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ANTIBIOTIC RESISTANCE TRENDS AND MICROBIOLOGICAL PROFILE OF URINARY TRACT INFECTIONS: A CROSS-SECTIONAL STUDY

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ABSTRACT

Introduction: Urinary tract infection (UTI) is one of the most common bacterial infections, with changing trends in antimicrobial susceptibility due to widespread antibiotic use. This study was conducted to determine the prevalence of UTI and the current antibiotic susceptibility patterns of uropathogens.

Materials and Methods: This was a retrospective analysis carried out in the Department of Microbiology and Department of General Medicine at a tertiary care centre. Patient demographics, organisms isolated, and antibiotic susceptibility profiles were recorded and analyzed.

Results: The overall prevalence of UTI was 33.5% (419/1250), with 280 (66.8%) female and 139 (33.2%) male cases. The majority of cases were observed in middle-aged females (31–45 years) and elderly males (>45 years). The most common uropathogen was *E. coli* (225/419, 53.7%), followed by *Klebsiella pneumoniae* (115/419, 27.4%), *Pseudomonas aeruginosa* (36/419, 8.6%), Proteus spp. (20/419, 4.8%), Enterobacter spp. (7/419, 1.7%), and *Staphylococcus aureus* (6/419, 1.4%). Meropenem, gentamicin, nitrofurantoin, and cotrimoxazole were the most effective antibiotics, while high resistance was noted against amoxicillin, fluoroquinolones, and third-generation cephalosporins.

Conclusion: Regular surveillance of antimicrobial susceptibility is essential to guide empirical therapy in UTI and to prevent the emergence of resistant strains.

Keywords: Urinary tract infection, antibiotic resistance, uropathogens, prevalence.

INTRODUCTION

Urinary tract infection (UTI) is one of the most common bacterial infections worldwide, affecting an estimated 150–200 million people annually across all age groups (1). The lifetime risk of developing at least one episode of UTI is about 60% in women compared to 13% in men, largely due to anatomic and hormonal factors (2). UTIs are typically classified as uncomplicated (in healthy individuals without structural or functional abnormalities of the urinary tract) and complicated (associated with risk factors such as obstruction, catheterization, diabetes, immunosuppression, or pregnancy) (3,4).

Women are more predisposed to UTIs due to the short urethra, proximity to the anal region, sexual activity, and pregnancy-related changes (5). In men, the incidence rises with age due to prostatic enlargement and urinary stasis (6).

Microbiologically, Gram-negative Enterobacterales dominate, with Escherichia coli accounting for up to 70–90% of community-acquired UTIs, followed by Klebsiella pneumoniae, Proteus spp., and Pseudomonas aeruginosa (7,8). Gram-positive organisms such as Enterococcus faecalis and Staphylococcus saprophyticus are less common but clinically relevant, especially in young women and hospitalized patients (9).

Antimicrobial resistance (AMR) is a growing global challenge. Widespread use of fluoroquinolones, cephalosporins, and penicillins has accelerated the emergence of multidrug-resistant (MDR) uropathogens (10). Indian surveillance networks (ICMR-AMRSN) report alarming resistance trends, with fluoroquinolone resistance in E. coli exceeding 70% and carbapenem resistance in K. pneumoniae reaching 20–30% in some centres (11,12). Even nitrofurantoin, long considered reliable for cystitis, is showing sporadic resistance in certain regions (13).

Global guidelines now emphasize antimicrobial stewardship in UTI management. The IDSA 2024 AMR guidance recommends nitrofurantoin and trimethoprim-sulfamethoxazole (TMP-SMX) as first-line agents for uncomplicated cystitis, reserving fluoroquinolones and carbapenems for complicated infections (14). Similarly, the WHO AWaRe classification (2023 update) places nitrofurantoin and TMP-SMX in the Access group, to preserve broad-spectrum agents in the Watch and Reserve categories (15,16).

Given the dynamic epidemiology of uropathogens and rapidly evolving resistance trends, periodic local surveillance is essential to inform empirical therapy. This study was therefore undertaken to evaluate the prevalence of UTI and analyze the antimicrobial susceptibility patterns of uropathogens isolated from patients.

MATERIAL AND METHODS

This was a retrospective analysis carried out in the Department of Microbiology and Department of General Medicine at a tertiary care centre, RMCH&RC. Patient demographics, organisms isolated, and antibiotic susceptibility profiles were recorded and analyzed. A total of 1,250 consecutive urine samples from patients with suspected urinary tract infection (UTI) were analyzed.

Study Population

The study included patients of all ages and both sexes presenting with clinical suspicion of UTI, either in outpatient or inpatient settings, who submitted urine samples for culture and sensitivity.

Inclusion Criteria

1. Midstream clean-catch urine samples from patients with clinical features suggestive of UTI (dysuria, frequency, urgency, suprapubic pain, fever, flank pain).
2. Catheterized urine samples collected under aseptic precautions from patients with suspected catheter-associated UTI.
3. Samples yielding significant bacteriuria, defined as colony count $\geq 10^5$ CFU/mL in symptomatic patients.
4. Patients of all age groups and both sexes.

Exclusion Criteria

1. Urine samples with mixed growth of more than two organisms, considered as contamination.
2. Samples from patients already on antibiotic therapy for >48 hours before collection.
3. Repeat cultures from the same patient within 14 days, unless a new clinical episode was documented.
4. Inadequately collected samples (unlabeled, insufficient quantity, or non-sterile container).

Sample Collection and Processing

Urine specimens were collected in sterile, wide-mouth, leak-proof containers following standard aseptic techniques. For catheterized patients, urine was aspirated from the sampling port after disinfection, avoiding collection from drainage bags. Samples were transported to the microbiology laboratory within 1 hour of collection; those delayed were refrigerated at 4 °C for a maximum of 6 hours before processing.

Culture and Identification of Isolates

Each specimen was inoculated using a calibrated 0.001 mL loop on Cystine Lactose Electrolyte-Deficient (CLED) agar, MacConkey agar, and Blood agar plates. Plates were incubated aerobically at 37 °C for 18–24 hours.

Colony counts were recorded, and significant growth ($\geq 10^5$ CFU/mL) was considered positive. Organisms were identified based on colony morphology, Gram staining, and a battery of standard biochemical tests, supplemented by automated identification systems where required.

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing (AST) was performed by the Kirby-Bauer disk diffusion method on Mueller–Hinton agar, and results were interpreted according to Clinical and Laboratory Standards Institute (CLSI) M100, 34th edition (2024) guidelines.

The following antibiotics were tested:
β-lactams: Amoxicillin, Amoxicillin–Clavulanic acid, Ceftriaxone, Cefepime. Aminoglycosides: Gentamicin. Fluoroquinolones: Ciprofloxacin, Norfloxacin. Nitrofurantoin. Sulfonamides: Trimethoprim–Sulfamethoxazole (Co-trimoxazole). Tetracycline. Carbapenems: Meropenem. Macrolides: Azithromycin (for Gram-positive isolates).
Quality control strains (E. coli ATCC 25922, S. aureus ATCC 25923, P. aeruginosa ATCC 27853) were included with each batch of AST.

Data Collection and Analysis

Demographic details (age, sex), culture results, and susceptibility profiles were extracted from laboratory registers. Data were compiled in Microsoft Excel 2019 and analyzed using SPSS version 25.0. Results were expressed as frequencies and percentages.

RESULTS

Out of 1250 urine samples, 419 (33.5%) showed significant bacterial growth. Of these, 139 (33.2%) were males and 280 (66.8%) females.

Table 1: Age- and Sex-wise Distribution of UTI Cases (n = 419)

Age group	Male n (%)	Female n (%)	Total n (%)
<18 years	10 (2.4%)	5 (1.2%)	15 (3.6%)
18–30 years	8 (1.9%)	38 (9.1%)	46 (11.0%)
31–45 years	11 (2.6%)	133 (31.7%)	144 (34.3%)
>45 years	110 (26.3%)	104 (24.8%)	214 (51.1%)
Total	139 (33.2%)	280 (66.8%)	419 (100%)

Table. 2. Uropathogen Distribution

Among the 419 isolates:

E. coli	225 (53.7%)
K. pneumonia	115 (27.4%)
P. aeruginosa	36 (8.6%)
Proteus spp	20 (4.8%)
Enterobacter spp	7 (1.7%)
S. aureus	6 (1.4%)

Table 3: Antibiotic Susceptibility of Uropathogens (n = 419)

Antibiotic	E. coli (225)	K. pneumoniae (115)	P. aeruginosa (36)	Proteus spp. (20)	Enterobacter spp. (7)	S. aureus (6)
Gentamicin	204 (90.7%)	78 (67.8%)	12 (33.3%)	19 (95.0%)	4 (57.1%)	3 (50.0%)
Amoxicillin	40 (17.8%)	9 (7.8%)	0 (0%)	9 (45.0%)	0 (0%)	1 (16.7%)
Amox-Clav.	116 (51.6%)	42 (36.5%)	0 (0%)	11 (55.0%)	1 (14.3%)	2 (33.3%)
Azithromycin	49 (21.8%)	27 (23.5%)	2 (5.6%)	6 (30.0%)	1 (14.3%)	1 (16.7%)
Cefepime	97 (43.1%)	60 (52.2%)	12 (33.3%)	14 (70.0%)	4 (57.1%)	2 (33.3%)
Ceftriaxone	73 (32.4%)	30 (26.1%)	5 (13.9%)	12 (60.0%)	1 (14.3%)	1 (16.7%)
Ciprofloxacin	67 (29.8%)	35 (30.4%)	6 (16.7%)	9 (45.0%)	3 (42.9%)	1 (16.7%)
Nitrofurantoin	179 (79.6%)	37 (32.2%)	0 (0%)	0 (0%)	1 (14.3%)	0 (0%)
Norfloxacin	64 (28.4%)	36 (31.3%)	6 (16.7%)	10 (50.0%)	3 (42.9%)	2 (33.3%)
Tetracycline	85 (37.8%)	35 (30.4%)	0 (0%)	0 (0%)	3 (42.9%)	2 (33.3%)
Cotrimoxazole	121 (53.8%)	62 (53.9%)	0 (0%)	15 (75.0%)	3 (42.9%)	2 (33.3%)
Meropenem	216 (96.0%)	81 (70.4%)	9 (25.0%)	19 (95.0%)	4 (57.1%)	2 (33.3%)

DISCUSSION

In this 1,250-sample retrospective series, 33.5% of urine cultures yielded significant growth, with a clear female predominance and age skew toward elderly men—patterns consistently reported in contemporary literature. E. coli remained the leading uropathogen (~54%), followed by Klebsiella pneumoniae (~27%), then Pseudomonas, Proteus, Enterobacter, and S. aureus. This distribution mirrors multicentre Indian reports and global syntheses, where Enterobacterales—especially uropathogenic E. coli (UPEC)—dominate community and mixed-setting UTIs (1,2).

The susceptibility profile in our cohort—good activity of nitrofurantoin and trimethoprim-sulfamethoxazole (TMP-SMX) against uncomplicated cystitis, with reduced activity of fluoroquinolones, amoxicillin, and third-generation cephalosporins—aligns with recent Indian trends and international guidance. Indian surveillance and hospital-level studies since 2023 describe rising resistance in Enterobacterales to fluoroquinolones and many β-lactams, while nitrofurantoin often retains activity against UPEC; carbapenem susceptibility varies by centre and case-mix (3–5). Meta-analysis and cohort data in 2024–2025 likewise report preserved nitrofurantoin performance in lower UTIs despite concerning global signals of emerging nitrofurantoin resistance in some regions—underscoring the need for local antibiograms to steer empiric choices (6,7).

Guideline convergence is notable. The 2024 IDSA AMR guidance recommends nitrofurantoin or TMP-SMX as preferred empiric therapy for uncomplicated cystitis due to ESBL-producing E. coli, reserving fluoroquinolones and carbapenems as alternatives when necessary; fosfomycin is an option for E. coli cystitis but not for pyelonephritis/cUTI (8). The 2023 WHO AWaRe framework similarly positions nitrofurantoin and co-trimoxazole in the Access group for lower UTIs to promote stewardship and curb resistance (9–11). Our findings—high activity of nitrofurantoin, moderate of TMP-SMX, poor fluoroquinolone/ceftriaxone performance—are consistent with these recommendations for uncomplicated lower UTIs. For complicated infections, men, suspected upper-tract disease, or prior multidrug exposure, agents should be tailored to culture results and

local susceptibility, with nitrofurantoin avoided in tissue-invasive disease given limited penetration (12,13).

Methodologically, we adhered to contemporary CLSI standards for AST interpretation (M100, 34th ed., 2024) (14). That said, as a single-centre, retrospective analysis, case-mix (OPD vs IPD, catheter-status) and prior antibiotic exposure were not stratified—factors known to influence resistance ecology. National ICMR-AMRSN outputs (2023) emphasize centre-to-centre variability in Enterobacterales resistance and the importance of continuous, standardized surveillance—precisely the rationale for updating our antibiogram annually (5).

DECLARATIONS:

Conflicts of interest: There is no any conflict of interest associated with this study
Consent to participate: There is consent to participate.
Consent for publication: There is consent for the publication of this paper.
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