Types of UTI

Urinary tract infections (UTIs) encompass a spectrum of clinical entities categorized by anatomical location, acquisition setting, and patient characteristics. Uncomplicated UTIs predominantly affect individuals with structurally normal urinary tracts and typically manifest as lower urinary tract infections (UTIs) such as cystitis or urethritis. Escherichia coli is the most common pathogen implicated in uncomplicated UTIs, although recent studies highlight variations in pathogen prevalence and resistance profiles [33]. Anatomically, UTIs can be further classified into lower and upper UTIs based on the involvement of the bladder and kidneys, respectively.

Lower UTIs typically present with localized symptoms such as dysuria and urgency, while upper UTIs manifest with systemic symptoms like fever and flank pain [34]. Early diagnosis and appropriate management tailored to the specific type and severity of UTI are critical for optimizing clinical outcomes and reducing the risk of complications, recent research underscores the evolving epidemiology and antimicrobial resistance patterns of UTIs, emphasizing the importance of targeted diagnostic and therapeutic approaches to improve patient care.

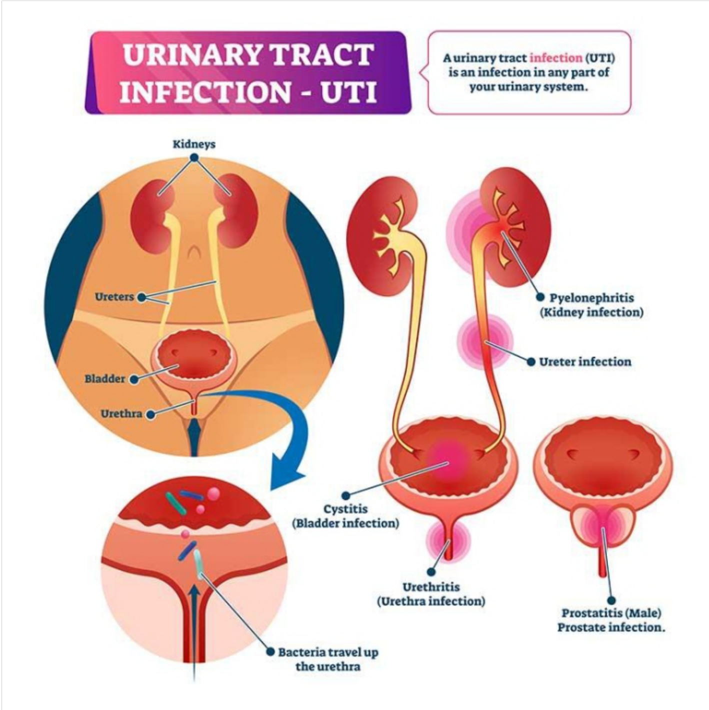

Fig.2.1 UTI – Causes, Symptoms and Treatment for UTI reference and sourcehttps://entrustcare.com

3. Comparative study of Community-Acquired UTIs (CA-UTIs) and Hospital-Acquired UTIs (HA-UTIs)

3.1 Community-Acquired UTIs (CA-UTIs)

Studies have consistently shown that *Escherichia coli* is the predominant pathogen in CA-UTIs. For instance, a study conducted in 2019 in Goa highlighted that *E. coli* was responsible for approximately 75% of CA-UTIs, followed by *Klebsiella pneumoniae* and *Proteus mirabilis* [35], the study noted that *Pseudomonas aeruginosa* and *Enterococcus faecalis* were less common but still significant pathogens in community settings [36]. Community-acquired urinary tract infections (CA-UTIs) are a significant public health concern in India, driven by various factors such as antibiotic resistance, healthcare access, and socio-economic conditions. CA-UTIs are commonly caused by pathogens like *Escherichia coli*, *Klebsiella pneumonia*, and *Proteus mirabilis* [37]. Women are more prone to CA-UTIs due to anatomical factors [38]. Studies indicate a significant prevalence of CA-UTIs among all age groups, with a higher incidence in the elderly and sexually active women [39].

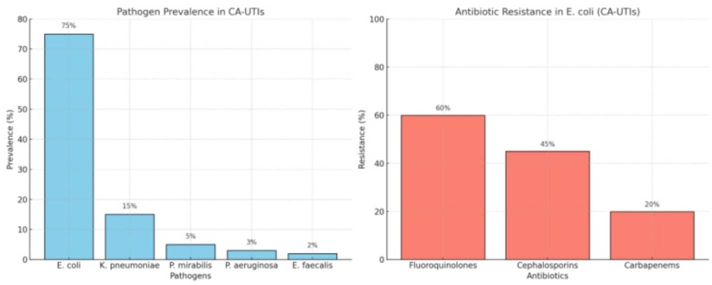

Fig 3.1 Community-Acquired UTIs (CA-UTIs)

1. Pathogen Prevalence in CA-UTIs (Community-Acquired Urinary Tract Infections): The bar chart illustrates that *Escherichia coli* accounts for 75% of CA-UTIs, followed by *Klebsiella pneumonia* (15%), *Proteus mirabilis* (5%), *Pseudomonas aeruginosa* (3%), and *Enterococcus faecalis* (2%).

2. Antibiotic Resistance in *E. coli* from CA-UTIs: This chart highlights the resistance of *E. coli* to common antibiotics: Fluoroquinolones: 60%, Cephalosporins: 45%, Carbapenems: 20%.The data reflects the critical challenges posed by antibiotic resistance and emphasizes the need for targeted interventions in managing CA-UTIs

3.2 Hospital-Acquired UTIs (HA-UTIs)

In the hospital setting, the diversity of uropathogens increases, with *E. coli* still being prevalent but with a higher incidence of multidrug-resistant strains. A study in 2020 reported that HA-UTIs in Goa often involved *E. coli*, *Klebsiella spp.*, and *Pseudomonas aeruginosa*, with a notable presence of *Acinetobacter baumannii* and *Candida spp.* [36]. These findings are consistent with global trends where hospital settings see a broader spectrum of pathogens due to various factors, including the use of catheters and broad-spectrum antibiotics [37]. Hospital-acquired urinary tract infections (HA-UTIs) are a significant concern in healthcare settings, particularly in India, due to their impact on patient morbidity, mortality, and healthcare costs. HA-UTIs are typically more severe than CA-UTIs and are associated with higher rates of antibiotic resistance [38].

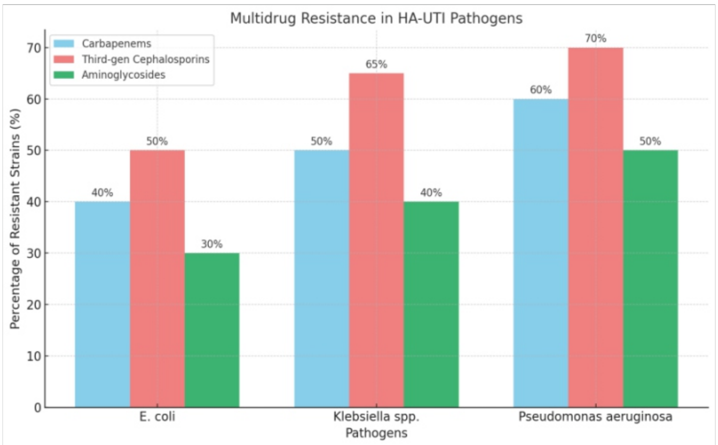

Fig. 3.2 Hospital-Acquired UTIs (HA-UTIs), a bar graph illustrating the percentage of resistant strains of major pathogens causing hospital-acquired urinary tract infections (HA-UTIs) against three classes of antibiotics: Carbapenems, Third-generation Cephalosporins, and Aminoglycosides.

4. Symptoms and Spread of Urinary Tract Infections (UTIs)

UTIs present a variety of symptoms depending on the part of the urinary tract affected. These symptoms can differ between lower UTIs, which affect the bladder and urethra, and upper UTIs, which affect the kidneys and ureters. UTIs are a significant health concern in the Goa region, as in many other parts of the world. Common Symptoms of Lower UTIs include dysuria, characterized by pain or burning during urination, as reported in multiple studies [39]. Patients often experience increased frequency of urination, documented as needing to urinate more frequently, which is a typical symptom noted in clinical reviews [40]. Urgency, defined as a sudden and strong need to urinate, is frequently observed and documented in various studies [41]. Hematuria, the presence of blood in the urine causing it to appear red or cola-colored, is another common symptom highlighted in the literature [42]. Additionally, cloudy or foul-smelling urine, indicative of bacterial presence or white blood cells, is commonly reported [43]. Lower abdominal discomfort, characterized by pain or pressure in the lower abdomen or pelvic area, is frequently noted in lower UTI cases.

5. Risk Factors for Urinary Tract Infections (UTIs)

Urinary tract infections (UTIs) are influenced by various risk factors that can predispose individuals to these infections. These risk factors can be categorized into several groups, including anatomical, behavioral, and medical factors. Understanding these risk factors is crucial for the prevention and management of UTIs [44].

6. Diagnostic Tests for Urinary Tract Infections (UTIs)

Diagnosing Urinary Tract Infections (UTIs) accurately is essential for effective treatment and management. Various diagnostic tests are utilized to confirm the presence of a UTI, identify the causative organisms, and determine their antibiotic sensitivities. This section provides a detailed explanation of common diagnostic tests for UTIs.

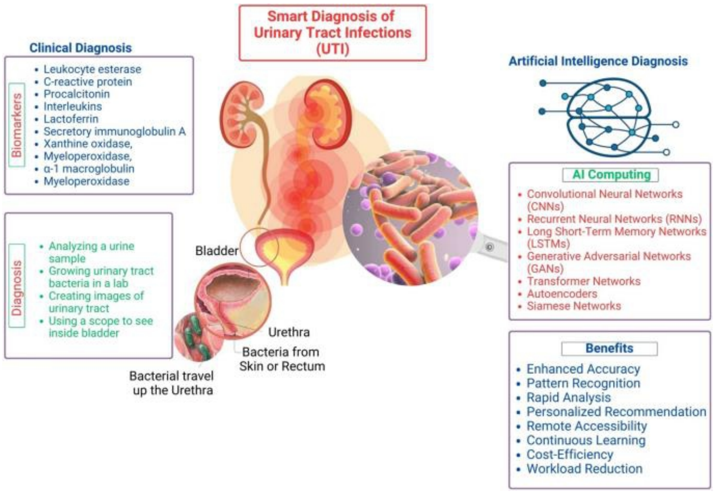

Fig 6.1 Diagnostic Tests for Urinary Tract Infections (UTIs) copyright from Springer and reference permission [57]

Diagnostic Methods for Urinary Tract Infections (UTIs)

6.1 Urine Dipstick Test

The urine dipstick test is a rapid, point-of-care diagnostic tool used to detect specific substances in urine. Chemically treated strips measure leukocyte esterase, an enzyme indicating the presence of white blood cells, which suggests infection, the test detects nitrites, produced by bacteria capable of reducing nitrate to nitrite, a marker of bacterial infection.

6.2 Urine Microscopy

Urine microscopy involves examining urine under a microscope to identify cells, bacteria, and crystals. The presence of white blood cells (WBCs) indicates infection, while red blood cells (RBCs) may signify hematuria. This technique provides a direct visualization of cellular and bacterial components in the urine.

6.3 Urine Culture and Antibiotic Sensitivity

Urine culture is the gold standard for identifying specific bacteria causing infection and determining their antibiotic sensitivities. The process begins with collecting a midstream clean-catch urine sample to minimize contamination (Hooton & Gupta, 2019).

The sample is streaked onto culture media, such as blood agar or MacConkey agar, and incubated at 35–37°C for 24–48 hours [46]. During incubation, bacteria grow and form colonies, which are identified based on morphology, color, and biochemical tests [47]. Common pathogens detected include *Escherichia coli*, *Klebsiella pneumonia*, *Proteus* species, and *Enterococcus* species.

6.4 Role of the 0.5 McFarland Standard

The 0.5 McFarland standard ensures the accuracy and reproducibility of bacterial cultures by standardizing the density of bacterial suspensions. This standard corresponds to a bacterial density of approximately 1.5×10^8 CFU/mL, which is critical for susceptibility testing and pathogen identification

Table no.1 VITEK® 2 Compact system in identifying UTI pathogens in India.

Year	Research Focus/Study Title	Location	Pathogens Identified	Findings
2014	Antibiotic Resistance in UTI Pathogens	Goa	*Escherichia coli*, *Klebsiella pneumoniae*	Highlighted increasing rates of MDR strains using VITEK® 2 Compact system.
2016	Prevalence of UTI Pathogens and Antibiotic Susceptibility Patterns	Tamil Nadu	*Pseudomonas aeruginosa*, *Proteus mirabilis*	Showed efficacy of VITEK® 2 Compact for rapid identification and antimicrobial profiling of UTI pathogens.
2018	Detection of Multidrug-Resistant UTI Pathogens	Karnataka	*Enterococcus faecalis*, *E. coli*	Reported the rising prevalence of ESBL-producing strains with precise detection by the VITEK® 2 Compact system.
2021	Rare Pathogens in UTI and Their Resistance Patterns	Goa	*Achromobacter xylosoxidans*, *Klebsiella spp.*	First report of rare UTI pathogens in Goa using VITEK® 2 for accurate identification.
2023	Molecular Epidemiology of UTI Pathogens in Coastal Regions	Kerala, Goa	*Enterobacter cloacae*, *E. coli*	Demonstrated the utility of VITEK® 2 in understanding MDR mechanisms, aiding in targeted therapy decisions.

Molecular techniques The Polymerase Chain Reaction (PCR) Test is a molecular technique that amplifies bacterial DNA to detect the presence of specific pathogens. The procedure involves extracting bacterial DNA from the urine sample and amplifying specific bacterial genes using PCR. This test is highly sensitive and specific, capable of detecting low levels of bacteria, and provides rapid results, it is expensive and requires specialized equipment and expertise, which are its limitations [48]. Sanger sequencing has been instrumental in advancing our understanding of urinary tract infections (UTIs) and the virulence factors associated with multidrug-resistant (MDR) pathogens. This method, known for its accuracy and reliability, allows researchers to identify and characterize genetic sequences of pathogens causing UTIs, thereby uncovering specific virulence factors and resistance genes. Pathogenesis of Urinary Tract Infections (UTIs) Urinary tract infections (UTIs) are characterized by the invasion and proliferation of microorganisms within the urinary tract, resulting in inflammation and various symptoms. The pathogenesis of UTIs encompasses several complex steps, including bacterial colonization, adhesion, invasion, and evasion of the host immune response.

Agents to Treat Urinary Tract Infections (UTIs)

Table no. 2 The antimicrobial agents used to treat UTIs, including their class, typical usage

Antimicrobial Agent	Class	Typical Usage
Amoxicillin/Clavulanate	Beta-lactam/Beta-lactamase inhibitor	Used for uncomplicated UTIs and in pregnant women; effective against a broad spectrum of bacteria.
Ceftriaxone	Third-generation cephalosporins	Used for severe or complicated UTIs, including pyelonephritis; broad-spectrum activity.
Cefuroxime	Second-generation cephalosporins	Used for uncomplicated UTIs; effective against Gram-positive and Gram-negative bacteria.
Ciprofloxacin	Fluoroquinolones	Used for complicated UTIs and pyelonephritis; increasing resistance limits use.
Fosfomycin	Phosphonic acid derivatives	Single-dose treatment for uncomplicated UTIs; effective against multi-drug resistant *E. coli*.
Levofloxacin	Fluoroquinolones	Similar to ciprofloxacin; used for complicated UTIs and pyelonephritis.
Meropenem	Carbapenems	Used for multi-drug resistant complicated UTIs; reserved for severe cases.
Nitrofurantoin	Nitrofurans	First-line for uncomplicated UTIs; effective against *E. coli* and other Gram-negative bacteria.
Piperacillin/Tazobactam	Beta-lactam/Beta-lactamase inhibitor	Used for complicated UTIs, especially in hospitalized patients; broad-spectrum activity.
Trimethoprim/Sulfamethoxazole (TMP/SMX)	Folate pathway inhibitors	Used for uncomplicated UTIs; effective against a wide range of pathogens. Resistance is increasing.

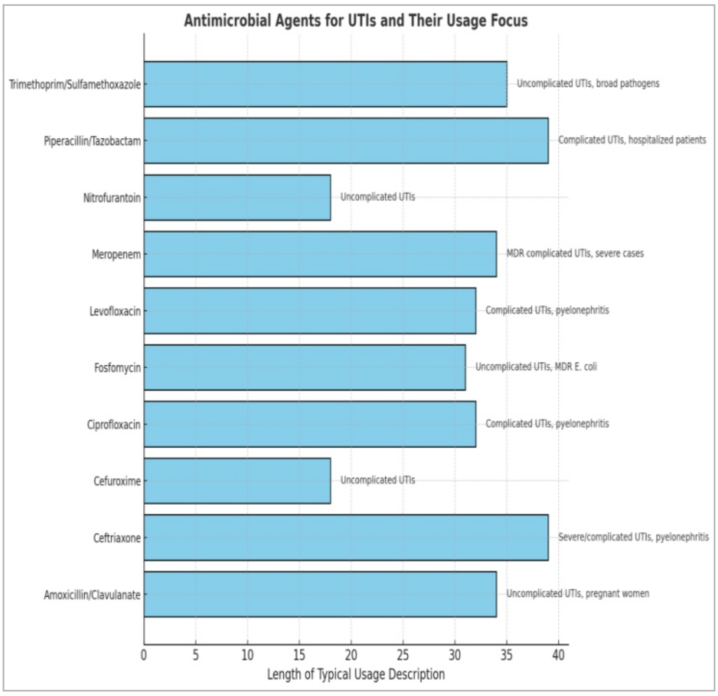

Fig.6 Antimicrobial agent for UTIs

A horizontal bar chart showcasing the antimicrobial agents used for UTIs and the corresponding descriptions of their typical usage. Each bar represents the antimicrobial agent, while the text next to the bars summarizes its application in treating UTIs.

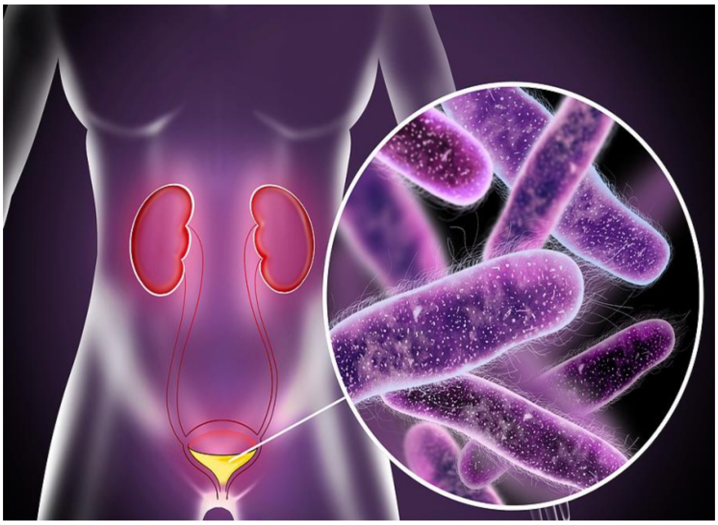

Fig .7 Antimicrobial Resistance in UTI

Virulence Factors in Uropathogenic Bacteria

Table 3 virulence factors associated with uropathogenic bacteria, their functions, and the pathogens that produce them.

Virulence Factor	Function	Pathogens
Type 1 Fimbriae	Adhesion to uroepithelial cells	*Escherichia coli* (E. coli)
P Fimbriae	Adhesion to kidney epithelial cells	*E. coli*
Hemolysin	Lysis of red blood cells and other host cells	*E. coli*, *Klebsiella* spp.
Cytotoxic Necrotizing Factor 1 (CNF1)	Disrupts host cell signaling and cytoskeletal structure	*E. coli*
Siderophores	Iron acquisition from host proteins	*E. coli*, *Klebsiella* spp.
Biofilm Formation	Protection from the immune system and antibiotics	*E. coli*, *Proteus mirabilis*, *Klebsiella* spp.
Capsule Production	Avoidance of phagocytosis and complement-mediated killing	*E. coli*, *Klebsiella* spp.
Urease	Hydrolyzes urea to ammonia, raising urine pH	*Proteus mirabilis*, *Klebsiella* spp.
Flagella	Motility and ascension through the urinary tract	*E. coli*, *Proteus mirabilis*
Antigenic Variation	Evades host immune system by altering surface antigens	*E. coli*, *Klebsiella* spp.

Treatment by Home Remedies

Urinary tract infections (UTIs) are a common health issue, particularly among women. While medical treatment is essential for managing UTIs, certain home remedies may help alleviate symptoms and support overall urinary health. This section explores various home remedies that are commonly recommended for managing UTIs, alongside their proposed mechanisms and supporting evidence.

Hydration

Adequate hydration is crucial for urinary health. Drinking plenty of water increases urine output, which can help flush out bacteria from the urinary tract and reduce the risk of infection . Increased urine flow clears bacteria from the urinary tract, potentially preventing colonization and reducing symptom duration . According to [27] higher fluid intake is associated with a decreased risk of UTIs, as it facilitates the removal of pathogens from the urinary system.

Cranberry Juice

Cranberry juice has traditionally been used to prevent UTIs. It is believed to prevent bacteria from adhering to the wall of the bladder and urinary tract. [3] demonstrated that cranberry products could reduce the frequency of UTIs, though results vary based on individual factors and the formulation of cranberry supplements.

Probiotics

Probiotics, particularly those containing *Lactobacillus* species, can help maintain a healthy balance of bacteria in the urinary tract, potentially reducing the risk of infection . Probiotics colonize the vaginal and urinary tracts, outcompeting pathogenic bacteria and producing substances that inhibit their growth . [15] found that *Lactobacillus*-containing probiotics can reduce the recurrence of UTIs by restoring the natural microbial flora of the urinary tract. [21] noted that D-mannose, often included in probiotic formulations, is effective in preventing recurrent UTIs with fewer side effects compared to antibiotics.

Warm Compresses

Applying a warm compress to the lower abdomen can help relieve pain and discomfort associated with UTIs. Heat increases blood flow to the affected area, which can reduce pain and inflammation. Hooton (2018) recommends using warm compresses as a non-pharmacological option for managing UTI-related discomfort.

Avoiding Irritants

Certain dietary and lifestyle factors can irritate the bladder and exacerbate UTI symptoms. Avoiding caffeine, alcohol, spicy foods, nicotine, and artificial sweeteners can help reduce bladder irritation. These irritants can worsen inflammation and discomfort in the bladder lining. [23-28]

advises individuals with UTIs to avoid such irritants to improve comfort and manage symptoms effectively.

Vaccines

UTIs are a prevalent health issue, particularly affecting women, children, and the elderly . Most UTIs are caused by bacteria such as *Escherichia coli* that colonize the gastrointestinal tract and can ascend into the urinary system . Despite significant research efforts, no widely available vaccine specifically designed to prevent UTIs exists as of January 2022.

Current research focuses on developing vaccines targeting specific pathogens like *E. coli* and their virulence factors, such as adhesins and toxins. Challenges in UTI vaccine development include the need for broad-spectrum efficacy, safety, and long-term immunity while addressing strain variability. According to [22] vaccines targeting fimbriae, a key adhesin in *E. coli*, have shown promise in preclinical trials. Developing vaccines requires overcoming unique obstacles, such as delivering antigens to mucosal sites and achieving robust immune responses. Advances in nanotechnology and adjuvant formulations may help address these challenges and accelerate progress toward a UTI vaccine. As research progresses, vaccines have the potential to become a valuable tool in preventing UTIs and mitigating the burden of antimicrobial resistance .

Discussion

The increasing burden of multidrug-resistant (MDR) urinary tract infections (UTIs) in both community (CA-UTIs) and hospital settings (HA-UTIs) represents a critical challenge for healthcare systems globally [23, 37, 29]. This review demonstrates that CA-UTIs are primarily caused by *Escherichia coli*, often affecting otherwise healthy individuals [33-34]. These infections, while generally less severe, are becoming increasingly difficult to treat due to rising resistance to commonly used antibiotics [16-19]. In contrast, HA-UTIs are associated with invasive medical procedures, prolonged hospital stays, and underlying comorbidities, making them more complex to manage [5-9]. These infections are often caused by opportunistic and MDR pathogens such as *Pseudomonas aeruginosa* and *Klebsiella pneumonia* [12-17]. The prevalence of extended-spectrum beta-lactamase (ESBL)-producing organisms in HA-UTIs further complicates treatment, necessitating the use of last-resort antibiotics like carbapenems or fosfomycin [15-19]. The alarming increase in antibiotic resistance underscores the importance of antimicrobial stewardship programs that monitor and regulate the use of antibiotics in healthcare and community settings[15-21]. This study highlights the necessity of rapid and accurate diagnostic methods to ensure timely and appropriate treatment [22-25]. Emerging technologies such as MALDI-TOF MS, whole-genome sequencing, and rapid susceptibility testing can enhance pathogen identification and resistance profiling [22]. Prevention strategies, including improved infection control measures, patient education on hygiene practices, and vaccination development, are vital [23]. In addition, further research into alternative therapies, such as phage therapy and probiotics, may offer promising solutions for the future [24]. By adopting a multidisciplinary approach involving clinicians, microbiologists, policymakers, and researchers, the healthcare system can effectively combat the challenges posed by MDR UTIs [25-56]. Future efforts should focus on tailored interventions that address local resistance patterns and prioritize the development of novel treatment options.

Conclusion

This study highlights the significant burden posed by Community-Acquired UTIs (CA-UTIs) and Hospital-Acquired UTIs (HA-UTIs) on global healthcare systems. While CA-UTIs predominantly affect healthy individuals and are largely caused by Escherichia coli, HA-UTIs present a more complex challenge due to their association with healthcare interventions and multidrug-resistant organisms such as Pseudomonas aeruginosa and Klebsiella pneumonia. The rise in antibiotic resistance exacerbates the difficulty of managing these infections, emphasizing the need for improved diagnostic methods, effective antimicrobial stewardship, and innovative therapeutic approaches. Addressing these challenges requires a multifaceted strategy involving patient education, healthcare professional training, and the development of novel antibiotics or alternative treatments. By understanding the unique and shared aspects of CA-UTIs and HA-UTIs, we can better tailor prevention and management strategies to reduce their prevalence and improve patient outcomes.

CONSENT

As per international standards or university standards, patient(s) written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

As per international standards or university standards written ethical approval has been collected and preserved by the author(s).

COMPETING INTERESTS

The authors have declared that no competing interests exist.

DISCLAIMER (AI)

The author(s) confirm that no generative AI tools, including Large Language Models (e.g., ChatGPT, Copilot) or text-to-image generators, were utilized in the writing or editing of this manuscript.

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