e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(8); 1028-1036

Original Research Article

Antimicrobial Resistance among Uropathogens in a Tertiary Care Hospital in Western Maharashtra

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Received: 01-05-2026 / Revised: 15-06-2026 / Accepted: 21-07-2026

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Conflict of interest: Nil

Abstract

Introduction: Urinary tract infections (UTIs) are among the most common bacterial infections and contribute substantially to antimicrobial use in community and hospital settings. Rising antimicrobial resistance, particularly among extended-spectrum beta-lactamase (ESBL)-producing uropathogens, has complicated empirical therapy and necessitates continuous local surveillance.

Aims and Objectives: To determine the prevalence of culture-positive UTIs, identify bacterial uropathogens, evaluate antimicrobial susceptibility patterns, and assess ESBL production in a tertiary care hospital in Western Maharashtra.

Materials and Methods: A retrospective laboratory-based study was conducted using urine culture and antimicrobial susceptibility records from January 2022 to January 2024. A total of 19,500 urine samples were analyzed. Demographic characteristics, bacterial isolates, antimicrobial susceptibility profiles, and ESBL production data were retrieved from laboratory records and analyzed using Microsoft Excel.

Results: Significant bacteriuria was detected in 1,726 samples (8.85%). Most isolates were from hospital wards (52.9%), followed by outpatients (34.1%) and intensive care units (12.8%). Females constituted 51.3% of culture-positive cases. Escherichia coli (59.2%) was the predominant uropathogen, followed by Klebsiella spp. (21.0%). High resistance was observed to ampicillin, third-generation cephalosporins, and cotrimoxazole, whereas nitrofurantoin retained good activity against E. coli. ESBL production was detected in 59.6% of E. coli and 44.7% of Klebsiella spp. isolates.

Conclusion: The high prevalence of ESBL-producing uropathogens and increasing antimicrobial resistance underscore the importance of regular local antibiogram surveillance to guide empirical therapy and strengthen antimicrobial stewardship programs.

Keywords: Urinary Tract Infection; Antimicrobial Resistance; Extended Spectrum Beta-Lactamase (ESBL); Carbapenem Resistance.

DOI: 10.25258/ijcpr.18.8.156

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Introduction

Urinary tract infections (UTIs) are among the most common bacterial infections encountered in clinical practice and constitute a major public health problem worldwide. Urinary tract infections (UTIs) occur in individuals of all age groups and in both sexes; however, females are more frequently affected owing to anatomical and physiological factors [1].

These infections represent a considerable proportion of both community-acquired and hospital- acquired infections and contribute significantly to global morbidity, healthcare costs, and the widespread use of antibiotics [1,2]. Clinically, UTIs may present with a broad spectrum of manifestations, ranging from asymptomatic bacteriuria and uncomplicated cystitis to more severe forms such as pyelonephritis, urosepsis, and septic shock, particularly among high-risk or vulnerable patient populations. [2,3].

Under normal physiological conditions, the urinary tract is sterile; however, bacterial invasion can occur via ascending, hematogenous, or, less commonly, lymphatic routes. The ascending route from the periurethral area to the bladder and kidneys remains the most frequent pathway of infection [3]. Several host-related factors predispose individuals to urinary tract infections (UTIs), including female gender, pregnancy, sexual activity, diabetes mellitus, urinary tract obstruction, neurogenic bladder, immunosuppression, and indwelling urinary catheterization [4,5]. Hospitalized patients, particularly those admitted to intensive care units, are at heightened risk due to prolonged catheterization, invasive medical procedures, and increased exposure to broad-spectrum antimicrobial agents [5].

Bacteria constitute the principal etiological agents of UTIs, with Gram-negative bacilli accounting for the majority of infections. Escherichia coli remains the most prevalent uropathogen globally, responsible for approximately 60–80% of community-acquired UTIs [6]. Other clinically significant Gram-negative organisms include Klebsiella species, Proteus species, Enterobacter species, Citrobacter species, and Pseudomonas aeruginosa, which are more frequently associated with complicated UTIs and healthcare-associated infections [7]. In addition, Gram-positive cocci such as Enterococcus species, Staphylococcus saprophyticus, and Staphylococcus aureus also contribute to UTIs in specific patient populations [7,8]. The distribution of these pathogens varies depending on geographic region, patient demographics, underlying comorbidities, and healthcare environments, underscoring the importance of region-specific epidemiological surveillance [8,9].

The laboratory diagnosis of UTIs is primarily based on urine culture and antimicrobial susceptibility testing, which remain the gold standard for confirming infection and identifying the causative organism [10]. Quantitative urine culture aids in distinguishing true infection from contamination and plays a crucial role in guiding targeted antimicrobial therapy.

Nevertheless, empirical antibiotic therapy is frequently initiated prior to the availability of culture results, particularly in outpatient and emergency care settings [6,11]. Although empirical treatment is often necessary to prevent complications, inappropriate antibiotic selection contributes substantially to the development and dissemination of antimicrobial resistance.

Antimicrobial resistance among uropathogens has become a significant global health concern. Increasing resistance has been reported against commonly used antibiotics, including penicillins, cephalosporins, fluoroquinolones, and trimethoprim-sulfamethoxazole [9,12]. Of particular concern is the growing prevalence of multidrug-resistant organisms, such as extended-spectrum β-lactamase (ESBL)-producing Enterobacterales, carbapenem-resistant Gram-negative bacilli, and resistant Enterococcus species [13]. Infections caused by these resistant pathogens are associated with limited therapeutic options, increased treatment failure, prolonged hospitalization, and higher mortality rates.

An antibiogram, defined as a cumulative summary of antimicrobial susceptibility patterns of bacterial isolates over a defined period, serves as an essential tool for guiding empirical therapy and monitoring antimicrobial resistance trends [14]. Local antibiograms provide critical information regarding the prevalent uropathogens and their susceptibility profiles, enabling clinicians to select appropriate first-line antibiotics and minimize the unnecessary use of broad- spectrum agents. Regular evaluation of antibiogram data is a key component of antimicrobial stewardship programs and plays an important role in optimizing antibiotic use and mitigating the emergence of resistance [14].

Resistance patterns among uropathogens are influenced by multiple factors, including antibiotic prescribing practices, the availability of over-the-counter antibiotics, patient compliance, and infection control practices within healthcare settings [12]. In many developing countries, indiscriminate antibiotic use and inadequate surveillance systems have contributed significantly to the rapid emergence of antimicrobial resistance, thereby reducing the effectiveness of standard treatment guidelines [12]. Catheter-associated urinary tract infections (CAUTIs) represent one of the most common healthcare-associated infections and are often associated with multidrug-resistant bacteria that form biofilms on catheter surfaces [5,15].

Furthermore, resistance patterns vary considerably between community-acquired and hospital-acquired urinary tract infections. Nosocomial infections, particularly catheter-associated UTIs, are frequently caused by highly resistant organisms such as Pseudomonas aeruginosa and Enterococcus species [5,15]. Given the high global burden of UTIs, the wide diversity of bacterial pathogens involved, and the alarming rise in antimicrobial resistance, periodic evaluation of bacterial etiology and antibiogram profiles is essential. Such data are crucial for guiding empirical antibiotic therapy, developing institution-specific antibiotic policies, and strengthening antimicrobial stewardship programs.

Therefore, studies investigating the bacterial pathogens responsible for UTIs and their antimicrobial susceptibility patterns are of significant clinical and public health importance in the current era of escalating antimicrobial resistance. The present study focuses on identifying the bacterial pathogens causing UTIs and analyzing their antibiogram patterns using recent data (2022–2024). By delineating pathogen distribution and resistance trends, the findings aim to reduce inappropriate antibiotic use and support broader efforts to combat antimicrobial resistance.

Aims & Objectives

1. To determine the prevalence of Urinary tract infections (UTI) at tertiary care hospital.
2. To evaluate the distribution of uropathogens across different hospital settings, including Wards, Outpatient Departments (OPD), and Intensive Care Units (ICU).
3. To identify the bacteriological profile of Urinary tract infections (UTI).
4. To determine antimicrobial susceptibility patterns of the uropathogens.
5. To determine the prevalence of MRSA, VRE, Extended-Spectrum Beta-Lactamase (ESBL) production and carbapenemase producers in Gram-positive and Gram-negative pathogens respectively.

Materials and Methods

The present study is a retrospective analysis of urine culture results conducted in the Department of Microbiology of a tertiary care hospital in Western Maharashtra. The study period extended from January 2022 to January 2024. A total of 19,500 urine samples received for culture and sensitivity were processed as per standard microbiology technique and AST were carried as per latest CLSI guidelines. Gram positive cocci were screened for methicillin resistance and vancomycin resistance. Gram negative isolates were screened for ESBL production. Mid-stream urine samples were received from OPD, Ward and ICU patients. However, from patients with catheter, sample was collected from the catheter and samples were sent for the culture sensitivity to the microbiology lab.

Demographic details of the patients, including age and sex, along with the bacterial isolates and their antimicrobial susceptibility profiles, were retrieved from laboratory registers using a standardized data collection format. The collected data were subsequently entered and analyzed using Microsoft Excel for descriptive statistical evaluation.

Result

During the study period, a total of 19,500 urine samples were processed for culture and sensitivity testing. Significant bacteriuria was observed in 1,726 samples, yielding an overall Urinary Tract Infection prevalence rate of 8.85%.

Female patients constituted a slightly higher proportions of cases accounting for 886 isolates (51.3%), whereas 840 isolates (48.6%) were obtained from male patients. (Figure No. 1) The adult population constituted the majority, with 1,594 cases (92.4%), whereas pediatric patients accounted for 132 cases (7.6%).

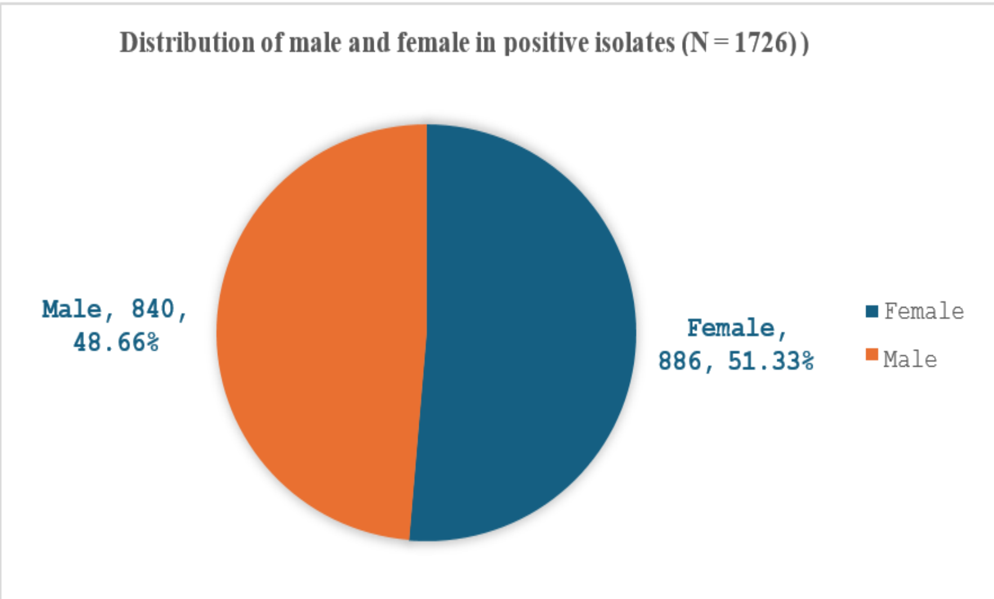

Figure 1: Distribution of male and female in total positive samples

Out of 1720 isolates recovered from urine, majority were from ward (914 isolates; 52.9%), followed by the outpatient department (OPD: 590 isolates; 34.1%) and critical care units (ICU: 222 isolates; 12.8%). (Figure No. 2)

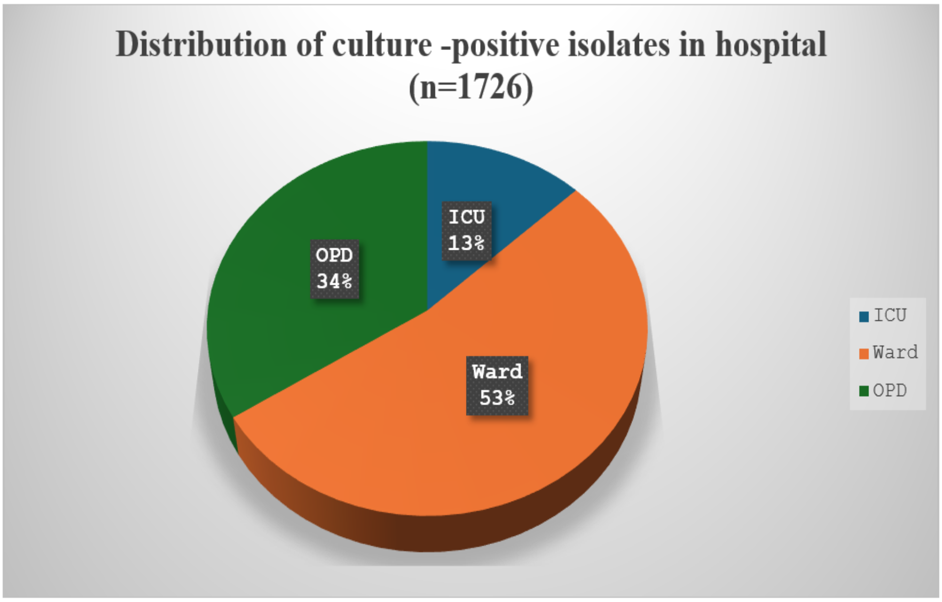

Figure 2: Distribution of isolates in hospital (n=1726)

Escherichia coli was the most frequently isolated organism, accounting for 1,023 isolates (59.2%). This was followed by Klebsiella spp. (364 isolates; 21%). Other organisms isolated included Pseudomonas spp. (94 isolates; 5.4%), Enterococcus spp. (77 isolates; 4.4%), Acinetobacter spp. (66 isolates; 3.8%), Enterobacter spp. (35 isolates; 2.0%), and Proteus spp. (34 isolates; 1.96%) Less frequently isolated organisms were Citrobacter spp. (8 isolates), Morganella morganii (7 isolates), Providencia spp. (5 isolates), and Burkholderia cepacia (1 isolate). (Figure no .3) Among the 89 Gram-positive cocci isolates, Enterococcus species were the most common (77), followed by MRCONS (7) and MRSA (2). No vancomycin-resistant Enterococcus (VRE) or high-level gentamicin-resistant (HLGR) Enterococcus isolates were detected.

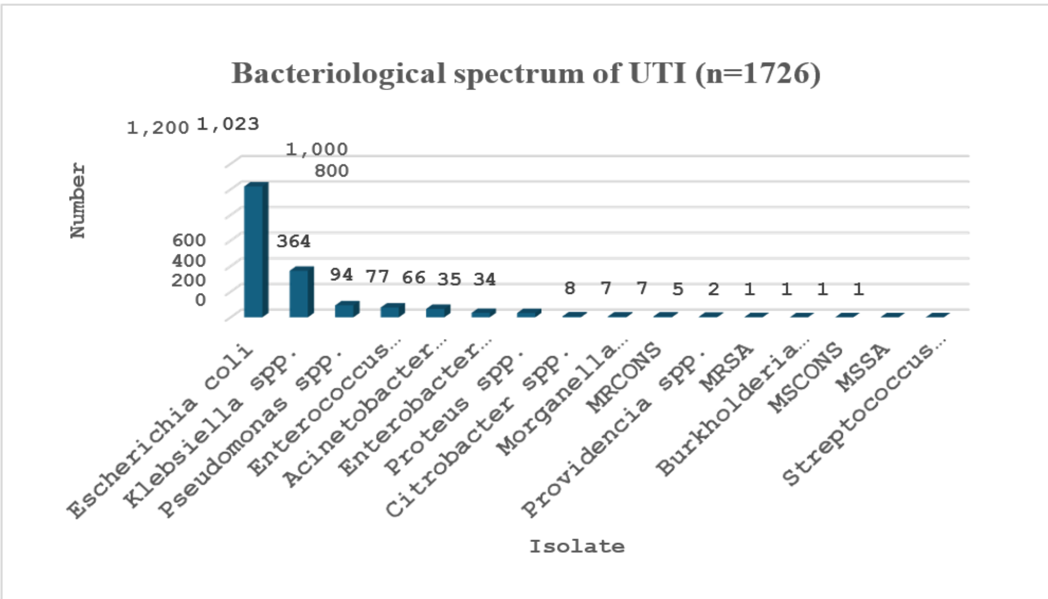

Figure 3: Bacteriological spectrum of UTI (n=1726)

Out of 1,726 bacterial isolates, Gram-negative bacilli (GNB) constituted the vast majority, accounting for 1,637 isolates (94.84%), while Gram-positive cocci (GPC) accounted for only 89 isolates (5.15%). This indicates a marked predominance of Gram-negative organisms among the isolates recovered in the study. (Figure no. 4)

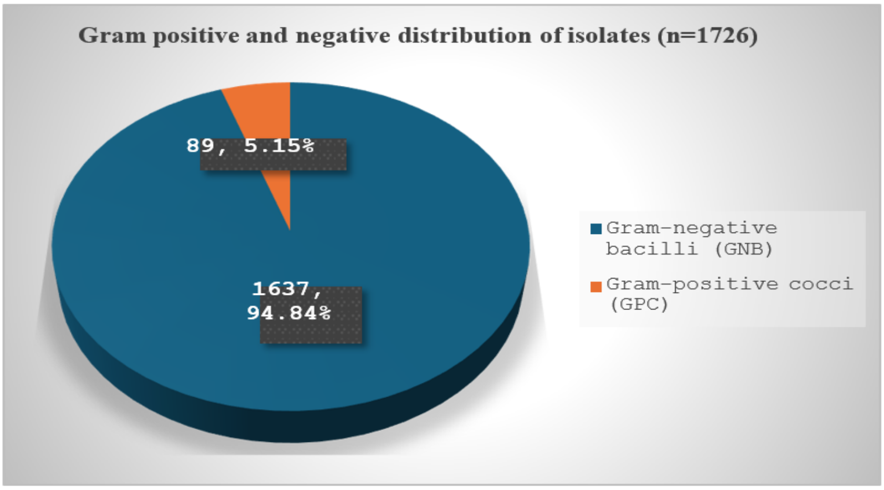

Figure 4: Gram positive and negative distribution of isolates (n=1726)

Analysis of the distribution of bacterial isolates revealed that Escherichia coli was the most common organism isolated from all areas of the hospital, followed by Klebsiella species and Pseudomonas species. However, Enterococcus species and Acinetobacter species were exclusively isolated from ICU and ward patients. (Table no .1)

Table 1: Percentage of isolates in ICU, Ward & OPD (n=1726)

Organism	ICU (%)	Ward (%)	OPD (%)
Escherichia coli	51.3	60.5	63.2
Klebsiella spp.	23.4	20.6	21.3
Acinetobacter spp.	4.9	4.26	2.5
Enterobacter spp.	2.2	1.96	2.0
Proteus mirabilis	0	2.5	1.69
Pseudomonas spp.	4.5	6.3	4.7
Enterococcus spp.	8.5	6.0	1.0

Out of 1,637 Gram-negative rod isolates, 825 (50.4%) were identified as ESBL producers, indicating a high prevalence of extended-spectrum β-lactamase production among Gram- negative bacterial isolates. Extended Spectrum Beta-Lactamase (ESBL) production was most commonly detected in E. coli (59.6%), followed by Klebsiella spp. (44.7%), Acinetobacter spp. (39.3%), Proteus spp. (29.4%), and Enterobacter spp. (11.4%). (Figure no. 5)

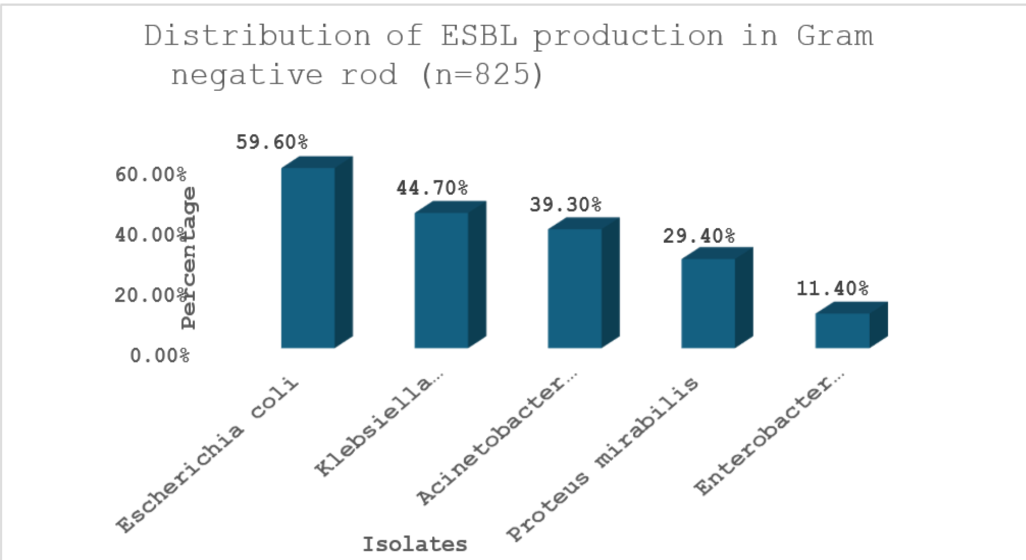

Figure 5: Distribution of ESBL production in Gram negative rod (n=825)

E. coli isolates demonstrated high resistance to ampicillin (89.6%), ceftriaxone (76.2%), and cotrimoxazole (60.5%). Resistance to piperacillin–tazobactam was observed in 38.4% of isolates, while nitrofurantoin resistance was comparatively low (10.1%) along with meropenem resistance which was 15.05%.

In ICU high level of resistance was seen in Ampicillin, Ceftriaxone, Nalidixic acid, Norfloxacin and Piperacillin-tazobactam and Meropenem, comparatively OPD isolates showed good susceptibility to Cotrimoxazole, Norfloxacin, Piperacillin-Tazobactam and Meropenem. (Table no. 2)

Table 2: Antibiotic resistance pattern of Escherichia coli Isolates from ICU, Ward, and OPD (n=1023)

Antibiotic	ICU (%)	Ward (%)	OPD (%)
AMP (Ampicillin)	94.7	93.3	83.7
CTR (Ceftriaxone)	89.4	83.0	64.1
COT (Cotrimoxazole)	78.9	64.3	49.8
NA (Nalidixic Acid)	93.8	81.4	85.2
NX (Norfloxacin)	89.4	80.9	63.3
NIT (Nitrofurantoin)	11.4	11.4	8.6
PTZ(Piperacillin–Tazobactam)	60.5	45.2	21.6
MRP (Meropenem)	30.7	17.7	6.6

Klebsiella spp. exhibited resistance to ceftriaxone (66.7%), cotrimoxazole (55.7%), nalidixic acid (62.6%), norfloxacin (52.4%), nitrofurantoin (46.9%), and piperacillin–tazobactam (46.4%). (Table no .3)

Table 3: Antibiotic resistance pattern of Klebsiella spp. Isolates to Antibiotics in ICU, Ward, and OPD

Antibiotic	ICU (%)	Ward (%)	OPD (%)
CTR (Ceftriaxone)	66.6	65.09	49.1
COT(Co-trimoxazole)	61.1	53.7	40.9
NA (Nalidixic Acid)	66.6	60.3	48.3
NX (Norfloxacin)	38.8	44.3	38.5
NIT (Nitrofurantoin)	27.7	40.5	40.1
PTZ (Piperacillin–Tazobactam)	22.2	21.6	20.6
MRP (Meropenem)	10.0	5.6	4.0

Pseudomonas spp. & Acinetobacter spp exhibited resistance to meropenem and piperacillin–tazobactam (40.5%) (38.3%) & (68.1%), (31.9%) respectively.

A majority of isolates remained susceptible to carbapenems. Carbapenem sensitivity was observed in 73.3% of E. coli isolates and 57.1% of Klebsiella spp. isolates.

Discussion

The present study evaluated the spectrum of uropathogens and their antimicrobial susceptibility patterns among urine samples. Of the 19,500 urine samples processed, significant bacteriuria was detected in 1,726 samples, yielding a culture positivity rate of 8.85%. Similar culture positivity rates have been reported in Indian studies. Shalini et al. [16] reported a positivity rate of 13.8%, whereas Dash et al. [17] documented a rate of 12.8% among patients with suspected urinary tract infection (UTI). The lower positivity rate observed in the present study may be attributed to differences in patient populations, antibiotic exposure, and healthcare-seeking behaviour. This could be because in a tertiary care hospital many patients receive antibiotics and are referred from primary health centers. Female patients constituted 51.3% of culture-positive cases, which is consistent with the established epidemiology of UTIs. Shalini et al. [16] reported female predominance in 58.4% of cases, while Sood and Gupta [18] observed that females accounted for 61.5% of UTI patients. The increased incidence among women is primarily related to anatomical and physiological predispositions, including a shorter urethra and proximity of the urethral opening to the perianal region.

Adults constituted 92.4% of cases in the present study, while pediatric patients represented only 7.6%. Similar observations have been reported by Kumar et al. [19], who found that adults represented approximately 88% of culture-positive UTI cases in a tertiary-care setting. The higher prevalence in adults may be associated with diabetes mellitus, urinary tract abnormalities, pregnancy, and catheterization. In our study the decreased rate in pediatric population could be due to less number of samples received for pediatric patients. Gram-negative bacilli accounted for 94.8% of isolates in the present study, while Gram-positive cocci represented only 5.2%. Sivaranjini et al. [20] reported Gram-negative organisms in 92.4% of urinary isolates, while Gupta et al. [21] documented Gram-negative bacilli in approximately 90% of isolates. This predominance reflects the established role of Enterobacterales as the principal etiological agents of UTIs.

Escherichia coli was the predominant uropathogen in the present study, accounting for 59.2% of all isolates, followed by Klebsiella spp. (21%). These findings are comparable with those reported by Sood and Gupta [18], who identified E. coli in 61.8% and Klebsiella spp. in 19.2% of isolates. Similarly, Mandal et al. [22] reported E. coli and Klebsiella spp. in 58.3% and 18.4% of urinary isolates, respectively. Data from the Indian Council of Medical Research (ICMR) antimicrobial resistance surveillance network by Veeraraghavan et al. [23] also demonstrated E. coli prevalence ranging from 52–67% and Klebsiella prevalence from 15–22% among urinary isolates.

The distribution of isolates according to hospital location demonstrated that E. coli remained the predominant pathogen in OPD, ward, and ICU settings. However, ICU samples showed relatively higher proportions of Klebsiella spp., Acinetobacter spp., and Enterococcus spp. similar findings have been reported by Taneja et al. [24], who observed increased recovery of multidrug-resistant Gram-negative bacilli from intensive care units compared with outpatient settings.

A major finding of the present study was the high prevalence of ESBL-producing Gram-negative bacilli. Among 1,637 Gram-negative isolates, 825 (50.4%) were identified as ESBL producers. ESBL production was most frequently observed in E. coli (59.6%) and Klebsiella spp. (44.7%). Comparable findings have been reported across India. Tankhiwale et al. [25] reported ESBL production in 52.4% of urinary isolates, while Umadevi et al. [26] documented an ESBL prevalence of 48.7% among Enterobacterales isolated from clinical specimens. Recent ICMR surveillance data reported by Veeraraghavan et al. [23] have also demonstrated ESBL rates ranging from 45% to 68% among urinary E. coli and Klebsiella isolates.

ESBL production was most common among E. coli (59.6%) and Klebsiella spp. (44.7%) in the present study. Umadevi et al. [26] reported ESBL production in 58% of E. coli and 46% of Klebsiella isolates. Similarly, Tankhiwale et al. [25] observed ESBL positivity in 61% of E. coli and 43% of Klebsiella spp. isolates. E. coli isolates in the present study exhibited high resistance to ampicillin (89.6%), ceftriaxone (76.2%), cotrimoxazole (60.5%), and fluoroquinolones. Similar resistance patterns have been documented by the ICMR surveillance programme [23], which reported ampicillin resistance exceeding 85%, ceftriaxone resistance between 70% and 80%, and fluoroquinolone resistance above 70% among urinary E. coli isolates. Veeraraghavan et al. [27] similarly reported ceftriaxone resistance of 74% and fluoroquinolone resistance exceeding 70% among E. coli isolates recovered from Indian hospitals.

Nitrofurantoin demonstrated excellent activity against E. coli, with resistance observed in only 10.1% of isolates. Similar susceptibility rates have been reported in Indian studies. Shanmugapriya and Manjula [28] reported nitrofurantoin susceptibility of 88.6%, while ICMR surveillance studies by Veeraraghavan et al. [23] documented susceptibility rates ranging from 82% to 90%. These findings support the continued use of nitrofurantoin as a first-line oral agent for uncomplicated UTIs. This could be because of cycling of antibiotics to prevent spread of resistant bacteria.

Klebsiella spp. demonstrated substantial resistance to ceftriaxone (66.7%), cotrimoxazole (55.7%), and nalidixic acid (62.6%). Joseph et al. [29] reported ceftriaxone resistance of 63% and cotrimoxazole resistance of 57% among Klebsiella urinary isolates, findings that are comparable to those observed in the present study.

Acinetobacter spp. and Pseudomonas spp. demonstrated considerable resistance to piperacillin–tazobactam and carbapenems. Particularly, Acinetobacter spp. showed meropenem resistance exceeding 68%. The high meropenem resistance observed in Acinetobacter spp. may be due to extensive use of broad-spectrum antibiotics in hospitalized patients, resulting in significant selective pressure. Additionally, the organism readily acquires resistance genes and can persist in the hospital environment, facilitating the emergence and spread of multidrug-resistant strains. Similar findings have been reported by the ICMR surveillance network [23], which documented carbapenem resistance rates of 40–70% among Acinetobacter spp. and 20–40% among Pseudomonas spp. isolated from tertiary-care centres across India.

Carbapenems remained among the most effective antibiotics against Enterobacterales in the present study in ICU and Ward. Carbapenem susceptibility was observed in 73.3% of E. coli and 57.1% of Klebsiella isolates. Similar susceptibility rates have been reported by Veeraraghavan et al. [27], who documented carbapenem susceptibility of approximately 80% among E. coli and 60–70% among Klebsiella spp. isolates. However, the emergence of carbapenem-resistant organisms remains a major concern. Among Gram-positive cocci, Enterococcus spp. were the predominant isolates. No vancomycin-resistant Enterococcus (VRE) or high-level gentamicin-resistant (HLGR) Enterococcus isolates were detected. Similar low rates of VRE (0–5%) have been reported by Praharaj et al. [30] and Mathur et al. [31]. Overall, the present study demonstrates the continued predominance of E. coli and Klebsiella spp. as uropathogens with emphasis on Acinetobacter and Enterococcus especially from ICU and ward, a high burden of ESBL-producing isolates, and substantial resistance to commonly prescribed antimicrobials.

The retained susceptibility of E. coli to nitrofurantoin and the continued efficacy of carbapenems against most multidrug-resistant isolates provide important guidance for empirical treatment strategies.

Conclusion

This study demonstrates that urinary tract infections in the study setting are predominantly caused by Gram-negative bacteria, with Escherichia coli and Klebsiella species being the most common uropathogens. A high prevalence of ESBL-producing organisms and significant resistance to first-line antibiotics such as cephalosporins, fluoroquinolones, and cotrimoxazole was observed. Nitrofurantoin remains an effective oral option for uncomplicated UTIs, while carbapenems continue to be reliable agents for critical infections, though emerging resistance is a cause for concern.

Institution of Anti-Microbial Stewardship Program to initiate appropriate empirical treatment, optimize the use of antibiotics and cycling of antibiotics is must to curb the spread of Anti-microbial resistance.

Limitations

Being retrospective in nature, detailed clinical information such as presenting symptoms, underlying comorbidities, catheterization status, and prior antibiotic exposure could not be evaluated. As the study was conducted at a single tertiary care center, the findings may not be fully generalizable to other healthcare settings or populations.

Declaration of Interests: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author Contributions: Sambhavi Sood: Conceptualization, Writing, Editing, Methodology, Data curation, original draft preparation, Visualization. Swapna Mali: Reviewing and Editing, Supervision. Reena Set: Supervision.

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