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Original Article

Bacterial Profile and Antibiotic Susceptibility Patterns of Uropathogens Among Patients with Urinary Tract Infection at a Tertiary Care Hospital: A Cross-Sectional Study.

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ABSTRACT

Objective: To determine the bacterial profile of urinary tract infections (UTIs) and evaluate the antimicrobial susceptibility and resistance patterns of uropathogens isolated from patients presenting to a tertiary care hospital.

Methodology: This hospital-based cross-sectional study was conducted in the Department of Pathology, Hayatabad Medical Complex, Peshawar, after obtaining ethical approval (IRB No. 1665), from December 5, 2023, to January 5, 2024. Patients with clinically diagnosed UTIs undergoing urine culture and sensitivity testing were included. A sample size of 150 patients was calculated using OpenEpi, assuming an 11% prevalence, 95% confidence level, and 5% margin of error. Consecutive sampling was employed, and demographic and clinical data were collected using a structured questionnaire. Data were analyzed using SPSS version 20.

Results: A total of 150 patients were enrolled, including 80 (53.3%) males and 70 (46.7%) females. Escherichia coli was the most frequently isolated uropathogen, accounting for 69 (46.0%) isolates, followed by Enterobacter 30 (20.0%), Providencia 19 (12.7%), Candida 17 (11.3%), Klebsiella 11 (7.3%), and Serratia 4 (2.7%). No significant gender-based difference in the distribution of uropathogens was observed (p = 0.339). E. coli demonstrated the highest sensitivity to clindamycin (82.6%), while nitrofurantoin showed the greatest activity against Candida (94.1%). Tigecycline exhibited high sensitivity against Enterobacter (83.3%) and Providencia (94.7%), whereas colistin showed 100% sensitivity against Klebsiella. The highest resistance among E. coli isolates was observed against imipenem (34.8%), while Candida demonstrated substantial resistance to colistin (64.7%).

Conclusion: Escherichia coli was the predominant uropathogen isolated from patients with UTIs. Several bacterial isolates demonstrated multidrug resistance to commonly prescribed antibiotics, highlighting the importance of regular surveillance of local antimicrobial susceptibility patterns to guide empirical therapy and optimize patient outcomes.

INTRODUCTION

Urinary tract infection (UTI) is one of the most common infectious diseases worldwide, affecting approximately 150 million individuals annually and posing a significant public health burden [1]. UTI occurs when pathogenic microorganisms, most commonly bacteria originating from the gastrointestinal tract, colonize and infect any part of the urinary system, including the kidneys, ureters, bladder, and urethra [2]. Females are generally more susceptible to UTIs because of their shorter urethra, which facilitates the ascent of microorganisms into the urinary tract [3]. Other predisposing factors include anatomical abnormalities, urinary obstruction, catheterization, diabetes mellitus, and impaired host defense mechanisms [4].A wide variety of microorganisms can cause UTIs; however, *Escherichia coli* and other members of the Enterobacteriaceae family account for approximately 75% of community-acquired infections. In hospitalized patients, resistant Gram-negative organisms such as *Pseudomonas* spp., *Enterobacter* spp., and *Enterococcus faecalis* are increasingly implicated [5]. The distribution of uropathogens varies according to age, gender, hospitalization status, catheterization, and geographical location.In developing countries such as Pakistan, the treatment of UTIs is frequently initiated empirically before culture and sensitivity results become available. Although this approach may provide rapid symptom relief, inappropriate antibiotic use contributes to the emergence and spread of antimicrobial resistance, resulting in treatment failure and increased healthcare costs [6]. Furthermore, resistance to one antimicrobial agent is often associated with resistance to multiple antibiotic classes, limiting therapeutic options and complicating clinical management [7].Considerable regional variation exists in the antimicrobial susceptibility patterns of uropathogens worldwide. Therefore, continuous surveillance of local bacterial profiles and antibiogram patterns is essential for guiding empirical therapy and developing effective antimicrobial stewardship strategies [8]. Knowledge of local resistance trends enables clinicians to select appropriate antibiotics and improve patient outcomes.The present study was conducted to determine the bacterial profile of urinary tract infections and evaluate the antimicrobial susceptibility and resistance patterns of uropathogens isolated from patients attending a tertiary care hospital in Peshawar, Pakistan.

Materials and Methods

Study Design and Setting

This hospital-based cross-sectional study was conducted in the Department of Pathology, Hayatabad Medical Complex, Peshawar, from December 5, 2023, to January 5, 2024, after obtaining ethical approval from the Institutional Review Board **(IRB/MTI/HMC/ERB/ 1665/04/08/23).**

Study Population and Sample Size

The study included patients aged 18 years and above of either gender with clinically diagnosed urinary tract infections who underwent urine culture and sensitivity testing. Clinical diagnosis was based on the presence of urinary symptoms, including dysuria, suprapubic pain, urinary frequency, urgency, and fever, Many reviewers will question clindamycin testing against Gram-negative uropathogens such as E. coli. If these are the actual laboratory findings, keep them. If not, verify the original sensitivity sheets before submission. This is the only remaining scientific issue likely to attract reviewer comments. The sample size of 150 patients was calculated using OpenEpi, assuming a uropathogen prevalence of 11%, a 95% confidence level, and a 5% margin of error. Consecutive sampling was employed. Demographic and clinical information was collected using a structured questionnaire and analyzed using SPSS version 20.

Specimen Collection and Processing

After obtaining informed consent, participants provided 5–10 mL of midstream clean-catch urine under sterile conditions. Samples were transported to the microbiology laboratory and processed within 2–3 hours of collection. When immediate processing was not possible, specimens were refrigerated until analysis.Urine samples were cultured according to standard microbiological procedures and incubated aerobically at 37°C for 24 hours. Colony counts were performed, and cultures demonstrating $\geq 10^5$ colony-forming units (CFU)/mL of a single organism were considered indicative of significant bacteriuria. Cultures showing no growth or mixed growth of more than two organisms were considered negative.Identification of isolates was based on colony morphology, Gram staining characteristics, and biochemical reaction profiles using standard microbiological methods.

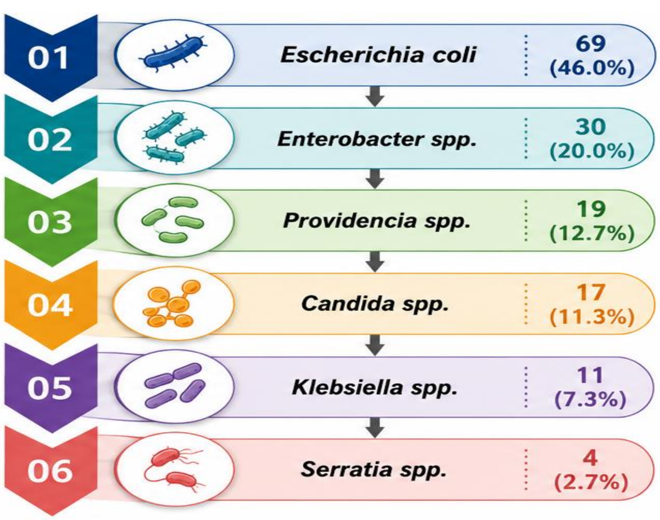
Antibiotic Susceptibility Testing

Antimicrobial susceptibility testing was performed using the Kirby–Bauer disk diffusion method in accordance with Clinical and Laboratory Standards Institute (CLSI) 2020 guidelines. Pure bacterial colonies were suspended in sterile saline (0.85% NaCl) and adjusted to a 0.5 McFarland turbidity standard. The bacterial suspension was inoculated onto Mueller–Hinton agar plates, and antibiotic discs were applied after allowing the surface to dry.The antibiotics tested included gentamicin, tetracycline, colistin, nitrofurantoin, imipenem, meropenem, ciprofloxacin, clindamycin, trimethoprim-sulfamethoxazole, chloramphenicol, nalidixic acid, ceftazidime, norfloxacin, amoxicillin-clavulanic acid, erythromycin, and cefotaxime. Following incubation, zones of inhibition were measured in millimeters and interpreted as sensitive, intermediate, or resistant according to CLSI 2020 criteria. All antibiotic discs were obtained from Oxoid Ltd.

Results

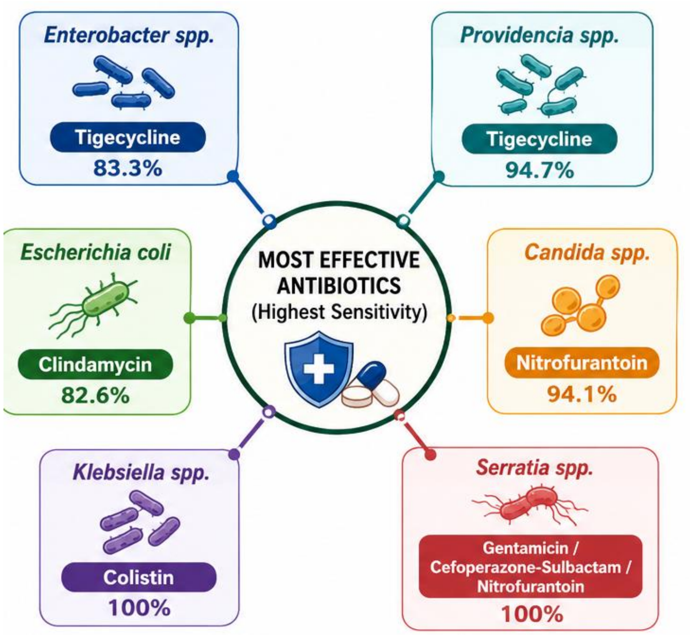
A total of 150 patients were included in the study, comprising 80 (53.3%) males and 70 (46.7%) females. Culture positivity was observed in 103 patients, while 47 patients showed no significant bacterial growth (Table 1).Among the isolated uropathogens, *Escherichia coli* was the most frequently identified organism, accounting for 69 (46.0%) isolates. Other pathogens included *Enterobacter* 30 (20.0%), *Providencia* 19 (12.7%), *Candida* 17 (11.3%), *Klebsiella* 11 (7.3%), and *Serratia* 4 (2.7%) (Table 2). The overall distribution of isolated uropathogens is illustrated in Figure 1.No statistically significant association was observed between gender and the distribution of uropathogens (p=0.339). The gender-wise distribution of isolated microorganisms is presented in Table 3.Antimicrobial susceptibility testing revealed that *E. coli* exhibited the highest sensitivity to clindamycin (82.6%), while nitrofurantoin showed the greatest activity against *Candida* (94.1%). Tigecycline demonstrated high sensitivity against *Enterobacter* (83.3%) and *Providencia* (94.7%), whereas colistin exhibited 100% sensitivity against *Klebsiella* isolates. Gentamicin, cefoperazone-sulbactam, and nitrofurantoin showed complete sensitivity against *Serratia* isolates. The antibiotics demonstrating the highest sensitivity against the major uropathogens are summarized in Figure 2 and detailed in Table 4.Regarding antimicrobial resistance, *E. coli* showed the highest resistance to ceftazidime (37.7%). *Candida* demonstrated substantial resistance to colistin (64.7%), whereas *Enterobacter* exhibited marked resistance to ceftazidime (46.7%). *Providencia* showed the highest resistance to meropenem (63.2%). Detailed resistance patterns of all isolated uropathogens are presented in Table 5.

Figure 1: Distribution of Uropathogens Isolated from Urine Culture Samples



This figure shows the frequency distribution of microorganisms isolated from urine cultures among patients with urinary tract infections. Escherichia coli was the predominant uropathogen, accounting for 46.0% of all isolates, followed by Enterobacter spp. (20.0%), Providencia spp. (12.7%), Candida spp. (11.3%), Klebsiella spp. (7.3%), and Serratia spp. (2.7%).

Figure 2: Most Effective Antibiotics Against Major Uropathogens



This figure summarizes the antimicrobial agents exhibiting the highest in vitro sensitivity against the isolated uropathogens. Clindamycin demonstrated the greatest activity against Escherichia coli (82.6%), nitrofurantoin against Candida spp. (94.1%), tigecycline against Enterobacter spp. (83.3%) and Providencia spp. (94.7%), and colistin against Klebsiella spp. (100%). Serratia isolates demonstrated complete sensitivity to gentamicin, cefoperazone-sulbactam, and nitrofurantoin.

Table 1. Distribution of Urine Culture Results by Gender (n=150)

Gender	Positive Culture n (%)	Negative Culture n (%)	Total n (%)
Male	53 (66.3)	27 (33.7)	80 (53.3)
Female	50 (71.4)	20 (28.6)	70 (46.7)
Total	103 (68.7)	47 (31.3)	150 (100)

Distribution of urine culture results among study participants according to gender. Positive culture indicates significant bacteriuria (≥10^5 CFU/mL), while negative culture indicates no significant bacterial growth.

Table 2. Distribution of Uropathogens Isolated from Urine Cultures (n=150)

Uropathogen	Frequency (n)	Percentage (%)
Escherichia coli	69	46.0
Enterobacter spp.	30	20.0
Providencia spp.	19	12.7
Candida spp.	17	11.3
Klebsiella spp.	11	7.3
Serratia spp.	4	2.7
Total	150	100.0

Frequency distribution of microorganisms isolated from urine cultures. Escherichia coli was the predominant uropathogen, accounting for nearly half of all isolates.

Table 3. Gender-wise Distribution of Isolated Uropathogens

Uropathogen	Male n (%)	Female n (%)	Total n (%)
Escherichia coli	34 (42.5)	35 (50.0)	69 (46.0)
Candida spp.	13 (16.3)	4 (5.7)	17 (11.3)
Enterobacter spp.	14 (17.5)	16 (22.9)	30 (20.0)
Providencia spp.	12 (15.0)	7 (10.0)	19 (12.7)
Klebsiella spp.	5 (6.2)	6 (8.6)	11 (7.3)
Serratia spp.	2 (2.5)	2 (2.8)	4 (2.7)
Total	80 (100)	70 (100)	150 (100)

P-value = 0.339

Gender-wise distribution of isolated uropathogens. No statistically significant association was observed between gender and the distribution of microorganisms (Chi-square test, p=0.339).

Table 4. Antibiotics Demonstrating the Highest Sensitivity Against Isolated Uropathogens

Uropathogen	Most Sensitive Antibiotic	Sensitivity (%)
Escherichia coli	Clindamycin	82.6
Candida spp.	Nitrofurantoin	94.1
Enterobacter spp.	Tigecycline	83.3
Providencia spp.	Tigecycline	94.7
Klebsiella spp.	Colistin	100.0
Serratia spp.	Gentamicin	100.0
Serratia spp.	Cefoperazone-Sulbactam	100.0
Serratia spp.	Nitrofurantoin	100.0

Antibiotics exhibiting the highest in vitro sensitivity against each isolated uropathogen. Sensitivity was determined using the Kirby–Bauer disk diffusion method according to CLSI 2020 guidelines.

Table 5. Antibiotics Demonstrating the Highest Resistance Against Isolated Uropathogens

Uropathogen	Most Resistant Antibiotic	Resistance (%)
Escherichia coli	Imipenem	37.7%
Candida spp.	Colistin	64.7
Enterobacter spp.	Ceftazidime	46.7
Providencia spp.	Meropenem	63.2
Klebsiella spp.	Imipenem	54.5
Serratia spp.	Tetracycline	100.0

Antibiotics demonstrating the highest resistance rates among isolated uropathogens. The findings highlight the growing challenge of antimicrobial resistance and underscore the importance of culture-guided therapy for urinary tract infections.

Discussion

Urinary tract infections (UTIs) remain among the most common bacterial infections worldwide and continue to represent a significant public health concern because of their high prevalence, recurrence, and increasing antimicrobial resistance. Knowledge of local uropathogen distribution and antimicrobial susceptibility patterns is essential for guiding empirical therapy and improving treatment outcomes [9,13]. In the present study, *Escherichia coli* was the predominant uropathogen, accounting for 46.0% of all isolates. This finding is consistent with previous studies that identified *E. coli* as the leading cause of urinary tract infections because of its ability to colonize the urinary tract and express multiple virulence factors [9,13,15]. Similar findings have been reported in studies from South Asia and other regions, where *E. coli* remains the most frequently isolated urinary pathogen [9,13].The second most common isolates in our study were *Enterobacter* spp. (20.0%) and *Providencia* spp. (12.7%), followed by *Candida* spp. (11.3%), *Klebsiella* spp. (7.3%), and *Serratia* spp. (2.7%). This distribution differs slightly from previous reports where *Klebsiella* spp. was commonly identified as the second most prevalent pathogen after *E. coli* [15,16]. Such variations may be attributed to differences in geographical location, patient demographics, healthcare settings, and antibiotic prescribing practices.No statistically significant association was observed between gender and the distribution of uropathogens (p=0.339). Although urinary tract infections are generally more common among females because of anatomical predisposition, the similar distribution observed in the present study may reflect the characteristics of the hospital-based study population and the inclusion of patients undergoing culture and sensitivity testing.Antimicrobial susceptibility testing demonstrated variable activity among the tested antibiotics. Several antibiotics showed good in vitro activity against the isolated organisms, whereas resistance was observed against commonly prescribed antimicrobial agents. These findings emphasize the importance of performing culture and sensitivity testing whenever possible and highlight the limitations of empirical treatment in areas with increasing antimicrobial resistance [7,13]. The resistance patterns observed in this study are clinically important. *E. coli*, *Enterobacter*, *Providencia*, and other isolates demonstrated resistance to multiple antimicrobial agents. Similar trends have been reported globally, where increasing multidrug resistance among uropathogens has complicated the management of urinary tract infections and reduced the effectiveness of previously reliable empirical therapies [7,9,18,19]. The emergence of multidrug-resistant organisms represents a growing challenge for healthcare systems. Inappropriate or excessive antibiotic use contributes significantly to resistance development, resulting in prolonged illness, increased healthcare costs, and higher risks of treatment failure. Regular surveillance of local antibiogram patterns and implementation of antimicrobial stewardship programs are therefore essential to optimize antibiotic utilization and improve patient outcomes.

Strengths

The strengths of this study include culture-confirmed diagnosis of urinary tract infections, standardized microbiological identification procedures, and comprehensive antimicrobial susceptibility testing. The findings provide valuable local epidemiological and antibiogram data that may assist clinicians in selecting appropriate empirical therapy.

Limitations

This study has several limitations. First, it was conducted over a relatively short period of one month, limiting the assessment of seasonal variations in pathogen prevalence and antimicrobial resistance patterns. Second, the study was conducted at a single tertiary care center, which may limit the generalizability of the findings to other healthcare settings. Future multicenter studies with larger sample sizes and longer study durations are recommended.

Conclusion

Escherichia coli was the most frequently isolated uropathogen among patients with urinary tract infections. Considerable variability in antimicrobial susceptibility and resistance patterns was observed among the isolated microorganisms, with evidence of multidrug resistance against several commonly used antibiotics. Regular surveillance of local bacterial profiles and antimicrobial susceptibility patterns is essential for guiding empirical therapy and supporting antimicrobial stewardship efforts.

Ethical Approval

Ethical approval for this study was obtained from the Institutional Review Board of Hayatabad Medical Complex, Peshawar (IRB No. 1665). The study was conducted in accordance with the principles of the Declaration of **Helsinki 2013.**

Informed Consent

Written informed consent was obtained from all participants before enrollment in the study.

Data Availability Statement

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

(AI) Disclosure Statement

During the preparation of this manuscript, artificial intelligence (AI)-assisted tools were used solely to improve language, grammar, readability, and manuscript organization. The authors critically reviewed, edited, and verified all AI-assisted content and take full responsibility for the accuracy, integrity, and originality of the manuscript. AI tools were not used for data collection, statistical analysis, interpretation of results, or generation of scientific conclusions.

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Final Approval of Manuscript: All authors

All authors contributed substantially to the conception, design, data acquisition, analysis, interpretation, manuscript preparation, and final approval of the manuscript in accordance with **the ICMJE authorship criteria.**

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