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Original Article

Incidence of Symptomatic Urinary Tract Infection and Antimicrobial Resistance Profiles of Isolated Uropathogens In Several Regions of Punjab, Pakistan

Ayesha Fazal[1], Hammad Qaiser[2], Tehrim Zafar[3], Ali Hasan[4], Zeeshan Asghar[3], Urooj Liaqat[3], Abrar Hussain[2]

1. Department of Biological Sciences, COMSATS university, Islamabad, Pakistan
2. Department of Biological Sciences, International Islamic University, Islamabad, Pakistan
3. Department of Urology University of Sialkot, Sialkot, Pakistan
4. Department of Microbiology, University of Faisalabad, Faisalabad, Pakistan

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Corresponding Author:
Abrar Hussain
Assistant Professor Department of Biological Sciences, International Islamic University, Islamabad, Pakistan
Email: abrar.phdbt100@iiu.edu.pk
ORCID ID: 0009-0006-9168-5210

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ABSTRACT

Background: Urinary tract infections (UTIs) are among the most common bacterial infections worldwide and represent a significant public health concern because of increasing antimicrobial resistance. Continuous surveillance of uropathogens and their susceptibility patterns is essential for guiding empirical therapy and improving clinical outcomes.

Objective: To determine the incidence of symptomatic urinary tract infections, identify the spectrum of causative uropathogens, and evaluate their antimicrobial resistance profiles in selected regions of Punjab, Pakistan.

Methodology: This multicenter cross-sectional observational study was conducted at Holy Family Hospital, Rawalpindi, and Col Sultan's Laboratory, Sialkot Cantt, Punjab, Pakistan, from June 2024 to October 2024. A total of 605 urine samples were collected from patients presenting with symptoms suggestive of UTI. Urine specimens were cultured using standard microbiological techniques, and bacterial isolates were identified through conventional laboratory methods. Antimicrobial susceptibility testing was performed according to Clinical and Laboratory Standards Institute (CLSI) guidelines.

Results: Of the 605 urine samples analyzed, 142 (23.5%) yielded positive cultures. A total of 154 microbial isolates were recovered, indicating polymicrobial growth in some specimens. Escherichia coli was the predominant uropathogen (42.9%), followed by Klebsiella pneumoniae (9.7%), Serratia spp. (7.8%), and Morganella morganii (6.5%). High resistance rates were observed against ampicillin, ceftriaxone, and fluoroquinolones. Conversely, nitrofurantoin and fosfomycin demonstrated excellent activity against most urinary isolates. Females were more frequently affected than males, and the majority of infections occurred among adults aged 21–50 years.

Conclusion: Escherichia coli remains the leading cause of symptomatic UTIs in Punjab, Pakistan. The increasing prevalence of antimicrobial resistance among uropathogens highlights the need for continuous regional surveillance, evidence-based empirical therapy, and strengthened antimicrobial stewardship programs.

INTRODUCTION

Urinary tract infections (UTIs) are among the most common bacterial infections worldwide and constitute a major cause of morbidity across all age groups. They affect the urinary system, including the kidneys, ureters, bladder, and urethra, and may present as either uncomplicated or complicated infections depending on the host factors and anatomical involvement. UTIs account for millions of healthcare visits annually and are associated with substantial healthcare costs, reduced quality of life, and increased antimicrobial consumption worldwide [1,2]. The majority of UTIs are caused by Gram-negative bacteria, particularly *Escherichia coli*, which is responsible for most community-acquired infections. Other important uropathogens include *Klebsiella pneumoniae*, *Proteus* spp., *Pseudomonas aeruginosa*, *Enterococcus* spp., and *Staphylococcus aureus* [3]. Women are disproportionately affected because of anatomical and physiological factors, including a shorter urethra and its proximity to the perianal region. Additional risk factors include advanced age, diabetes mellitus, pregnancy, urinary catheterization, urinary tract abnormalities, immunosuppression, and previous history of UTIs [4,5].The emergence and rapid spread of antimicrobial resistance among uropathogens have become a significant global public health challenge. Increasing resistance to commonly prescribed antibiotics, including fluoroquinolones, β-lactams, and third-generation cephalosporins, has limited therapeutic options and complicated the empirical management of UTIs [6]. In many low- and middle-income countries, including Pakistan, inappropriate antibiotic use, self-medication, limited antimicrobial stewardship programs, and inadequate surveillance systems have further accelerated the development of multidrug-resistant organisms [7].Pakistan continues to face a substantial burden of UTIs, with several regional studies reporting variations in the prevalence of uropathogens and their antimicrobial susceptibility patterns. These differences may reflect variations in healthcare access, prescribing practices, sanitation, socioeconomic conditions, and local microbial ecology [8,9]. Consequently, continuous regional surveillance of uropathogens and their resistance profiles is essential to guide evidence-based empirical therapy and support antimicrobial stewardship initiatives.Therefore, the present study was conducted to determine the incidence of symptomatic urinary tract infections, identify the distribution of causative uropathogens, and evaluate their antimicrobial resistance patterns among patients presenting to healthcare facilities in selected regions of Punjab, Pakistan.

MATERIALS AND METHODS

Study Design and Setting

This multicenter cross-sectional observational study was conducted at Holy Family Hospital, Rawalpindi, and Col Sultan's Laboratory, Sialkot Cantt, Punjab, Pakistan, between June 2024 and October 2024. The study was designed to determine the incidence of symptomatic urinary tract infections (UTIs), identify the distribution of causative uropathogens, and evaluate their antimicrobial susceptibility patterns among patients presenting with symptoms suggestive of UTI.

Study Population and Sample Collection

A total of 605 urine samples were collected from patients aged 1–90 years who presented with clinical features suggestive of UTI. Patients from both genders residing in Rawalpindi, Islamabad, and Sialkot were included in the study. Midstream clean-catch urine specimens were obtained whenever possible, while catheterized urine samples were collected from patients with indwelling urinary catheters according to standard clinical procedures.

Inclusion Criteria

- Patients of either gender aged ≥1 year.
- Patients presenting with symptoms suggestive of UTI, including dysuria, urinary frequency, urgency, suprapubic discomfort, flank pain, or fever.
- Patients providing urine samples for culture and sensitivity testing.

Exclusion Criteria

- Contaminated urine specimens.
- Samples showing mixed growth suggestive of contamination.
- Duplicate samples from the same patient during the study period.
- Patients with incomplete demographic or laboratory data.

Bacterial Culture and Identification

Urine specimens were cultured on Cystine Lactose Electrolyte Deficient (CLED) agar, MacConkey agar, and Blood agar plates and incubated aerobically at 35–37°C for 18–24 hours. Significant bacteriuria was defined as growth of $\geq 10^5$ colony-forming units (CFU)/mL of a single bacterial species. Isolates were identified based on colony morphology, Gram staining characteristics, and standard biochemical tests. Samples showing mixed growth or contamination were excluded from analysis.

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing was performed using the Kirby–Bauer disk diffusion method on Mueller–Hinton agar according to Clinical and Laboratory Standards Institute (CLSI) guidelines. A standardized inoculum equivalent to 0.5 McFarland turbidity standard was prepared for each isolate. The diameters of inhibition zones were measured and interpreted as Sensitive (S), Intermediate (I), or Resistant (R) according to CLSI criteria. Quality control was ensured using standard reference strains including Escherichia coli ATCC 25922, Pseudomonas aeruginosa ATCC 27853, Staphylococcus aureus ATCC 25923, and Enterococcus faecalis ATCC 29212.

Data Management and Statistical Analysis

Data were entered into a standardized database and analyzed using Statistical Package for the Social Sciences (SPSS) version 25.0 and R software version 4.3. Descriptive statistics were used to summarize demographic characteristics, culture positivity rates, bacterial distribution, and antimicrobial susceptibility patterns. Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were presented as frequencies and percentages. Comparisons between groups were performed using the Chi-square test, and a p-value <0.05 was considered statistically significant.

Ethical Considerations

Ethical approval was obtained from the Board of Advanced Studies and Research (BASR), International Islamic University Islamabad (IIUI), Pakistan (Approval No.IIU/1134/ERB/05/2023). Written informed consent was obtained from all participants or their legal guardians prior to sample collection. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki, and patient confidentiality was maintained throughout the study.

RESULTS

Culture Positivity and Demographic Characteristics

A total of 605 urine samples were processed during the study period, including 120 (19.8%) samples from Sialkot and 485 (80.2%) samples from Rawalpindi/Islamabad. Overall, 142 (23.5%) samples yielded significant microbial growth, whereas 463 (76.5%) showed no growth. Culture positivity was significantly higher in Sialkot, where 62 of 120 samples (51.7%) were positive, compared with 80 of 485 samples (16.5%) in Rawalpindi/Islamabad ($p < 0.001$). Detailed regional culture positivity data are presented in Table 1 and Figure 1. Regional Distribution of Culture-Positive Urinary Tract Infections Among Study Participants and Figure 2. Demographic Characteristics of Study Participants by Region.

Distribution of Uropathogens

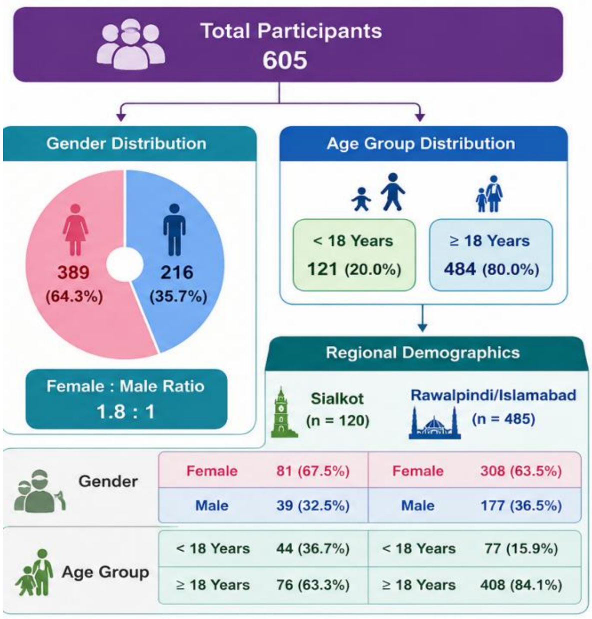
Among the 142 culture-positive urine samples, a total of 154 microbial isolates were recovered, indicating polymicrobial growth in a subset of specimens. Gram-negative organisms predominated and accounted for the majority of isolates.Escherichia coli was the most frequently isolated pathogen, accounting for 66 (42.9%) isolates, followed by Klebsiella pneumoniae 15 (9.7%), Serratia spp. 12 (7.8%), and Morganella morganii 10 (6.5%). Other isolated organisms included Enterococcus spp. 5 (3.2%), Candida albicans 5 (3.2%), Pseudomonas aeruginosa 4 (2.6%), Staphylococcus aureus 4 (2.6%), Klebsiella spp. 3 (1.9%), Enterobacter spp. 2 (1.3%), Citrobacter spp. 2 (1.3%), Pseudomonas spp. 2 (1.3%), Enterobacter cloacae 1 (0.6%), Enterobacter sakazakii 1 (0.6%), and other organisms 22 (14.3%). The overall distribution of uropathogens is presented in Table 3.Regional differences in pathogen distribution were observed. In Rawalpindi/Islamabad, Escherichia coli was the predominant isolate, whereas Sialkot demonstrated a relatively higher proportion of Klebsiella pneumoniae, Morganella morganii, and Streptococcus species.

Antimicrobial Susceptibility Patterns

Antimicrobial susceptibility testing revealed substantial variation among the isolated uropathogens. Escherichia coli demonstrated high susceptibility to amikacin (97.1%), gentamicin (93.8%), imipenem (93.3%), and fosfomycin (84.6%). Resistance was most frequently observed against ampicillin (85.7%), ceftriaxone (71.0%), ciprofloxacin (40.0%), and ofloxacin (59.4%). Nitrofurantoin retained good activity, with 79.4% of isolates remaining susceptible.Klebsiella pneumoniae showed high susceptibility to gentamicin (100%), fosfomycin (88.9%), and imipenem (80.0%), whereas resistance to ceftriaxone (62.5%) and fluoroquinolones (50.0%) was observed. Pseudomonas aeruginosa remained susceptible to imipenem and piperacillin-tazobactam but demonstrated reduced susceptibility to cephalosporins.Among Gram-positive isolates, Staphylococcus aureus and Enterococcus faecalis demonstrated complete susceptibility to vancomycin and linezolid (100%). Overall, aminoglycosides, carbapenems, fosfomycin, and nitrofurantoin exhibited the highest antimicrobial activity against the majority of urinary isolates.

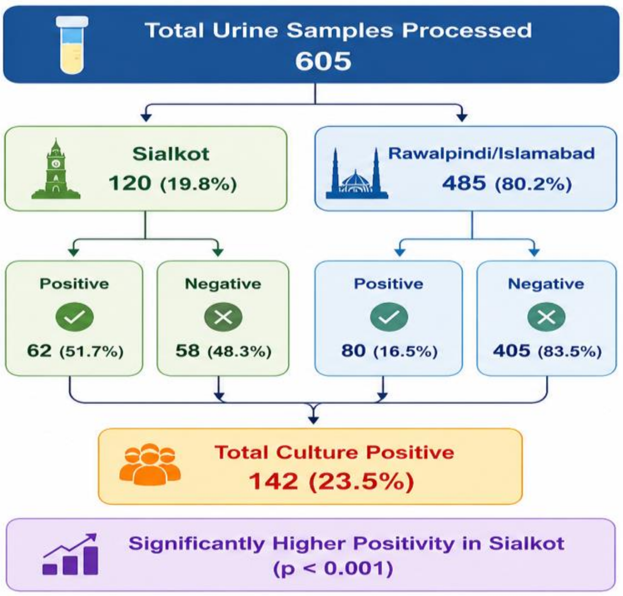
Figure 1. Demographic Characteristics of Study Participants by

Region.



Distribution of study participants according to gender and age group in Sialkot and Rawalpindi/Islamabad. Females constituted 64.3% (389/605) of the study population, while males accounted for 35.7% (216/605), yielding a female-to-male ratio of 1.8:1. Pediatric patients (<18 years) represented a greater proportion of participants in Sialkot (36.7%) than in Rawalpindi/Islamabad (15.9%), whereas adults (≥18 years) predominated in Rawalpindi/Islamabad (84.1%).

Figure 2. Regional Distribution of Culture-Positive Urinary Tract Infections Among Study Participants



A total of 605 urine samples were processed during the study period, including 120 samples from Sialkot and 485 samples from Rawalpindi/Islamabad. Culture positivity was significantly higher in Sialkot (51.7%; 62/120) compared with Rawalpindi/Islamabad (16.5%; 80/485), resulting in an overall positivity rate of 23.5% (142/605). The difference between the two regions was statistically significant ($p < 0.001$).

Table 1. Culture Positivity According to Study Region

Region	Total Samples, n (%)	Culture Positive, n (%)	Culture Negative, n (%)
Sialkot	120 (19.8)	62 (51.7)	58 (48.3)
Rawalpindi/Islamabad	485 (80.2)	80 (16.5)	405 (83.5)
Total	605 (100)	142 (23.5)	463 (76.5)

Distribution of urine samples and culture positivity rates among study participants from Sialkot and Rawalpindi/Islamabad. Culture positivity was significantly higher in Sialkot than in Rawalpindi/Islamabad ($p < 0.001$).

Table 2. Demographic Characteristics of Study Participants

Variable	Sialkot (n=120)	Rawalpindi/Islamabad (n=485)	Total (n=605)
Female, n (%)	81 (67.5)	308 (63.5)	389 (64.3)
Male, n (%)	39 (32.5)	177 (36.5)	216 (35.7)
<18 years, n (%)	44 (36.7)	77 (15.9)	121 (20.0)
≥18 years, n (%)	76 (63.3)	408 (84.1)	484 (80.0)

Demographic characteristics of participants according to study region. Females constituted the majority of the study population, and adults represented approximately four-fifths of all participants.

Table 3. Distribution of Uropathogens Isolated from Culture-Positive Urine Samples (n = 154)

Uropathogen	Number of Isolates (n)	Percentage (%)
Escherichia coli	66	42.9
Klebsiella pneumoniae	15	9.7

Serratia spp.	12	7.8
Morganella morganii	10	6.5
Enterococcus spp.	5	3.2
Candida albicans	5	3.2
Pseudomonas aeruginosa	4	2.6
Staphylococcus aureus	4	2.6
Klebsiella spp.	3	1.9
Enterobacter spp.	2	1.3
Citrobacter spp.	2	1.3
Pseudomonas spp.	2	1.3
Enterobacter cloacae	1	0.6
Enterobacter sakazakii	1	0.6
Other organisms	22	14.3
Total	**154**	**100.0**

Distribution of microorganisms isolated from culture-positive urine specimens collected from Sialkot and Rawalpindi/Islamabad. Gram-negative bacteria predominated, with Escherichia coli representing the most frequently isolated uropathogen.

DISCUSSION

Urinary tract infections (UTIs) remain one of the most common bacterial infections worldwide and continue to pose a significant public health challenge because of the increasing prevalence of antimicrobial resistance. The present study evaluated the incidence of symptomatic UTIs, distribution of uropathogens, and antimicrobial susceptibility patterns among patients from two regions of Punjab, Pakistan. Of the 605 urine samples analyzed, 142 (23.5%) yielded significant microbial growth. This culture positivity rate is comparable to findings reported in previous regional and international studies, which documented positivity rates ranging from 20% to 35% among symptomatic patients presenting to healthcare facilities [10,11]. The significantly higher culture positivity observed in Sialkot compared with Rawalpindi/Islamabad (51.7% vs. 16.5%; $p < 0.001$) may reflect differences in healthcare utilization patterns, antimicrobial exposure, referral practices, and local epidemiological factors. Similar geographic variations in UTI prevalence have been reported in previous studies, emphasizing the importance of regional surveillance programs for guiding empirical antimicrobial therapy [12,13].Similar geographic variations in UTI prevalence have been reported in other developing countries, emphasizing the importance of regional surveillance programs for guiding empirical antimicrobial therapy [14].The study demonstrated a clear female predominance, with females accounting for 64.3% of all participants. This finding is consistent with established epidemiological evidence indicating that women are more susceptible to UTIs because of anatomical and physiological factors, including a shorter urethra, hormonal influences, and proximity of the urethral opening to the gastrointestinal tract [15,16]. Furthermore, adults represented the majority of study participants, which is in agreement with previous reports showing increased healthcare utilization and higher exposure to risk factors among adult populations [17]. Escherichia coli was identified as the predominant uropathogen, accounting for 42.9% of all isolates. This observation is consistent with numerous studies demonstrating that E. coli remains the principal causative organism responsible for both community-acquired and healthcare-associated UTIs worldwide [18,19]. Other commonly isolated organisms included Klebsiella pneumoniae, Serratia spp., and Morganella morganii, reflecting the diverse spectrum of Gram-negative pathogens associated with urinary tract infections. The predominance of Gram-negative organisms observed in this study is similar to findings reported from neighboring countries and other low- and middle-income settings [18,20]. The antimicrobial susceptibility profile revealed substantial resistance to several commonly prescribed antibiotics. Escherichia coli exhibited high resistance to ampicillin, ceftriaxone, and fluoroquinolones, highlighting the growing challenge of antimicrobial resistance among urinary pathogens. Similar resistance trends have been reported globally and are largely attributed to inappropriate antibiotic use, self-medication practices, and widespread availability of antibiotics without prescription [20,21]. The high resistance rates observed against third-generation cephalosporins and fluoroquinolones raise concerns regarding their continued use as empirical therapy in uncomplicated UTIs.In contrast, amikacin, gentamicin, imipenem, fosfomycin, and nitrofurantoin retained excellent activity against the majority of isolates. These findings are consistent with recent studies demonstrating sustained susceptibility of urinary pathogens to aminoglycosides, carbapenems, fosfomycin, and nitrofurantoin despite increasing resistance to other antibiotic classes [22]. The preservation of activity against these agents supports their role in the management of uncomplicated and complicated UTIs, particularly in regions with a high prevalence of multidrug-resistant organisms.Among Gram-positive isolates, Staphylococcus aureus and Enterococcus faecalis remained uniformly susceptible to vancomycin and linezolid. Similar susceptibility patterns have been reported in contemporary surveillance studies and support the continued effectiveness of these agents for the treatment of resistant

Gram-positive urinary pathogens [23]. Nevertheless, careful antimicrobial stewardship remains essential to preserve their clinical utility.The findings of this study have important implications for clinical practice and public health policy. The observed regional differences in pathogen distribution and resistance profiles underscore the need for continuous local surveillance to guide evidence-based empirical treatment. Strengthening antimicrobial stewardship programs, promoting rational antibiotic prescribing, and enhancing public awareness regarding the appropriate use of antibiotics are critical measures for limiting the spread of antimicrobial resistance.

Limitations

This study has several limitations. First, the investigation was conducted at only two healthcare centers in Punjab, which may limit the generalizability of the findings to other regions of Pakistan. Second, molecular characterization of resistance mechanisms was not performed. Third, clinical outcomes and treatment responses were not evaluated. Despite these limitations, the study provides valuable contemporary data regarding uropathogen distribution and antimicrobial resistance patterns in Pakistan.

CONCLUSION

Urinary tract infections remain a significant healthcare concern in Pakistan, with substantial regional variation in culture positivity rates and antimicrobial resistance patterns. In the present study, Escherichia coli was identified as the predominant uropathogen, followed by Klebsiella pneumoniae, Serratia spp., and Morganella morganii. High levels of resistance were observed against commonly prescribed antibiotics, particularly ampicillin, ceftriaxone, and fluoroquinolones, whereas aminoglycosides, carbapenems, fosfomycin, and nitrofurantoin retained excellent antimicrobial activity. These findings highlight the growing challenge of antimicrobial resistance and emphasize the importance of continuous surveillance of local resistance trends. Regular monitoring of uropathogen distribution, implementation of antimicrobial stewardship programs, and evidence-based empirical antibiotic selection are essential to optimize patient outcomes and reduce the emergence of multidrug-resistant organisms. Further multicenter studies incorporating molecular resistance profiling are warranted to strengthen national surveillance efforts and guide future treatment strategies.

Author Contributions

Ayesha Fazal: Conceptualization, study design, data collection, data interpretation, manuscript drafting, and final approval of the manuscript.

Hammad Qaiser.Laboratory processing, microbiological analysis, data collection, and manuscript review.

Tehrim Zafar.Data collection, literature review, manuscript preparation, and data interpretation.

Ali Hasan: Statistical analysis, data management, interpretation of results, and critical revision of the manuscript.

Zeeshan Asghar:Laboratory investigations, antimicrobial susceptibility testing, data validation, and manuscript editing.

Urooj Liaqat: Literature review, data collection, manuscript drafting, and proofreading.

Abrar Hussain: Supervision, study coordination, critical revision of the manuscript, and final approval of the submitted version.

All authors contributed substantially to the study, reviewed the final manuscript, approved the submitted version, and agree to be accountable for all aspects of the work.

Conflict of Interest

The authors declare no conflict of interest.

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This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data Availability Statement

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

AI Disclosure Statement

The authors declare that artificial intelligence (AI)-assisted tools were used solely for language editing and manuscript refinement. All scientific content, data interpretation, analysis, and final manuscript approval were performed by the authors, who take full responsibility for the accuracy and integrity of the work.

Informed Consent

Written informed consent was obtained from all participants or their legal guardians prior to enrollment in the study.

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