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A Comprehensive Review

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

ABSTRACT

Urinary tract infections (UTIs) are among the most common bacterial infections worldwide and are increasingly complicated by antimicrobial resistance (AMR). Limited region-specific data in Pakistan hinder effective empiric therapy. To determine the prevalence, uropathogen distribution, and antimicrobial susceptibility patterns of bacterial isolates from urine cultures in the Sialkot and Rawalpindi/Islamabad regions of Pakistan. A cross-sectional analysis of 605 urine specimens was performed: 120 from Sialkot and 485 from Rawalpindi/Islamabad. Culture and susceptibility data were extracted from laboratory records, standardized, and harmonized. Organism identification followed routine microbiological protocols. Antimicrobial susceptibility testing was performed according to CLSI guidelines and recorded as susceptible, intermediate, or resistant. Overall, 142/605 (23.5%) cultures were positive, with significantly higher positivity in Sialkot (51.7%) than Rawalpindi/Islamabad (16.5%, $p<0.001$). Gram-negative bacteria predominated (81.2%), with Escherichia coli as the most frequent isolate (42.9%), followed by Klebsiella pneumoniae and Serratia spp. E. coli exhibited high resistance to Ampicillin, Ceftriaxone, and Fluoroquinolones, while retaining high susceptibility to Nitrofurantoin, Fosfomycin, Aminoglycosides, and Carbapenems. Gram-positive isolates remained universally susceptible to Vancomycin and Linezolid. E. coli is the dominant Gram-negative uropathogen in both regions, with alarming resistance to commonly prescribed antibiotics. Empiric therapy should prioritize nitrofurantoin and Fosfomycin for uncomplicated UTIs, while stewardship-guided use of aminoglycosides or carbapenems is recommended for complicated cases.

Keywords: Antimicrobial susceptibility, Antibiotic resistant, Urinary Tract Infections

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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: https://orcid.org/0000-0003-2948-921X

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INTRODUCTION

Urinary tract infections (UTIs) are a common health problem affecting the urinary system, including the kidneys, ureters, bladder, and urethra. These infections are primarily caused by bacteria, with E. coli being the main culprit. UTIs can be categorized into lower (affecting the bladder) and upper (affecting the kidneys) infections depending on the location [1]. Typically, UTIs start with bacteria entering the urethra and traveling up to the bladder. In severe cases, they can reach the kidneys. Certain factors, like anatomical differences, weakened immune systems, urinary catheters, and sexual activity, can increase the risk of UTIs. Women are especially susceptible due to their shorter urethras [2]. Symptoms of UTIs include burning urination, frequent urination with a strong urge, and lower abdominal pain. Upper UTIs may also cause fever, chills, and back pain. Diagnosis usually involves urine tests to detect white blood cells (pyuria) and bacteria (bacteriuria), followed by urine cultures to identify the specific bacteria and determine which antibiotics will work [3]. UTIs are a significant global health issue, leading to numerous doctor visits and antibiotic prescriptions. Estimates suggest around 150 million people experience UTIs worldwide each year, with women disproportionately affected. Up to 60% of women may have a UTI at least once in their lifetime, and some experience recurrent infections [4]. The burden of UTIs varies depending on factors like access to healthcare, sanitation, and demographics. Developed countries have well-documented UTI prevalence, with a higher rate in healthcare settings due to catheter use. Developing countries often face challenges in data collection, but UTIs are likely just as common due to limited access to clean water and proper sanitation, which increases exposure to bacteria [5].In Pakistan Urinary Tract Infections (UTIs) are an alarming condition which is specific to women and mainly causes an issue for the women, the children and the elderly. Both community acquired and hospital acquired infects hold high prevalence rates. The distinct prevalence of this condition is hard to spot because of underreporting, and no national statistics. However, the studies give some insight into regions [6]. Moreover, an increase in the number of multidrug-resistant bacteria in Pakistan is an emerging problem, thus complicating treatment. UTIs are very common in Pakistan due to a number of reasons. These are poor healthcare facilities, poor sanitation and hygiene, lack of general awareness, and access to medical services. This is also aggravated by the extensive prescription free use of antibiotics, which further leads to the development of antibiotic resistance in bacteria [7].This study focuses on the identification of common bacteria causing UTI in urine samples collected from patients and to find their susceptibility to various antibiotics.

METHODOLOGY

Sample collection

This is a cross-sectional hospital-based study carried out from June 2024 to October 2024 in Holy Family Hospital, Rawalpindi and Col sultan's lab, Sialkot Cantt. All patients with symptomatic UTI, ranging from age of 1 year to 90 years of both genders belonging from Rawalpindi, Islamabad and Sialkot, regions of Punjab. A total of 576 samples were collected who attended Holy Family Hospital, Rawalpindi and Col sultan's lab, Sialkot Cantt with symptoms of UTI or for testing of UTI.

Bacterial Culture and identification

A total of 605 urine samples were collected. Samples consisted of mid-stream clean-catch urine, catheterized urine, or other clinically indicated specimens. Urine samples were inoculated on Cystine–Lactose–Electrolyte-Deficient (CLED) agar, MacConkey agar, and blood agar plates, and incubated aerobically at 35–37 °C for 18–24 h. Growth of $\geq 10^5$ colony-forming units (CFU)/mL of a single organism was considered significant. Mixed growth or growth of contaminants was excluded from further analysis. The identification of isolates were performed on the base of gram reaction, colonial morphology and biochemical characterization [8].

Antibiotic susceptibility test

Antimicrobial susceptibility testing (AST) was conducted by means of Kirkby-Bauer disk diffusion technique on Mueller-Hinton agar based on Clinical and Laboratory Standards Institute (CLSI) guidelines [9]. One normal inoculum (0.5 McFarland) was swabbed onto the growth medium. The critical values of inhibition were taken and categorized under CLSI interpretive value as Sensitive (S) or Resistant (R). AST accuracy was checked with quality control strains (*E. coli* ATCC 25922, *P. aeruginosa* ATCC 27853, *S. aureus* ATCC 25923 and *E. faecilis* ATCC 29212).

Statistical analysis

All patient and isolate information was compiled into a standardized database. Records labeled as “no growth,” “mixed growth,” or “contaminated” were excluded from analysis. Organism names were standardized (e.g., “*E. coli*” → *Escherichia coli*) and antibiotics were harmonized to generic names (e.g., Augmentin → amoxicillin–clavulanate).The prevalence of culture-positive UTIs was calculated overall, and stratified by sex, age group, and region. The distribution of Gram-negative and Gram-positive uropathogens was determined. Antibiograms were generated as proportions of S/R for each organism–antibiotic combination. Data were analyzed in SPSS v25 and R v4.3. Results are presented as counts, percentages, and susceptibility rates.

RESULTS

Ethical approval

The study’s ethical approval was taken by the Board of Advance Studies and Research (BASR) of the International Islamic University, Islamabad (IIUI).

Culture positivity

During the study period, a total of 605 urine samples were processed, comprising 120 (19.8%) from Sialkot and 485 (80.2%) from Rawalpindi/Islamabad. Out of these, 142 samples (23.5%) yielded significant bacterial growth, while the remaining 463 (76.5%) showed no growth. Marked regional variation was observed: in Sialkot, 62 of 120 samples (51.7%) were culture positive, compared with only 80 of 485 (16.5%) in Rawalpindi/Islamabad. Thus, although Sialkot contributed fewer total samples, it accounted for nearly half (43.7%) of all positive isolates. The difference in positivity rates between the two regions was statistically significant ($p < 0.001$), with patients in Sialkot being approximately three times more likely to yield a positive culture than those in Rawalpindi/Islamabad (shown in figure 1).

Demographic characteristics

Of the total specimens analyzed, 389 (64.3%) were obtained from females and 216 (35.7%) from males, giving an overall female-to-male ratio of approximately 1.8:1. In Sialkot, females contributed 81/120 (67.5%) of the samples, whereas in Rawalpindi/Islamabad they contributed 308/485 (63.5%). Pediatric patients (<18 years) constituted a larger share of the Sialkot cohort (44/120; 36.7%) than of the Rawalpindi/Islamabad cohort (77/485; 15.9%), whereas adults (≥18 years) dominated in Rawalpindi/Islamabad (408/485; 84.1%) (shown in figure 2).

Distribution of uropathogens

Across both regions, Gram-negative organisms predominated, accounting for more than four-fifths of all isolates. *Escherichia coli* was the most frequently isolated uropathogen (66/154; 42.9%), followed by *Klebsiella pneumoniae* (14/154; 9.1%), *Serratia spp.* (12/154; 7.8%), and *Morganella morganii* (10/154; 6.5%). Less common Gram-negative isolates included *Pseudomonas aeruginosa* (2.6%), *Citrobacter spp.* (1.3%), and *Enterobacter spp.* (1.3%). Among Gram-positive organisms, *Staphylococcus aureus* (2.6%) and *Enterococcus spp.* (3.2%) were identified, together representing 14.3% of all isolates. Fungal pathogens were rare, with *Candida albicans* accounting for 3.2% of positive cultures (shown in table 1 and figure 3-4).Regional differences were also evident. In Rawalpindi/Islamabad, *E. coli* was predominant (51.3% of isolates), followed by *Serratia spp.* (15.4%), whereas in Sialkot *E. coli* accounted for a smaller proportion (34.2%) and was followed by *K. pneumoniae* (13.2%), *M. morganii* (13.2%), and *Streptococcus spp.* (11.8%) (shown in figure 5). These differences suggest potential regional variation in pathogen ecology and clinical case-mix.

Antimicrobial susceptibility patterns

Detailed analysis of antimicrobial resistance revealed high rates of resistance among Gram-negative uropathogens to several first-line antibiotics.*Escherichia coli* exhibited high susceptibility to Amikacin (97.1%), Gentamicin (93.8%), Imipenem (93.3%), and Fosfomycin (84.6%), while demonstrating marked resistance to Ampicillin (85.7%), Ceftriaxone (71.0%), and Fluoroquinolones (ciprofloxacin 40% resistant; ofloxacin 59.4% resistant). Nitrofurantoin retained moderate efficacy (79.4% susceptible). *Klebsiella pneumoniae* showed good sensitivity to gentamicin (100%), fosfomycin (88.9%), and imipenem (80%), but resistance to ceftriaxone (62.5%) and fluoroquinolones (50%). *Pseudomonas aeruginosa*, though less frequent, showed variable sensitivity; imipenem and piperacillin-tazobactam retained activity, while resistance to cephalosporins was notable. Among Gram-positives, *Staphylococcus aureus* and *Enterococcus spp.* were uniformly sensitive to vancomycin and linezolid (100%), while displaying resistance to penicillin and ampicillin (shown in table 2).

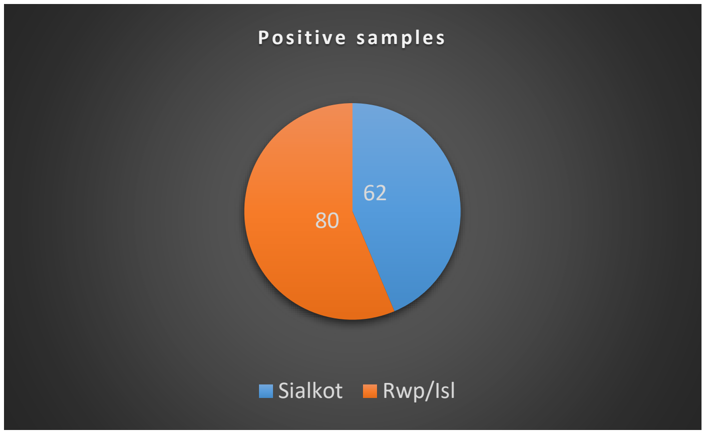

Figure 1. *Graph showing positive samples from two different regions*

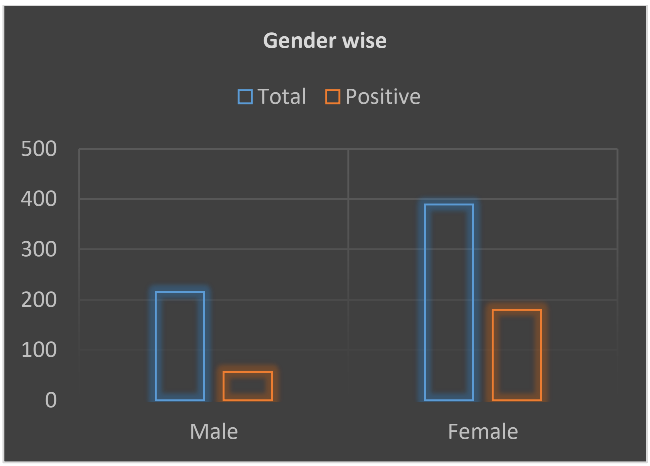

Figure 2. *Graph showing gender wise positive samples from Sialkot and Rawalpindi/Islamabad*

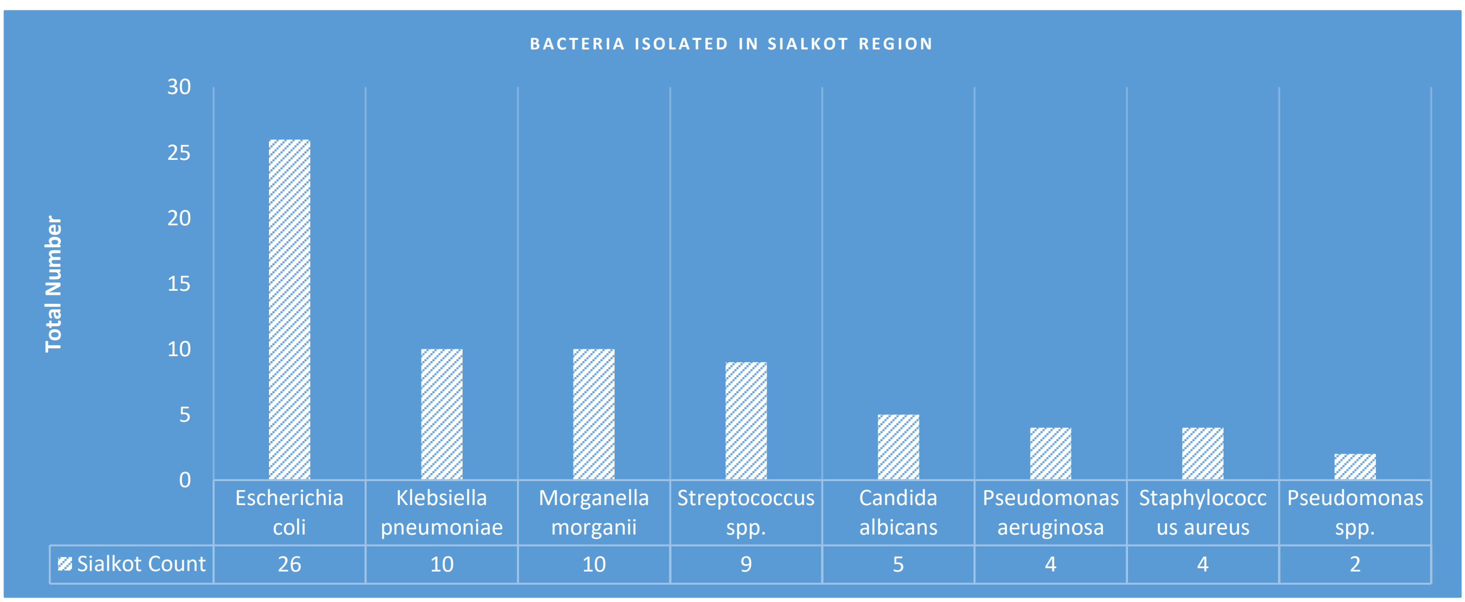

Figure 3. *Graph showing total bacterial isolates from Sialkot region*

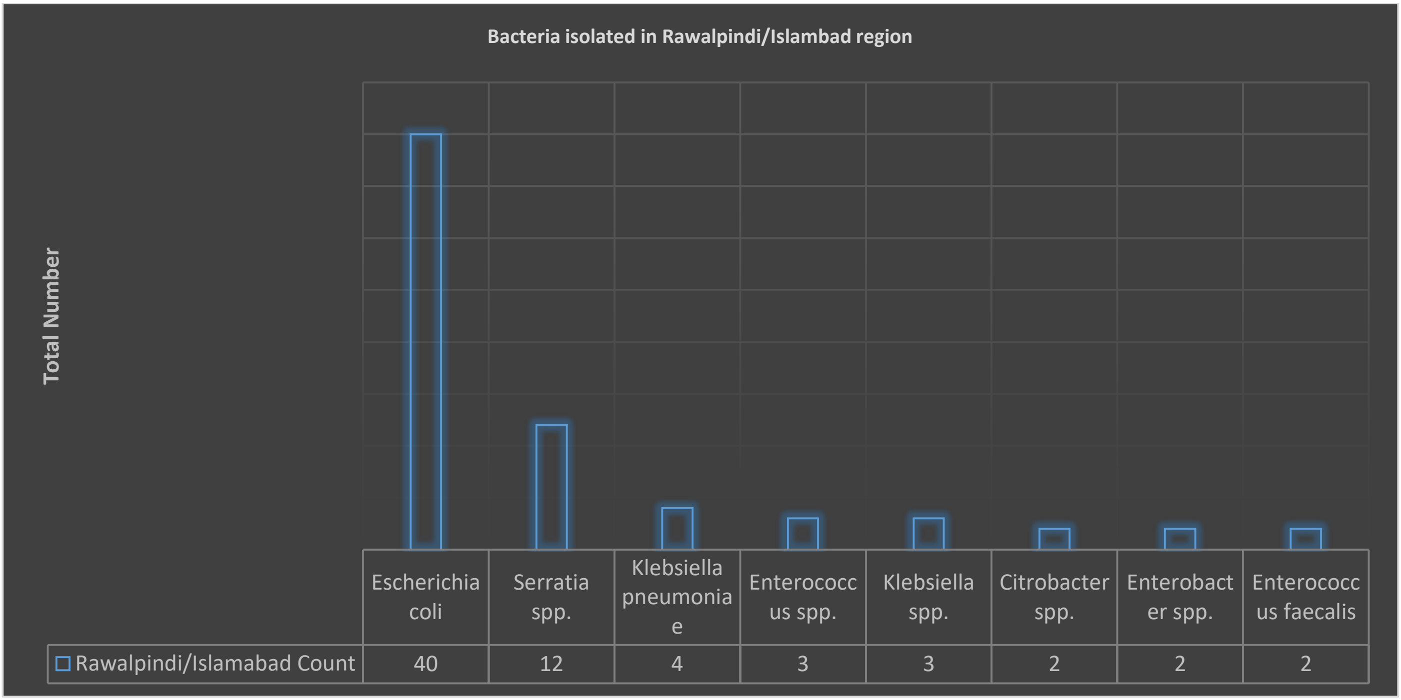

Figure 4. *Graph showing total bacterial isolates from Rawalpindi/Islamabad region*

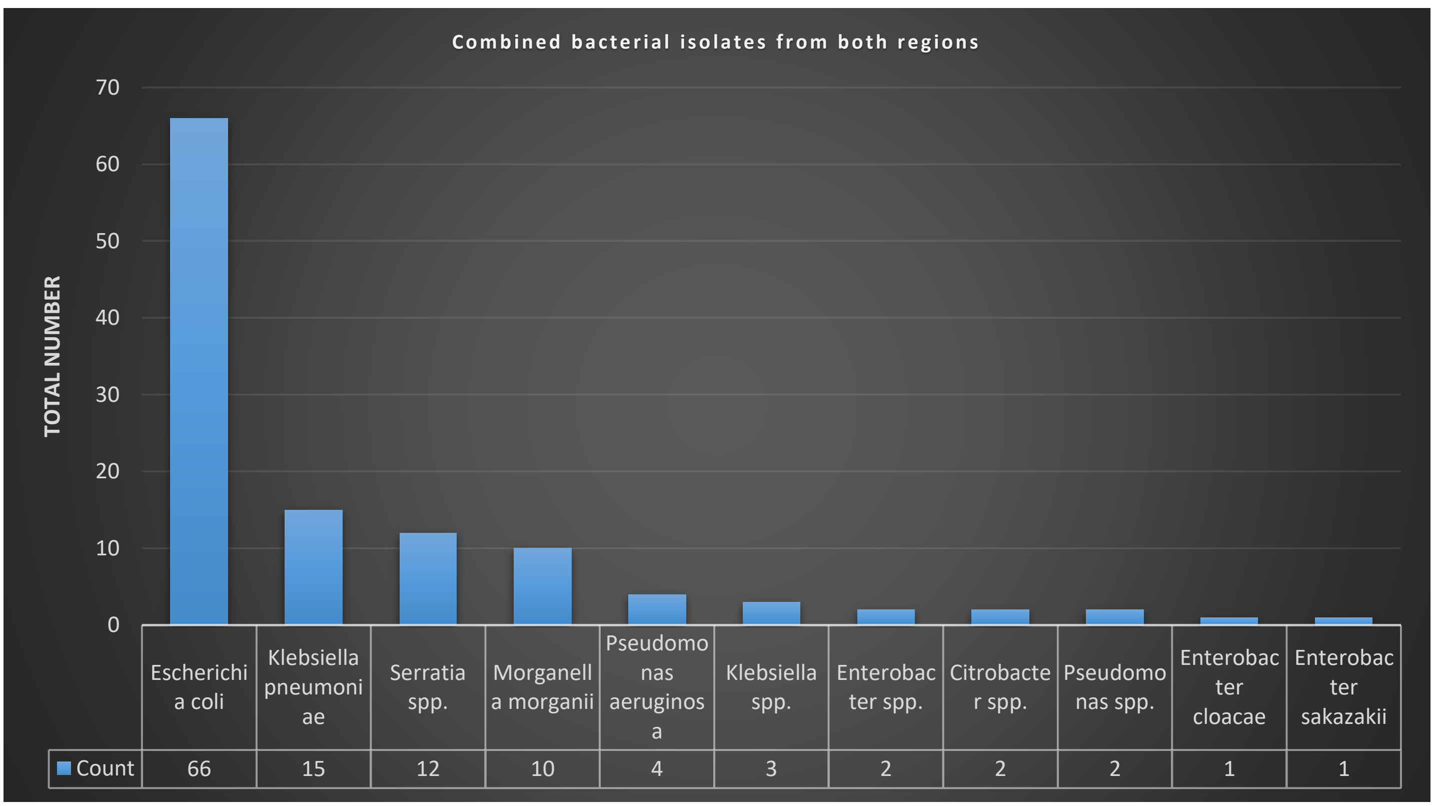

Figure 5. *Graph showing combined bacterial isolates form Sialkot and Rawalpindi/Islamabad region*

Table 1. Total bacterial isolates from Sialkot and Rawalpindi/Islamabad region

Escherichia coli	66	52.80%
Klebsiella pneumoniae	15	12.00%
Serratia spp.	12	9.60%
Morganella morganii	10	8.00%
Pseudomonas aeruginosa	4	3.20%
Klebsiella spp.	3	2.40%
Enterobacter spp.	2	1.60%
Citrobacter spp.	2	1.60%
Pseudomonas spp.	2	1.60%
Enterobacter cloacae	1	0.80%
Enterobacter sakazakii	1	0.80%

Table 2. *Antimicrobial Susceptibility Pattern of Bacterial Isolates from Sialkot and Rawalpindi/Islamabad region*

Escherichia coli	Ampicillin	3	30
	Ceftriaxone	8	22
	Ciprofloxacin	5	19
	Gentamicin	40	5
	Imipenem	34	1
	Nitrofurantoin	27	7
Klebsiella pneumoniae	Ampicillin	1	5
	Ceftriaxone	2	5
	Ciprofloxacin	2	2
	Gentamicin	7	1
	Imipenem	6	1
Pseudomonas aeruginosa	Cefepime	1	3
	Ceftazidime	2	2
	Imipenem	3	1
Staphylococcus aureus	Penicillin	0	4
	Vancomycin	4	0
Enterococcus faecalis	Ampicillin	2	1
	Vancomycin	3	0

DISCUSSION

This Sialkot/Rawalpindi/Islamabad multi-regional plant study contributes to granular, current data on the epidemiology and resistance of UTI in Pakistan. It was noted that, overall culture positivity was 23.5% with a significant difference between Sialkot (51.7%) and Rawalpindi/Islamabad (16.5%). As observed in other parts of the country and globally, *Escherichia coli* was the leading uropathogen (about 43%), followed by *Klebsiella pneumoniae*, and a smaller proportion was represented by Gram-positive cocci (especially *Staphylococcus aureus* and *Enterococcus spp*.). First-line oral agent resistance was high, particularly with β-lactam (e.g., ampicillin) and third-generation cephalosporins (e.g., ceftriaxone) but not with nitrofurantoin, Fosfomycin, amikacin, gentamicin, or carbapenems, which remained relatively active in our cohort. These results all argue against continuing empiric therapy with fluoroquinolones/third-generation cephalosporins and in favor of nitrofurantoin or Fosfomycin to treat uncomplicated cystitis, with aminoglycosides/carbapenems being used to treat complicated disease as long as stewardship safeguards exist.The increased positivity in Sialkot may be due to (i) another case-mix (more pediatric submissions), (ii) patterns of pre-culture antibiotic exposure, and (iii) care-access effects. As recently reported in pediatrics (Sialkot, children/adolescents, tertiary hospital), E. coli predominated with greater activity by nitrofurantoin than by cephalosporins, once again in agreement with our signal in that area [10].The case of this study prevalence, and mixture of species, agrees with your two anchor points. The multicenter national study Infection and Drug Resistance (IDR) reported *E. coli* predominance of culture positivity in the Pakistani sites and also emphasized on sustained activity of nitrofurantoin/fosfomycin and carbapenems despite widespread resistance of many popular agents [11]. The Kohat study likewise documented *E. coli* as the leading uropathogen and a high burden of resistance among Gram-negatives, foreshadowing the empiric challenges our dataset now underscores [8]. Khan, Shahzad (12) showed *E. coli* 66% of positives; Ciprofloxacin resistance ~66%; Fosfomycin with the most favorable profile among orals, converging with our Rawalpindi/Islamabad data and underscoring temporal stability of this signal. Idrees, Rasool (13) showed in 1000 urine (south Punjab region) culture positivity was 57% with *E. coli* had been most active with Nitrofurantoin/Fosfomycin and carbapenems, very consistent with our data and recommendations. Khatoon, Khanam (6) conducted a Pakistan-wide study and showed *E. coli* predominance, significant resistance to β-Lactams/Fluoroquinolones, and comparatively high susceptibility to nitrofurantoin and Fosfomycin, paralleling our combined regional antibiogram. Tariq (14) targeted analysis of nitrofurantoin shows generally favorable activity across urinary isolates, supporting our preference for nitrofurantoin as a first-line oral option for uncomplicated cystitis in appropriate patients. Waqas, Khan (15) reported *E. coli* 57.7%; Fosfomycin 91% sensitivity, imipenem/meropenem/amikacin ~83–95% sensitive; cefixime/ciprofloxacin among the least active, mirroring our resistance pattern and reinforcing the need to avoid Cephalosporins/Fluoroquinolones for empiric therapy. Fatima, Rizvi (16) highlighted emergence of Nonfermenting gram-negative bacilli (NFGNB) in UTIs and their complex resistance, which matches our observation that *Pseudomonas* and other non-fermenters underperform against cephalosporins/fluoroquinolones and often require antipseudomonal β-lactam/β-lactamase inhibitor combinations or carbapenems when clinically justified. Collectively, these studies spanning Rawalpindi, South Punjab/Multan, Peshawar, Karachi, and Lahore, arrive at a coherent picture: *E. coli* predominance; deteriorating performance of fluoroquinolones and third-generation cephalosporin's; and preserved utility of Nitrofurantoin, Fosfomycin, Aminoglycosides, and Carbapenems. Our data from Sialkot and Rawalpindi/Islamabad fit squarely within this landscape, lending external validity and timeliness to our recommendations. Given the concordant national evidence, empiric treatment algorithms for community-acquired cystitis in Pakistan should prioritize Nitrofurantoin or Fosfomycin (where available), with de-escalation guided by culture results. For complicated infections or suspected NFGNB, targeted therapy based on local antibiograms is essential. Routine, site-specific antibiogram updates (separate for Sialkot and Rawalpindi/Islamabad) and auditing of fluoroquinolone/cephalosporin use should be institutional priorities.

CONCLUSION

Escherichia coli is the predominant Gram-negative uropathogen in Sialkot and Rawalpindi/Islamabad, showing high resistance to ampicillin, ceftriaxone, and fluoroquinolones. Empiric therapy for UTIs should prioritize nitrofurantoin or Fosfomycin for uncomplicated cases, while aminoglycosides and carbapenems should be reserved for complicated infections. Region-specific antibiograms are essential to guide rational prescribing and slow resistance spread. These findings highlight the urgent need to revise empirical UTI treatment protocols at the regional level, prioritizing nitrofurantoin and Fosfomycin for uncomplicated infections and reserving broader agents for complicated disease. Regular local antibiogram surveillance and strengthened antimicrobial stewardship are critical to curb the rising resistance burden and to ensure effective therapy for community and hospital-acquired UTIs in Pakistan.

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Ethical approval: Ethical approval was taken from IRB, IIUI.

Consent to participate: Consent forms were signed from patients.

Consent for publication: Consent was taken.

Availability of data and materials: The data used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of interests: Declared None.

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