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Original Research Article

Laboratory-based antibiogram of uropathogens from a tertiary care hospital in Pakistan: A five-year retrospective study

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Abstract

Purpose: *To describe the distribution of uropathogens and their recorded antimicrobial susceptibility proportions in urine culture reports from a tertiary care hospital over five years.*
Methods: *This retrospective laboratory-based observational study analyzed urine culture and sensitivity records from 2020 to 2024 at Rehman Medical Institute, Peshawar. All eligible records were included. Reports from patients who had received antibiotics within the preceding 7 days and reports with no bacterial growth were excluded, leaving 322 reports for analysis. Data were summarized using descriptive statistics in SPSS version 29.*
Results: *Escherichia coli was the most frequently recorded uropathogen (309/322; 96.0 %), followed by Enterococcus species (189/322; 58.7 %), whereas Serratia odorifera was the least frequent (46/322; 14.3 %). Using the total analyzed reports (n = 322) as the denominator, fosfomycin showed the highest observed susceptibility proportion for E. coli (86.5 %) and Enterococcus species (46.0 %). Colistin showed the highest observed proportion for Pseudomonas species (43.1 %), while amikacin showed the highest observed proportions for Klebsiella pneumoniae (47.5 %), Klebsiella aerogenes (formerly Enterobacter aerogenes) (31.2 %), Citrobacter (32.4 %), Serratia odorifera (25.8 %), and Staphylococcus aureus (24.9 %). Co-trimoxazole showed the highest observed proportion for Salmonella species (16.8 %).*
Conclusion: *E. coli was the most frequently recorded uropathogen. Fosfomycin, tigecycline, carbapenems, colistin, nitrofurantoin, amikacin, and piperacillin/tazobactam showed comparatively higher observed susceptibility proportions than several fluoroquinolones and cephalosporins. These findings support routine culture-guided therapy and local antimicrobial stewardship.*

Keywords: *Antibiogram, Antimicrobial resistance, Antimicrobial susceptibility, Urinary tract infection, Uropathogens*

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INTRODUCTION

Urinary tract infections (UTIs) are among the most common bacterial infections encountered in clinical practice and can range from lower urinary tract disease to severe upper-tract infection and sepsis [1,2]. *Escherichia coli* is consistently reported as the leading uropathogen, although the distribution of organisms and their antimicrobial susceptibility vary across populations and healthcare settings [3–5]. Antimicrobial resistance can arise through intrinsic bacterial characteristics or acquired mechanisms, and increasing resistance complicates empirical treatment [6].

The global burden of UTIs remains substantial. An analysis of Global Burden of Disease 2019 data estimated approximately 404.61 million UTI cases and 236,790 deaths worldwide in 2019, with the age-standardized mortality rate increasing from 2.77 to 3.13 per 100,000 population between 1990 and 2019 [2]. Geographic variation in resistance patterns reinforces the need for local surveillance and culture-guided treatment [1,7,8].

In Pakistan and other settings where empirical antibiotic use and self-medication are common, inappropriate antimicrobial exposure can accelerate the selection of resistant organisms [9]. Regular surveillance of local uropathogens and their susceptibility profiles is therefore important for rational prescribing, antimicrobial stewardship, and the development of locally relevant empirical treatment guidance [6,8].

Although studies from Pakistan have described uropathogen distribution and antimicrobial susceptibility in specific populations [3–5,10], local laboratory data covering multiple age groups and both sexes remain useful for hospital-level stewardship. The present study therefore aimed to describe the distribution of uropathogens and their recorded antimicrobial susceptibility proportions in urine culture reports collected at a tertiary care hospital over five years.

METHODS

Study design

This was a retrospective laboratory-based observational study of urine culture and antimicrobial susceptibility covering the five calendar years from 2020 through 2024. The analysis was performed between February and June 2025.

Setting

The study was conducted in the Department of Microbiology, Rehman Medical Institute, Peshawar, Pakistan, a tertiary care hospital that receives clinical specimens from inpatient and outpatient services.

Study population and eligibility

All available urine culture and sensitivity reports from patients investigated for suspected UTI during the study period were screened using a universal (census) sampling approach. A total of 472 reports were initially identified. Reports were excluded when the patient had received antibiotics within the preceding 7 days or when the urine culture showed no bacterial growth. After these exclusions, 322 reports were included in the final analysis.

Data collection and microbiological procedures

Data were extracted from archived urine culture and sensitivity reports. Bacterial identification followed standard microbiological procedures [11]. Antimicrobial susceptibility testing was performed using standardized disk diffusion and dilution methods [12]. Colistin susceptibility was assessed by minimum inhibitory concentration using broth microdilution with Sensititre plates (TREK Diagnostic Systems Ltd., part of Thermo Fisher Scientific, East Grinstead, UK). Interpretation of susceptibility results followed the Clinical and Laboratory Standards Institute (CLSI M100, 2024) and European Committee on Antimicrobial Susceptibility Testing (EUCAST, 2024) criteria recorded in the laboratory procedure. Variables extracted for this analysis included age group, sex, identified uropathogen, and antimicrobial susceptibility result.

Ethical considerations

The study was approved by the Institutional Research and Ethics Committee of Rehman Medical Institute (Ref. no. RMI/RMI-REC/Approval/164). The analysis used existing laboratory records, involved no direct patient contact, and maintained confidentiality and anonymity of patient information.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS), version 29 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize patient characteristics, uropathogen distributions, and

antimicrobial susceptibility results. Frequencies and percentages were calculated using the 322 analyzed reports as the denominator, consistent with the archived summary dataset. No inferential statistical testing was performed. Because organism-specific numbers tested against each antimicrobial agent were not available in the archived summary data, antimicrobial percentages are reported as descriptive proportions of the total analyzed report set and should not be interpreted as isolate-specific susceptibility rates.

RESULTS

A total of 322 urine culture and sensitivity reports were included in the analysis after exclusion of reports from patients with antibiotic exposure within the preceding 7 days and reports with no bacterial growth.

Participant characteristics and uropathogen distribution

The distribution of recorded uropathogens by age group and sex is presented in Table 2. *E. coli* was the most frequently recorded uropathogen, with a reported frequency of 309 (96.0 %), followed by *Enterococcus* species at 189 (58.7 %) and *Pseudomonas* species at 170 (52.8 %). *Serratia odorifera* was the least frequent at 46 (14.3 %; Table 1). Across age and sex strata, *E. coli* remained the most frequently recorded organism, with the largest single stratum observed among females aged 16 – 49 years (138/322; 42.9 %) (Table 2). The overall sex distribution of recorded organisms is summarized in Figure 1.

Table 1: Frequency of recorded uropathogens among analyzed culture-positive reports (n = 322)

Uropathogen	Frequency	Analyzed reports (%)
Escherichia coli	309	96.0
Enterococcus species	189	58.7
Pseudomonas species	170	52.8
Klebsiella pneumoniae	154	47.8
Klebsiella aerogenes	127	39.4
Citrobacter	109	33.9
Staphylococcus aureus	83	25.8
Salmonella species	74	23.0
Serratia odorifera	46	14.3

Note: Percentages use n = 322 as the denominator. The archived summary frequencies across organism categories collectively exceed n = 322; therefore, these categories cannot be interpreted as mutually exclusive isolate prevalence, and the percentages are not expected to total 100 %. Report-level linkage needed to determine whether more than one organism occurred in an individual report was not available in the supplied summary data.

Table 2: Distribution of recorded uropathogens by age group and sex (n = 322)

Uropathogen	≤15 years		16–49 years		>49 years	
	Male	Female	Male	Female	Male	Female
Escherichia coli	28 (8.7 %)	31 (9.6 %)	45 (14.0 %)	138 (42.9 %)	32 (9.9 %)	35 (10.9 %)
Enterococcus species	23 (7.1 %)	17 (5.3 %)	43 (13.4 %)	49 (15.2 %)	27 (8.4 %)	30 (9.3 %)
Pseudomonas species	24 (7.5 %)	22 (6.8 %)	36 (11.2 %)	31 (9.6 %)	23 (7.1 %)	34 (10.6 %)
Klebsiella pneumoniae	23 (7.1 %)	27 (8.4 %)	24 (7.5 %)	29 (9.0 %)	22 (6.8 %)	29 (9.0 %)
Klebsiella aerogenes	14 (4.3 %)	19 (5.9 %)	30 (9.3 %)	33 (10.2 %)	6 (1.9 %)	25 (7.8 %)
Citrobacter	3 (0.9 %)	11 (3.4 %)	13 (4.0 %)	29 (9.0 %)	31 (9.6 %)	22 (6.8 %)
Staphylococcus aureus	4 (1.2 %)	21 (6.5 %)	18 (5.6 %)	16 (5.0 %)	18 (5.6 %)	6 (1.9 %)
Salmonella species	2 (0.6 %)	7 (2.2 %)	14 (4.3 %)	9 (2.8 %)	19 (5.9 %)	23 (7.1 %)
Serratia odorifera	7 (2.2 %)	3 (0.9 %)	18 (5.6 %)	11 (3.4 %)	2 (0.6 %)	5 (1.6 %)

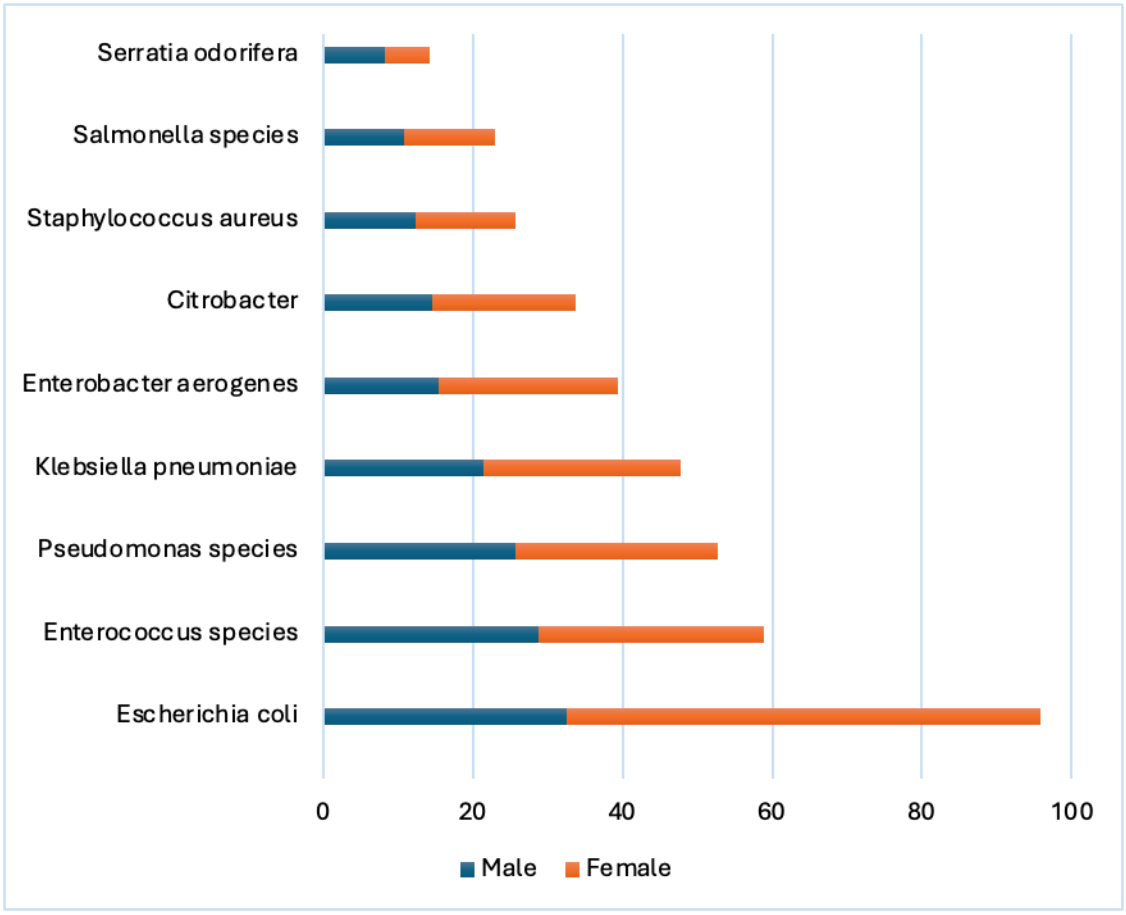


Figure 1: Overall distribution of recorded uropathogens by sex (n = 322)

Antimicrobial susceptibility results are summarized in Tables 3A–B. Based on the total analyzed report set (n = 322), fosfomycin showed the highest observed susceptibility proportion for *E. coli* (86.5 %) and *Enterococcus* species (46.0 %). Colistin showed the highest observed proportion for *Pseudomonas* species (43.1 %). Amikacin showed the highest observed proportions for *Klebsiella pneumoniae* (47.5 %), *Klebsiella aerogenes* (31.2 %), *Citrobacter* (32.4 %), *Serratia odorifera* (25.8 %), and *Staphylococcus aureus* (24.9 %). Co-trimoxazole showed the highest observed proportion for *Salmonella* species (16.8 %).

Table 3A: Observed antimicrobial susceptibility proportions (%) by uropathogen, based on the total analyzed reports (n = 322)

Antimicrobial	*E. coli*	*Enterococcus spp.*	*Pseudomonas spp.*	*K. pneumoniae*	*E. aerogenes*
Fosfomycin	86.5	46.0	12.3	30.1	23.3
Tigecycline	84.1	44.2	11.8	29.4	22.9
Imipenem	74.6	21.3	28.2	26.3	18.0
Meropenem	71.1	15.7	27.6	25.2	21.1
Colistin	67.3	14.5	43.1	25.3	17.3
Nitrofurantoin	68.2	41.4	11.5	42.4	25.6
Amikacin	65.7	23.7	36.3	47.5	31.2
Piperacillin/tazobactam	61.3	13.5	37.2	40.1	17.3
Gentamicin	51.4	37.6	22.3	26.2	17.2
Cefoperazone/sulbactam	53.8	13.6	35.1	29.4	17.1
Tetracycline	46.4	38.1	22.1	28.8	13.5
Ceftazidime	29.3	3.5	16.7	9.1	1.5
Co-trimoxazole	21.3	12.8	2.0	18.7	11.6
Levofloxacin	17.3	13.0	21.4	20.1	2.0
Ciprofloxacin	15.9	12.9	21.1	20.0	2.0
Ceftriaxone	20.1	11.2	2.0	19.2	11.7

Table 3B: Observed antimicrobial susceptibility proportions (%) by uropathogen, continued

Antimicrobial	*Citrobacter*	*S. odorifera*	*S. aureus*	*Salmonella* spp.
Fosfomycin	22.9	16.0	12.7	13.9
Tigecycline	22.5	16.0	14.9	12.0
Imipenem	18.8	15.7	11.6	11.4
Meropenem	19.7	15.6	11.5	13.8
Colistin	22.1	5.0	4.0	4.4
Nitrofurantoin	19.3	15.3	3.0	4.0
Amikacin	32.4	25.8	24.9	3.0
Piperacillin/tazobactam	18.2	16.4	12.4	2.0
Gentamicin	24.3	16.6	12.3	3.0
Cefoperazone/sulbactam	17.2	16.3	13.0	14.0
Tetracycline	13.6	15.9	12.0	13.0
Ceftazidime	3.5	2.0	3.0	2.0
Co-trimoxazole	2.0	16.1	2.0	16.8
Levofloxacin	2.0	14.3	2.0	14.5
Ciprofloxacin	2.0	14.1	2.0	4.0
Ceftriaxone	13.5	2.0	2.0	4.2

Note: Values are percentages of the total analyzed report set (n = 322), consistent with the summary data archived. Organism-specific numbers tested against each antimicrobial were not available; therefore, these values are descriptive proportions and not isolate-specific susceptibility rates

DISCUSSION

E. coli was the most frequently recorded uropathogen in the present dataset. Its predominance is consistent with studies from Pakistan and other regions, although the proportion reported here is higher than isolate-specific prevalences commonly described elsewhere [4,5,13–18]. This difference should be interpreted in light of the supplied summary data: organism frequencies collectively exceed the 322 analyzed reports, and report-level linkage was unavailable. The frequencies therefore should not be interpreted as mutually exclusive isolate prevalence.

The distribution of other organisms also varied across the analyzed reports, with *Enterococcus* species, *Pseudomonas* species, and *Klebsiella pneumoniae* among the more frequently recorded organisms. Differences between studies may reflect patient mix, inpatient versus outpatient sampling, local antimicrobial exposure, laboratory practices, and regional epidemiology [1,15,16,18,19].

The present analysis showed comparatively higher observed susceptibility proportions for fosfomycin, tigecycline, imipenem, meropenem, colistin, nitrofurantoin, amikacin, and piperacillin/tazobactam for several organism-antimicrobial combinations. In contrast, lower observed proportions were recorded for several fluoroquinolones and cephalosporins. Similar concerns regarding reduced activity of commonly used agents have been reported in studies from Sudan, Ethiopia, Bangladesh, and Brazil, while amikacin, nitrofurantoin, fosfomycin, and carbapenems have retained useful activity against selected uropathogens in several settings [17–20].

These findings support routine microbiological confirmation of UTI when clinically appropriate and reinforce the value of local antimicrobial stewardship. Empirical treatment policies should be informed by current local susceptibility data, but the present descriptive percentages should not be used alone to define first-line therapy because organism-specific numbers tested against each antimicrobial were not available in the archived summary dataset.

Females accounted for a larger share of recorded uropathogen detections than males, particularly in the 16 – 49-year age group. This pattern is consistent with previous studies reporting a higher burden of UTIs among women [18–20]. *E. coli* remained the leading recorded organism across the age strata in the present dataset. Age-related differences in uropathogen distribution and antimicrobial susceptibility have also been described in pediatric populations, older adults, and women of childbearing age [3,10,21–23].

In the present dataset, *E. coli* remained the most frequently recorded organism across all three age strata. Among patients aged ≤15 years, the recorded *E. coli* counts were 28 in males and 31 in females; among those aged 16–49 years, the counts were 45 and 138, respectively; and among those aged >49 years, the counts were 32 and 35, respectively (Table 2). *Klebsiella pneumoniae* and *Pseudomonas* species were also recorded across all age strata. These

findings describe age-related organism distribution only and should not be interpreted as age-specific antimicrobial susceptibility. Pediatric studies in Pakistan and Saudi Arabia likewise identify *E. coli* and other Enterobacterales as important uropathogens [3,10,23], while studies in adults and women of childbearing age report age-related variation in uropathogen distribution [21,22].

From a stewardship and public health perspective, the study supports continued surveillance, culture-guided prescribing, and periodic updating of hospital antibiograms. Future multicenter studies should retain isolate-level denominators, distinguish repeated or polymicrobial records, and evaluate temporal changes in susceptibility using standardized laboratory criteria.

Strengths and limitations

The strength of this study is the use of five years of laboratory records from a tertiary care setting, providing locally relevant descriptive information on uropathogen distribution and antimicrobial susceptibility. Important limitations include the retrospective single-center design, exclusion of patients with recent antibiotic exposure, and limited clinical covariate information. The study also did not analyze year-by-year changes; therefore, the results should not be interpreted as demonstrating a temporal increase or decrease in antimicrobial resistance.

The archived summary data did not provide organism-specific numbers tested against each antimicrobial agent. Consequently, the antimicrobial percentages were calculated and presented using n = 322 as the denominator, consistent with the supplied dataset, and should not be interpreted as conventional isolate-specific antibiogram rates. This limitation restricts direct comparison with studies that calculate susceptibility as the number susceptible divided by the number of isolates tested for each organism-antimicrobial combination.

CONCLUSION

E. coli was the most frequently recorded uropathogen in this five-year laboratory dataset. Fosfomycin, tigecycline, carbapenems, colistin, nitrofurantoin, amikacin, and piperacillin/tazobactam showed comparatively higher observed susceptibility proportions for several organism-antimicrobial combinations, whereas several fluoroquinolones and cephalosporins showed lower observed proportions. The findings support local antimicrobial surveillance, culture-guided therapy, and stewardship. Because organism-specific test denominators were unavailable, these descriptive proportions should not be interpreted as isolate-specific susceptibility rates or as direct evidence for a year-on-year resistance trend.

DECLARATIONS

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The authors acknowledge the use of generative artificial intelligence–assisted language tools solely for language refinement, including improvement of grammar, sentence structure, readability, and clarity of expression during manuscript revision. These tools were not used to generate study data, perform statistical analyses, interpret the findings, or draw scientific conclusions. All AI-assisted revisions were critically reviewed, verified, and approved by the authors, who take full responsibility for the accuracy, integrity, and final content of the manuscript.

Ethics statement

Approval was obtained from the Institutional Research and Ethics Committee of Rehman Medical Institute (Ref. no. RMI/RMI-REC/Approval/164; approval date: 24 October 2022).

Conflict of Interest

No conflicts of interest are associated with this study.

Contribution of Authors

We declare that this work was done by the author(s) named in this article, and all liabilities pertaining to claims relating to the content of this article will be borne by the authors. Syed Sikandar Shah, Rizwan Faisal, Aizaz Imran, and Abid Ullah made major contributions to the conception and development of the study, interpretation of the findings, methodological review, critical revision of the manuscript, and preparation of the final version for publication. Ashfaq Ahmad Shah Bukhari, Rasha Aziz Attia Salama, Jamil Ahmad, Aftab Alam, Hadeel Eyad Shalabi, and Rasha Babiker contributed to manuscript writing, literature review, critical review, language editing, and refinement of the final manuscript. All authors reviewed and approved the final manuscript and agree to be accountable for the integrity and accuracy of the work.

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