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Original Research Article

A Retrospective Study on Aerobic Bacteriological Profile and Antibiotic Susceptibility Pattern of Urinary Tract Isolates in Tertiary Care Hospital of Sagar, Bundelkhand

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Abstract

Urinary tract infections (UTIs) are among the most common bacterial infections affecting individuals worldwide, often leading to significant morbidity if untreated. Accurate bacteriological profiling of urinary isolates is crucial for appropriate diagnosis and effective antimicrobial therapy, especially in the face of rising antibiotic resistance. This study aimed to identify the aerobic bacterial pathogens isolated from urine samples and to determine their antibiotic susceptibility patterns in a tertiary care hospital setting. A cross-sectional study was conducted over a period of one year (January 2024 to December 2024), where urine samples from suspected UTI patients were cultured and bacterial isolates were identified using standard microbiological techniques. Antibiotic susceptibility testing was performed following Clinical and Laboratory Standards Institute (CLSI -2024) guidelines using Kirby-Bauer disk diffusion method. The results revealed Escherichia coli as the predominant pathogen, followed by Klebsiella pneumoniae and Pseudomonas aeruginosa. Nitrofurantoin and amikacin showed the highest susceptibility rates, whereas a notable resistance to Fluoroquinolones was observed. These findings underscore the importance of continuous surveillance of urinary pathogens and their resistance profiles to guide empirical treatment and combat the spread of multidrug-resistant organisms in hospital settings. Implementation of antibiotic stewardship programs is imperative to optimize antibiotic use and improve patient outcomes.
Keywords: Urinary tract infection, Aerobic bacteria, Escherichia coli, Antibiotic susceptibility, Antibiotic resistance, Uro-pathogen.

INTRODUCTION

Urinary tract infections (UTIs) represent one of the most prevalent bacterial infections encountered in both community and healthcare settings in India, contributing significantly to morbidity across all age groups [1]. The epidemiology and antimicrobial resistance patterns of UTI pathogens vary regionally and evolve over time, necessitating continuous local surveillance to guide empirical treatment strategies.

Studies across India consistently identify *Escherichia coli* as the predominant uro-pathogen, accounting for 40–75% of isolates in diverse tertiary-care settings. For instance, a hospital in central Kerala reported *E. coli* in 74.3% of adult UTI cases, followed by *Klebsiella* spp., with both showing high sensitivity to nitrofurantoin, amikacin, and imipenem, but pronounced resistance to ampicillin (>90%) [2]. Similarly, a tertiary hospital in Western Rajasthan found *E. coli* responsible for 37.2% of cases, with *Klebsiella pneumoniae* (10.2%) and *Pseudomonas* spp. (1.9%) as notable pathogens; resistance levels were particularly high against co-trimoxazole, cefuroxime, and ciprofloxacin [3].

The predominance of Gram-negative bacteria (over 90% of isolates) and the emergence of multidrug-resistant (MDR) strains—including extended-spectrum β-lactamase (ESBL) producers—have been well documented in settings such as Karnataka and Gujarat. A Karnataka tertiary hospital cohort reported *E. coli* (58.9%) and *K. pneumoniae* (22.7%), with ESBL production observed in 17.5% and 21% of isolates respectively; susceptibility remained relatively preserved for meropenem, piperacillin-tazobactam, and nitrofurantoin [4]. Another retrospective paediatric UTI study from South Gujarat observed a predominance of *Enterococcus* spp. among young children, suggesting the influence of age and demographic factors on pathogen distribution [5].

More extensive surveillance over time further highlights an alarming increase in antibiotic resistance among uro-pathogens. A South Indian retrospective analysis from 2011–2017 documented growing resistance in *E. coli* and *K. pneumoniae* toward fluoroquinolones, carbapenems, nitrofurantoin, and even aminoglycosides. Resistance to imipenem rose by ~30%, nitrofurantoin by ~11%, and ciprofloxacin by ~26%, underscoring the urgency for robust antimicrobial stewardship [6]. These resistance patterns complicate treatment choices and often necessitate the use of more expensive or toxic antibiotics. The emergence of resistant strains has posed significant challenges in managing UTIs, including increased treatment failures and recurrent infections [7]. The dynamic nature of bacterial resistance calls for ongoing surveillance and revision of empirical treatment guidelines to ensure effective management. Additionally, the lack of rapid diagnostic tools in many settings delays targeted therapy, further exacerbating resistance issues.

Given this background, there is a critical need for updated, region-specific data on bacterial prevalence and antibiotic susceptibility in tertiary care settings. Such data not only informs empirical therapy but also supports policy decisions around antibiotic usage and stewardship interventions. Considering rising MDR prevalence and evolving trends, the present retrospective study aims to evaluate the aerobic bacteriological profile and antibiotic susceptibility pattern of uro-pathogens isolated in our tertiary care hospital, with the goal of guiding optimal management of UTIs in our local context.

Experimental Section:

Study Design and Setting

This was a retrospective, cross-sectional study conducted in the Department of Microbiology, Bansal hospital, a tertiary care hospital located in Sagar District, Bundelkhand Region of Madhya Pradesh India.

Study Duration

The data was collected over a one-year period, from January 2024 to December 2024.

Study Population and Sample Collection

All urine samples submitted to the microbiology laboratory for culture and sensitivity testing from inpatients and outpatients with clinically suspected urinary tract infection (UTI) during the study period were included.

Inclusion Criteria

- Midstream, clean-catch urine samples from patients of all age groups and genders
- Samples with significant bacteriuria ($\geq 10^5$ CFU/mL of a single uro-pathogen)
- Only aerobic bacterial isolates were considered

Exclusion Criteria

- Samples showing mixed growth of more than two organisms (indicative of contamination)
- Repeat samples from the same patient within 7 days
- Urine samples from patients already on antibiotic therapy
- Samples yielding no growth or non-bacterial pathogens

Laboratory Processing

- **Urine specimens were processed within 2 hours of collection:**
  - Samples were cultured using a standard calibrated loop (0.001 mL) on CLED (Cystine Lactose Electrolyte Deficient) agar and blood agar.
  - Plates were incubated at 37°C for 18–24 hours under aerobic conditions.
  - Significant growth was interpreted as $\geq 10^5$ colony-forming units (CFU)/mL.
  - Bacterial identification was performed using standard biochemical tests (e.g., oxidase, catalase, indole, citrate, urease, TSI etc.) and automated systems where available (e.g., VITEK 2 Compact, bioMérieux).

- **Antibiotic Susceptibility Testing (AST)**
  - AST was conducted using the Kirby-Bauer disc diffusion method on Mueller-Hinton agar as per Clinical and Laboratory Standards Institute (CLSI) guidelines, 2024 [8].
  - Antibiotic discs were tested depending on organism: Gram-negative and Gram-positive.
  - Quality control was maintained using standard ATCC strains:
- *E. coli* ATCC 25922
- *P. aeruginosa* ATCC 27853
- *S. aureus* ATCC 25923
- *Enterococcus faecalis* ATCC 29212

Data Collection and Statistical Analysis

- Data was extracted from microbiology laboratory records and hospital information systems (HIS).
- The following variables were recorded: patient age, gender, sample type, organism isolated, and antibiotic susceptibility pattern.
- Data was entered into Microsoft Excel and analysed.
- Results were expressed as Percentages and different charts.

- MDR (multi-drug resistance) was defined as resistance to at least one agent in three or more antimicrobial categories.

RESULTS AND DISCUSSION

1. Demographic Data

A total of 426 urine samples were collected from patients suspected of urinary tract infections out of these 185 (38.06%) samples were culture positive. We have considered these 185 samples for further analysis. The age of patients ranged from 1 to 80 years with a mean age. The sex distribution showed a higher prevalence in females -111 (60%) compared to males – 74 (40%). Both inpatient and outpatient departments contributed to the sample pool, with 80 (43.24%) from inpatients and 108 (58.38%) from outpatients.

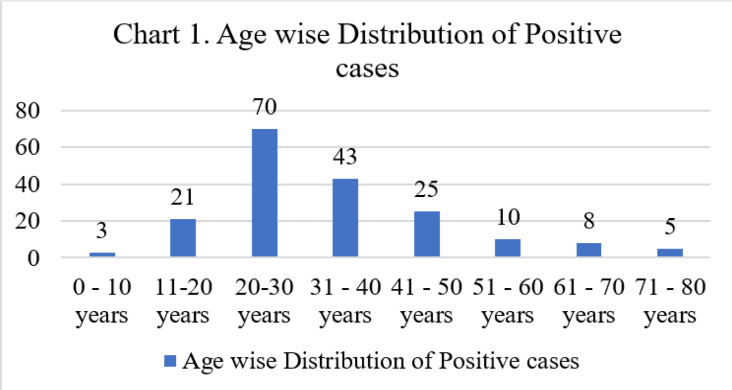

Chart 1. Age wise Distribution of Positive cases

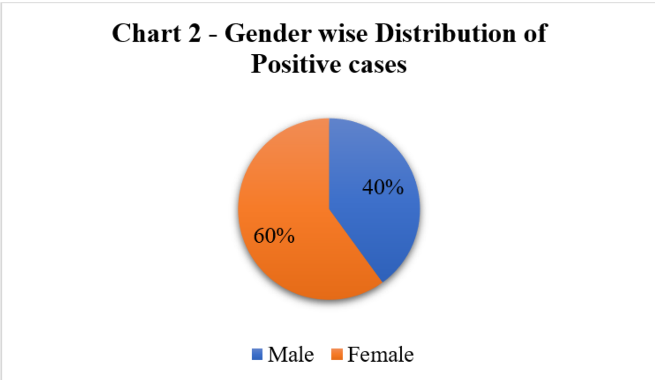

Chart 2 - Gender wise Distribution of Positive cases

2. Bacterial Isolates

Among the 185 aerobic bacterial isolates, Escherichia coli was the predominant pathogen, accounting for 55.13% of isolates, followed by Klebsiella pneumoniae (15.68%), Pseudomonas aeruginosa (9.73%), and Enterococcus spp. (6.49%). 169 (91.35%) isolates were Gram negative whereas 16 (8.65%) isolates were Gram positive. The distribution is summarized in Table 1.

Table-1: Distribution of Organisms

Gram positive isolates		**Gram negative Isolates**	
Organism	No. of isolates	**Organism**	No. of isolates
Enterococcus spp.	12	E.coli	102
Staphylococcus saprophyticus	4	Klebsiella pneumoniae	29
		Pseudomonas aeruginosa	18
		Acinetobacter spp.	6
		Proteus mirabilis	3
		Cirobacter koseri	3
		Enterobacter cloacae	2
		Other GNB	6
Total	16 (8.65%)	**Total**	169 (91.35%)

3. Antibiotic Susceptibility Pattern

Gram negative isolates are mostly susceptible to Colistin, Tigecycline, Imipenem, Meropenem. Gram positive isolates mostly showed sensitivity to Linezolid, Vancomycin, Nitrofurantoin. Pseudomonas aeruginosa was found to be the most resistant organism with high level of resistance among, 3rd and 4th generation Cephalosporins and Fluroquinolones. Detailed susceptibility profiles are provided in Table 2 and Table 3.

Table-2: Sensitivity of Gram-Negative Isolates (in%)

Drugs	E. coli (n=102)	Klebsiella (n=29)	Acinetobacter spp. (n=6)	Pseudomonas (n=18)
Ampicillin	8	-	-	-
Amoxicillin/clavulanic acid	34	24	-	-
Ticarcillin	12	-	-	-
Piperacillin/tazobactum	50	40	20	25
Cefoxitin	50	32	-	-
Cefalotin	8	25	-	-
Cefixime	6	33	-	-
Ceftriaxone	24	39	25	-
Ceftazidime	29	9	25	16
Cefuroxime	5	9	-	-
Cefuroxime axetil	5	36	-	-
Cefaperazone/ sulbactum	27	25	25	-
Cefipime	25	53	25	16
Ertapenem	79	38	-	-
Imipenem	76	62	50	25
Meropenem	76	62	50	25
Amikacin	67	55	25	38
Gentamicin	60	40	25	-
Nalidixic acid	5	25	-	-
Ciproflaxacin	19	33	20	20
Levofloxacin	19	33	20	20
Ofloxacin	19	-	-	20
Norfloxacin	22	55	-	20
Fosfomycin	95	85	-	-
Nitrofurantoin	58	25	-	-
Tigecycline	100	90	-	-
Colistin	90	48	100	95
Tirimethoprim/sulfamethoxazole	40	42	52	-

Table-3: Sensitivity of Gram-Positive Isolates (in%)

Drugs	Staph saprophyticus (n=4)	Enterococcus spp. (n=12)
Ampicillin	-	0
Benzyl Penicillin	0	0
Rifampicin	50	-
Linezolid	100	100
Vancomycin	100	50
Chloramphenicol	100	-
Gentamycin	50	-
Ciprofloxacin	0	33
Levofloxacin	-	33
Erythromycin	25	33
Clindamycin	25	-
Tetracycline	75	50
Cotrimoxazole	50	-
Cefoxitin	25	-
High level Gentamycin	-	50
High level Streptomycin	-	50
Nitrofurantoin	100	83
Tigecycline	-	100

This study aimed to evaluate the prevalence, etiological agents, and antimicrobial susceptibility patterns of uro-pathogens isolated from patients with suspected urinary tract infections (UTIs). Out of 426 urine samples, 38.06% were culture-positive, consistent with previous reports showing culture positivity rates ranging between 30–45% in suspected UTI cases [9,10].

➢ **Demographic Insights**

Females (60%) were more affected than males (40%), aligning with global trends that attribute this disparity to anatomical and physiological factors [11]. Most samples were from outpatients, suggesting UTIs are frequently managed in ambulatory care settings [12].

➢ **Etiological Agents**

Escherichia coli was the predominant isolate (55.13%), reaffirming its status as the leading uropathogen globally [13,14]. Other Gram-negative pathogens such as *Klebsiella pneumoniae* (15.68%) and *Pseudomonas aeruginosa* (9.73%) were also significant contributors. *Enterococcus spp.* (6.49%) represented the majority of Gram-positive isolates. This distribution is similar to findings from other regional studies in South Asia and sub-Saharan Africa [15,16].

➢ **Antibiotic Resistance Patterns**

The high resistance of Gram-negative organisms to commonly used antibiotics such as ampicillin, cefuroxime, and fluoroquinolones is concerning. *E. coli* and *Klebsiella* showed low sensitivity to ciprofloxacin (19–33%) and cephalosporins, consistent with the growing resistance trends observed in multiple surveillance studies [17,18]. Conversely, carbapenems (imipenem, meropenem) showed relatively good activity, although the 50–76% sensitivity suggests emerging resistance even to these critical drugs.

Colistin and tigecycline showed the highest efficacy among Gram-negative isolates, especially against *Acinetobacter* and *Pseudomonas*, supporting their use as last-resort agents [19,20]. However, their use should be carefully reserved to prevent resistance development.

Among Gram-positive isolates, linezolid, vancomycin, and nitrofurantoin were the most effective agents, which aligns with data from similar surveillance studies [21,22]. The observed 100% sensitivity of *Staphylococcus saprophyticus* to nitrofurantoin and linezolid supports their empirical use in uncomplicated UTIs caused by Gram-positive bacteria.

➢ **Clinical and Public Health Implications**

The findings underscore the need for routine antimicrobial susceptibility testing, as empirical therapy without local resistance data can lead to treatment failure and promote resistance. The high rate of multidrug-resistant *Pseudomonas* isolates is particularly alarming, necessitating infection control measures and antimicrobial stewardship initiatives.

➢ **Limitations**

The study was limited to aerobic culture methods, potentially overlooking anaerobic or fastidious organisms. Molecular characterization of resistance mechanisms was not performed, which could provide deeper insights into resistance trends.

CONCLUSION

This study highlights the predominance of *Escherichia coli* as the leading cause of urinary tract infections, followed by *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*, with *Enterococcus spp.* being the most common Gram-positive pathogen. The observed high resistance to first-line and commonly used antibiotics such as ampicillin, cephalosporins, and fluoroquinolones underscores the growing challenge of antimicrobial resistance in uro-pathogens. Encouragingly, agents like nitrofurantoin, amikacin, carbapenems, and tigecycline maintained relatively good efficacy, particularly against multidrug-resistant strains.

These findings reinforce the importance of routine urine culture and susceptibility testing to guide evidence-based antimicrobial therapy. They also highlight the critical need for implementing antimicrobial stewardship programs and local resistance surveillance to prevent further resistance development and ensure optimal clinical outcomes. Future studies incorporating molecular diagnostics and resistance gene profiling are recommended to gain deeper insights into resistance mechanisms and guide advanced treatment strategies.

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