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Original Research Article

Antibiotic Susceptibility Patterns of Uropathogens in a Rural Tertiary Care Centre of Western Maharashtra: A Prospective Study

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Abstract

Introduction: Urinary tract infections (UTIs) are among the most common bacterial infections and a major cause of morbidity. The increasing prevalence of antimicrobial resistance (AMR) among uropathogens has reduced the effectiveness of commonly used antibiotics, complicating empirical therapy. Continuous surveillance through institutional antibiograms is essential to monitor resistance trends and guide rational antimicrobial use, particularly in rural tertiary care settings.

Methodology: A prospective longitudinal study was conducted over two years in a rural tertiary care hospital in Western Maharashtra. Adult patients with suspected UTIs whose urine samples were sent for culture and sensitivity testing were included. Identification of pathogens and antibiotic susceptibility testing were performed using the Kirby–Bauer disk diffusion method as per CLSI guidelines. Data were analyzed to determine the spectrum of uropathogens and their antimicrobial susceptibility patterns.

Results: A total of 691 urine samples were analyzed. The predominant isolates were Escherichia coli, Klebsiella spp., Pseudomonas spp., Staphylococcus aureus, and Enterococcus spp. Carbapenems showed high sensitivity against Gram-negative organisms, including E. coli (88%) and Klebsiella spp. (90%). Piperacillin–tazobactam and cefoperazone–sulbactam demonstrated moderate to high sensitivity (78–85%), while amikacin showed good efficacy (75–80%). High resistance was observed with fluoroquinolones and cotrimoxazole. Nitrofurantoin and fosfomycin retained good activity, especially against E. coli. Gram-positive isolates showed high sensitivity to vancomycin, linezolid, and teicoplanin (>90%).

Discussion: The findings indicate rising resistance to commonly used antibiotics, emphasizing the need for judicious use of reserve drugs and promoting effective oral agents for uncomplicated UTIs.

Conclusion: High AMR burden necessitates regular antibiogram surveillance to guide empirical therapy and strengthen antimicrobial stewardship.

Keywords: Antimicrobial Resistance, Antibiogram, Urinary Tract Infection, Culture Sensitivity, Antimicrobial Stewardship.

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Introduction

Infectious diseases remain a major cause of morbidity and mortality worldwide despite advances in antimicrobial therapy. Urinary tract infections (UTIs) are among the most frequently encountered bacterial infections in both community and hospital settings and contribute significantly to healthcare burden. [1,2] The increasing prevalence of antimicrobial resistance (AMR) among uropathogens has compromised the effectiveness of commonly used antibiotics, making empirical therapy increasingly challenging. [3]

The emergence and global spread of multidrug-resistant (MDR) organisms, including methicillin-resistant Staphylococcus aureus, vancomycin-resistant Enterococcus spp., extended-spectrum β-lactamase (ESBL)-producing Enterobacteriaceae, carbapenem-resistant organisms, and non-fermenters such as Pseudomonas aeruginosa and Acinetobacter spp., have further complicated infection management. [4] In India, resistance to fluoroquinolones and third-generation cephalosporins exceeds 50–70% among common pathogens, with emerging resistance even to last-resort agents such as colistin. [5]

Inappropriate antibiotic use, irrational prescribing, poor compliance, and hospital-acquired infections

contribute to the rapid emergence of resistance. Nosocomial infections particularly affect vulnerable populations and are associated with prolonged hospital stay, increased costs, and higher mortality. [3]

Periodic surveillance of bacterial isolates and their antimicrobial susceptibility patterns is essential for guiding empirical therapy. Antibiograms provide a summary of institutional susceptibility patterns and serve as a valuable tool for antimicrobial stewardship. [6]

This study aimed to evaluate the antibiotic susceptibility patterns of uropathogens in a rural tertiary care hospital and to develop an institutional antibiogram to guide rational antibiotic use.

Materials and Methods

Study Design and Setting: This prospective longitudinal study was conducted over a period of two years (March 2023 to June 2025) in the Departments of Pharmacology and Microbiology in collaboration with clinical departments of a rural tertiary care hospital in Western Maharashtra.

Study Population: Adult patients (18–60 years) with suspected infections whose clinical samples, including urine, were sent for culture and sensitivity testing were included after obtaining informed consent.

Inclusion Criteria

- Adult patients (18–60 years) with suspected infectious diseases
- Clinical samples (urine, blood, pus, sputum, etc.) sent for culture and sensitivity
- Patients providing informed consent

Exclusion Criteria

- Pediatric patients
- Samples with incomplete reports
- Improperly collected or contaminated samples
- Sample Processing and Identification

Specimens were collected and processed using standard microbiological techniques. Identification of isolates was performed using conventional methods, including colony morphology, Gram staining, and biochemical tests.

Antimicrobial Susceptibility Testing: Antibiotic susceptibility testing (AST) was performed using the Kirby–Bauer disk diffusion method on Mueller–Hinton agar. Results were interpreted as sensitive or resistant according to Clinical and Laboratory Standards Institute (CLSI) guidelines.

Quality control was ensured using standard ATCC strains.

Data Collection

The following variables were recorded:

- Demographic data (age, sex)
- Clinical diagnosis and department
- Type of specimen
- Identified microorganisms
- Antibiotic sensitivity and resistance patterns
- Antibiogram Construction

Only the first isolate per patient was included to avoid duplication. Organisms with adequate sample size were included for analysis. The antibiogram was constructed based on percentage susceptibility.

Statistical Analysis: Data were analyzed using descriptive statistics. Categorical variables were expressed as frequencies and percentages. Antibiotic susceptibility was reported as percentage sensitivity (%). Statistical significance was considered at $p < 0.05$.

Ethical Considerations: The study was conducted after obtaining approval from the Institutional Ethics Committee. Informed consent was obtained from all participants.

Results

A total of 2280 patients with infective illnesses were included in the study.

The highest proportion of patients belonged to the >60 years age group (37.8%), followed by ≤40 years (34.3%) and 41–60 years (27.9%). (Fig-1) This difference was statistically significant ($p < 0.001$). There was a slight male predominance (52.7% males vs 47.3% females). (Fig-2)

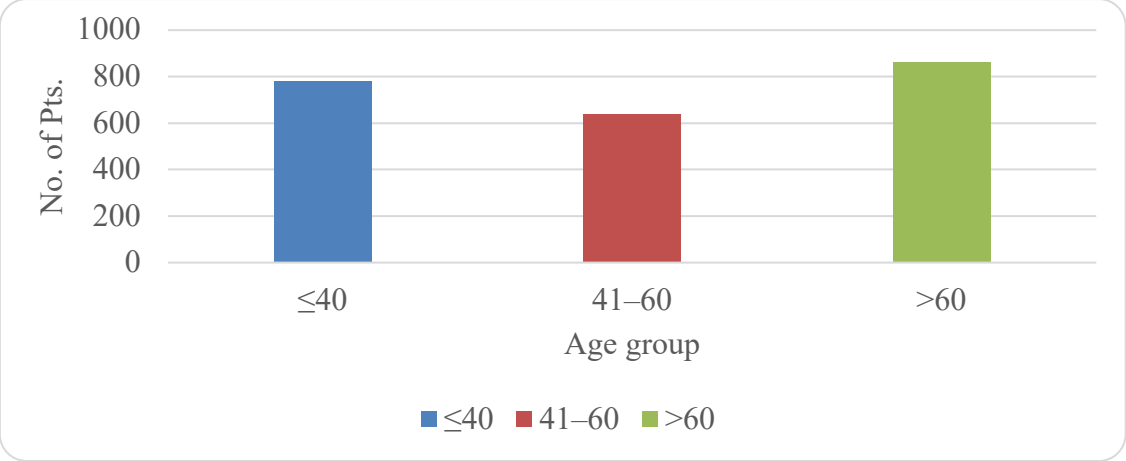

Figure 1: Age-wise Distribution of Patients with Infective Illness

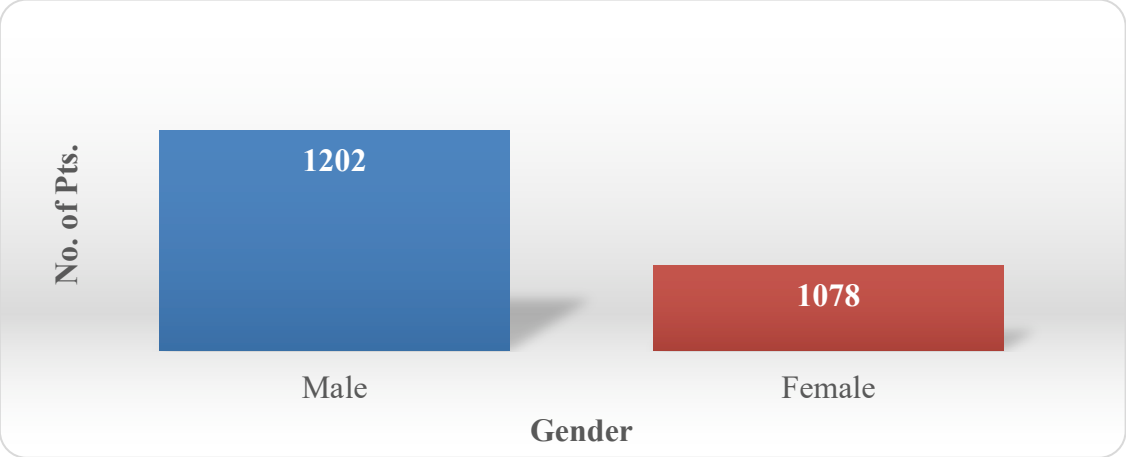

Figure 2: Gender Distribution of Patients

Department-wise distribution showed that the majority of cases were from General Medicine (48.2%), followed by General Surgery (15.4%), ICU variants (9.0%), Obstetrics and Gynecology (8.4%), MICU (7.2%), Orthopedics (5.9%), and other departments (5.9%).(Fig-3)

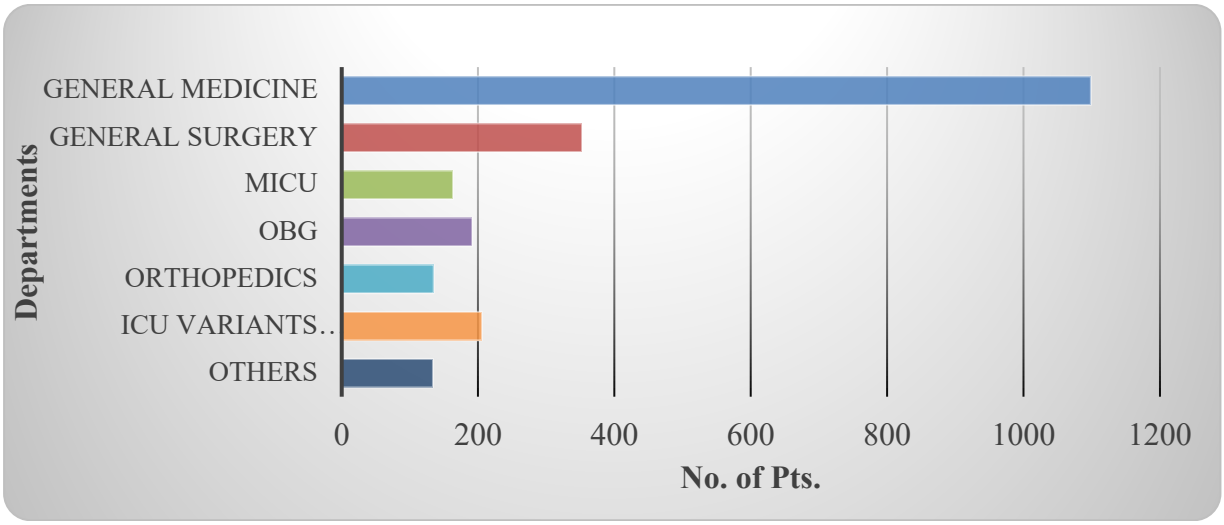

Figure 3: Department-wise Distribution of Patients

Out of all samples, 87.6% were non-sterile and 13.3% were sterile.(fig-4) The most common clinical specimens were blood (964), followed by urine (691), pus (389), and other samples.(fig-5)

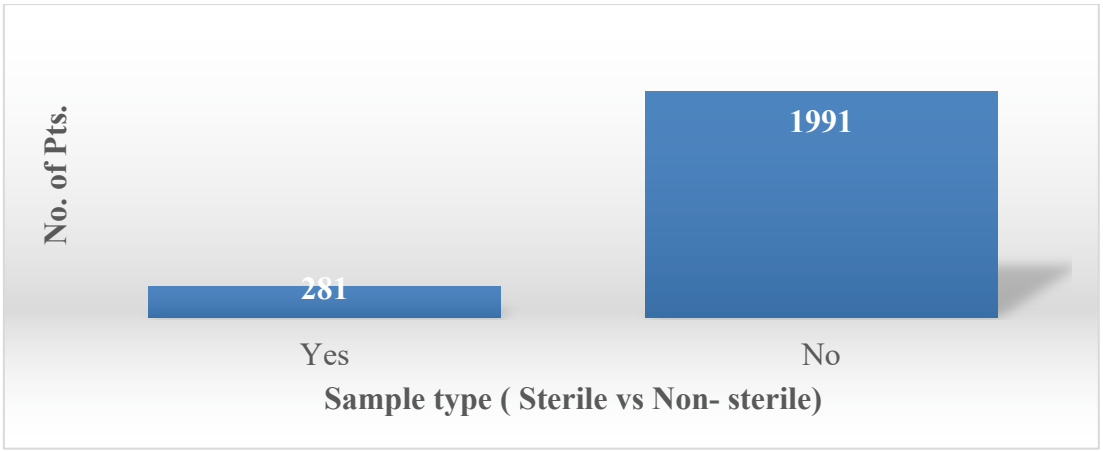

Figure 4: Distribution of Sample Types (Sterile vs Growth)

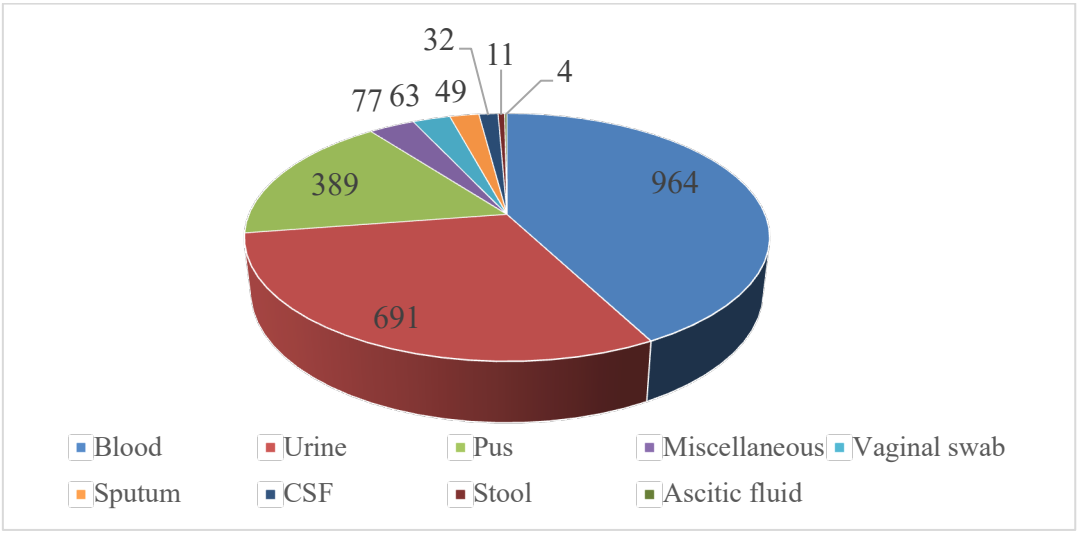

Figure 5: Type of sample- wise distribution

Microbiological Profile: Diagnosis-wise distribution showed that UTIs were commonly associated with Escherichia coli (105 cases), Staphylococcus aureus (95), Pseudomonas spp. (70), and Enterococcus spp. (35).(Fig-7)

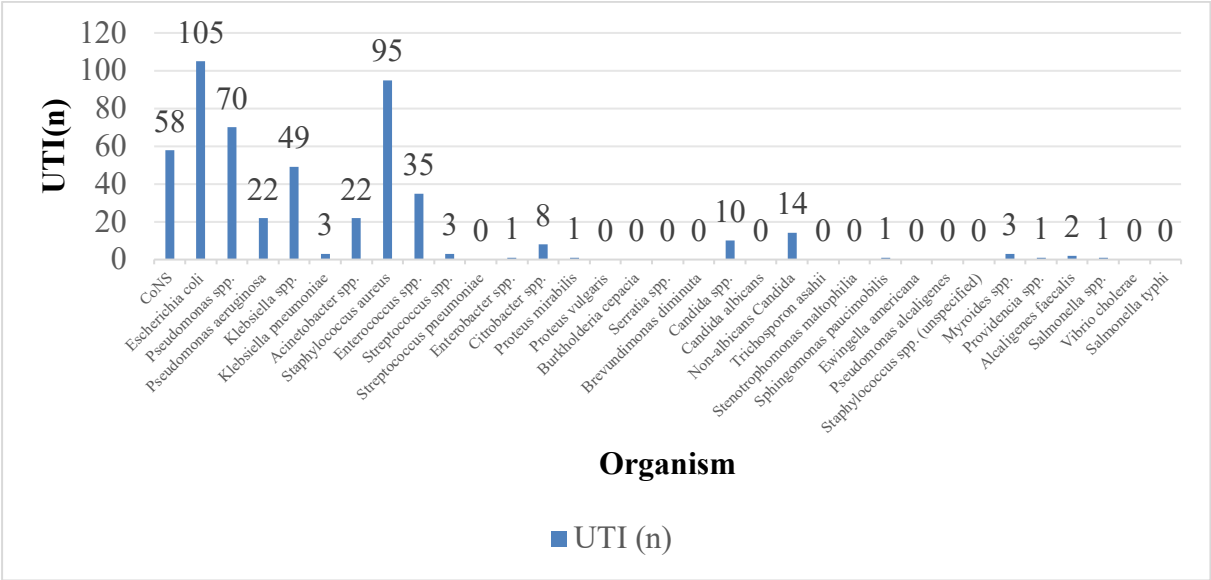

Figure 6: Organism distribution in UTI

Antibiotic Susceptibility Pattern in UTI (Table - 1): Carbapenems (imipenem/meropenem) demonstrated high sensitivity against Gram-negative uropathogens, including Klebsiella spp. (90%) and Escherichia coli (88%). Piperacillin–tazobactam and cefoperazone–sulbactam showed moderate to high sensitivity (78–85%), while amikacin exhibited good efficacy (75–80%). Cephalosporins such as cefepime showed moderate sensitivity (60–68%). High resistance was observed with fluoroquinolones (ciprofloxacin) and cotrimoxazole, particularly in E. coli and Pseudomonas spp. Among oral agents, nitrofurantoin (70–75%) and fosfomycin (75–80%) retained good activity, especially against E. coli. Among Gram-positive isolates, vancomycin, linezolid, and teicoplanin showed excellent sensitivity (>90%), while clindamycin and erythromycin showed moderate resistance. Colistin demonstrated high sensitivity (85–90%) among resistant Gram-negative organisms, including Acinetobacter spp.

Table 1: UTI Antibiotic Susceptibility Pattern

Antibiotic	Klebsiella spp. S/R (%)	E. coli S/R (%)	Pseudomonas spp. S/R (%)	Acinetobacter spp. S/R (%)	Staphylococcus aureus S/R (%)	CoNS S/R (%)	Enterococcus spp. S/R (%)	Streptococcus spp. S/R (%)	Proteus spp. S/R (%)	Salmonella spp. S/R (%)	Citrobacter spp. S/R (%)	Enterobacter spp. S/R (%)	Sphingomonas spp. S/R (%)	Myroides spp. S/R (%)
Imipenem /Meropenem	90/10	88/12	85/15	40/60	NA	NA	NA	NA	80/20	85/15	82/18	83/17	90/10	NA
Piperacillin–Tazobactam	82/18	85/15	83/17	35/65	NA	NA	NA	NA	78/22	80/20	78/22	80/20	85/15	NA
Cefoperazone–Sulbactam	80/20	82/18	78/22	45/55	NA	NA	NA	NA	75/25	78/22	76/24	77/23	82/18	NA
Amikacin	75/25	78/22	80/20	40/60	NA	NA	NA	NA	72/28	75/25	74/26	75/25	78/22	NA
Cefepime	60/40	65/35	68/32	30/70	NA	NA	NA	NA	62/38	65/35	64/36	65/35	68/32	NA
Ciprofloxacin	55/45	50/50	58/42	25/75	NA	NA	NA	NA	55/45	60/40	58/42	60/40	70/30	NA
Cotrimoxazole	40/60	35/65	20/80	20/80	NA	NA	NA	NA	45/55	50/50	48/52	45/55	55/45	NA
Nitrofurantoin	70/30	75/25	30/70	20/80	65/35	60/40	70/30	75/25	60/40	65/35	68/32	70/30	75/25	NA
Fosfomycin	75/25	80/20	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Colistin	88/12	90/10	85/15	75/25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vancomycin	NA	NA	NA	NA	92/8	90/10	94/6	NA	NA	NA	NA	NA	NA	NA
Linezolid	NA	NA	NA	NA	94/6	93/7	95/5	90/10	NA	NA	NA	NA	NA	NA
Teicoplanin	NA	NA	NA	NA	92/8	90/10	93/7	NA	NA	NA	NA	NA	NA	NA
Clindamycin	NA	NA	NA	NA	60/40	55/45	NA	NA	NA	NA	NA	NA	NA	NA
Erythromycin	NA	NA	NA	NA	50/50	48/52	NA	NA	NA	NA	NA	NA	NA	NA
Doxycycline	NA	NA	NA	NA	70/30	68/32	NA	80/20	NA	NA	NA	NA	NA	NA

S/R (%) = Percentage of Sensitive/Resistant isolates NA = Not applicable (antibiotic not tested or not routinely used for the organism)

Discussion

The present study provides a focused evaluation of the epidemiological profile, microbial spectrum, and antibiotic susceptibility patterns of uropathogens in a rural tertiary care setting. Older adults (>60 years) constituted the largest proportion of infective cases (37.8%), likely due to age-related immune decline and higher comorbidity burden, leading to increased severity and hospitalization. Younger adults (≤40 years) also contributed substantially (34.3%), possibly reflecting greater exposure and healthcare-seeking patterns. This bimodal distribution highlights the need for age-stratified surveillance and targeted antimicrobial strategies in tertiary care settings. [7]

Male patients constituted 52.7% of cases, showing a slight predominance over females (47.3%), consistent with previous studies reporting higher infection rates in males, particularly in bloodstream and respiratory infections.

This difference may be attributed to biological factors such as immunomodulatory effects of sex hormones—testosterone being relatively immunosuppressive and estrogen enhancing

immune responses—as well as behavioral factors like increased exposure to risk-prone environments. Similar findings have been reported by Falagas et al., [8] supporting male predominance in infectious diseases. However, in contrast, urinary tract infections are often more common in females in community settings, indicating that gender distribution is infection-specific and context-dependent. In the present study, most patients with infective illnesses were admitted under General Medicine (48.2%), followed by General Surgery (15.4%) and ICU settings (~16.2%), with smaller contributions from OBG, Orthopedics, and other departments. This pattern is consistent with previous hospital-based studies showing that infectious diseases are predominantly managed in medical wards due to their nonsurgical nature and need for antimicrobial therapy. The proportion of surgical cases reflects the burden of surgical site and postoperative infections, while ICU admissions, though fewer, are associated with severe and multidrug-resistant infections, as reported in earlier studies.

Overall, this distribution aligns with established evidence that tertiary care hospitals manage the bulk of infectious diseases in medical units, with critical care settings contributing disproportionately to severe infections. [9] In the present study, non-sterile samples predominated (87.6%), consistent with previous reports where urine, sputum, and pus are the most commonly processed specimens in hospital microbiology laboratories. While such samples pose challenges in interpretation due to commensal flora, sterile samples, though fewer, remain clinically significant for diagnosing invasive infections, highlighting the need for careful analysis and antimicrobial stewardship. [10]

In the present study, blood samples were the most common, followed by urine and pus, reflecting the high burden of systemic infections and UTIs in tertiary care settings, consistent with previous reports. Gram-negative organisms predominated, with Escherichia coli being the most frequent uropathogen and Pseudomonas spp. commonly isolated across multiple samples, aligning with earlier studies on hospital-acquired infections. The presence of MDR organisms such as Klebsiella and Acinetobacter highlights increasing antimicrobial resistance. Gram-positive organisms like Staphylococcus aureus and CoNS were also significant, particularly in bloodstream and wound infections. These findings are comparable with published literature and emphasize the need for continuous surveillance and institution-specific antibiograms. [4]

The present study demonstrates a distinct variation in microbial distribution across different clinical syndromes, highlighting the relationship between pathogen profile and site of infection.In urinary tract infections (UTI), E. coli was the predominant organism, followed by Staphylococcus aureus, Pseudomonas spp., Klebsiella spp., and Enterococcus spp.. This aligns with established evidence that E. coli is the leading cause of UTIs, owing to its virulence factors such as adhesins and biofilm formation. The presence of other organisms like Enterococcus and non-fermenting Gram-negative bacilli suggests complicated or hospital-acquired UTIs, especially in catheterized patients. [1]

The present study demonstrates that Gram-negative uropathogens, particularly Escherichia coli, Klebsiella spp., and Pseudomonas spp., showed high sensitivity to carbapenems (85–90%), reaffirming their role in managing complicated UTIs. However, reduced sensitivity in Acinetobacter spp. indicates emerging carbapenem resistance, consistent with global trends of MDR non-fermenters. [4] β-lactam/β-lactamase inhibitor combinations exhibited good sensitivity (78–85%), supporting their role as carbapenem-sparing options. [6] A declining trend was observed with cephalosporins and fluoroquinolones, likely due to widespread use and ESBL production, as reported in Indian studies (Taneja N, Sharma M. Antimicrobial resistance in uropathogens in India. Indian J Med Res. 2019;149(2):153–9.). High resistance to cotrimoxazole further limits its empirical utility. [5] Among oral agents, nitrofurantoin and fosfomycin retained good activity (70–80%), supporting their use in uncomplicated UTIs. [6] Colistin showed high sensitivity in resistant Gram-negative isolates but should be reserved due to toxicity concerns. [4] Gram-positive organisms demonstrated excellent sensitivity to vancomycin, linezolid, and teicoplanin (>90%). These findings highlight the growing challenge of antimicrobial resistance and the need for region-specific antibiograms and antimicrobial stewardship.

Conclusion

This prospective study highlights that uropathogens in a rural tertiary care center of Western Maharashtra are predominantly Gram-negative, with Escherichia coli as the leading isolate. High susceptibility to carbapenems and β-lactam/β-lactamase inhibitor combinations was observed, while increasing resistance to fluoroquinolones and cotrimoxazole is concerning. The preserved efficacy of nitrofurantoin and fosfomycin supports their role in uncomplicated UTIs. The emergence of multidrug-resistant organisms underscores the urgent need for continuous local antibiogram surveillance and strict antimicrobial stewardship to guide rational empirical therapy and improve clinical outcomes.

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