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Prevalence of Uropathogens and Their Antimicrobial Susceptibility Patterns in Urinary Tract Infections: A Three-Year Retrospective Study from a Tertiary Care Hospital

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ABSTRACT

Background: Urinary tract infections are among the most common bacterial infections worldwide, and rising antimicrobial resistance among uropathogens increasingly compromises empirical therapy.
Aim and Objectives: To determine the prevalence of uropathogens and evaluate their antimicrobial susceptibility patterns among patients with urinary tract infections attending a tertiary care teaching hospital over a three-year period.
Methods: This retrospective study reviewed laboratory records of urine samples received in the Department of Microbiology of a tertiary care teaching hospital in North India between January 2021 and December 2023. Specimens were cultured on cystine lactose electrolyte-deficient agar, isolates were identified by standard microbiological methods, and antimicrobial susceptibility testing was performed by the Kirby–Bauer disk diffusion method and interpreted according to Clinical and Laboratory Standards Institute guidelines.
Results: Of 801 urine samples processed, 298 (37.2%) yielded significant microbial growth. Females accounted for 62.4% of culture-positive cases, with infection most frequent in the 21–30-year age group (25.2%). *Escherichia coli* was the predominant uropathogen (39.3%), followed by *Enterococcus* spp. (28.9%), coagulase-negative staphylococci (9.1%), and *Klebsiella* spp. (7.0%); Gram-negative bacilli predominated overall (55.4% of bacterial isolates). Fosfomycin (96%) and nitrofurantoin (78%) were the most active oral agents against *E. coli*, whereas fluoroquinolone susceptibility was poor (ciprofloxacin 21%; levofloxacin 27%). Linezolid, vancomycin, and teicoplanin retained excellent activity (93–100%) against Gram-positive isolates, including all MRSA isolates. *Klebsiella* spp. showed maximum susceptibility to cotrimoxazole (84%), and carbapenem susceptibility among non-fermenters was suboptimal.
Conclusions: *Escherichia coli* remained the predominant uropathogen, with higher prevalence among females. Sustained local surveillance, culture-guided therapy, and antimicrobial stewardship are essential to preserve the effectiveness of the remaining oral agents.

Keywords: Urinary tract infection; Uropathogens; *Escherichia coli*;

Antimicrobial susceptibility; Antibiotic resistance; Retrospective study

INTRODUCTION

Urinary tract infections are among the most common bacterial infections encountered in clinical practice and represent a major cause of morbidity worldwide [1]. They affect individuals across all age groups and account for a substantial proportion of outpatient visits, emergency department consultations, and hospital admissions [2]. It has been estimated that more than 150 million cases of UTIs occur annually worldwide, resulting in significant healthcare costs and loss of productivity [3]. Women are particularly susceptible because of anatomical and physiological factors such as a shorter urethra, proximity of the urethral opening to the anus, sexual activity, pregnancy, and postmenopausal hormonal changes [2]. In addition to causing acute illness, recurrent and complicated UTIs may lead to pyelonephritis, renal damage, bacteremia, and sepsis, thereby increasing the overall burden on healthcare systems [3].

The treatment of UTIs has become increasingly challenging because of the emergence and rapid spread of antimicrobial resistance among common uropathogens [4]. Empirical antibiotic therapy is often initiated before culture and susceptibility results become available, making knowledge of local pathogen prevalence and resistance patterns essential for effective management [5]. Over recent years, increasing resistance has been reported against commonly prescribed antimicrobial agents, particularly fluoroquinolones, cephalosporins, and β-lactam antibiotics, as reflected in national surveillance data [6]. The emergence of multidrug-resistant organisms, including extended-spectrum beta-lactamase-producing Enterobacterales, carbapenem-resistant Gram-negative bacilli, methicillin-resistant staphylococci, and resistant *Enterococcus* species, has further complicated therapeutic decisions [7]. Inappropriate and excessive antibiotic use contributes to treatment failure, prolonged hospitalization, recurrent infections, increased healthcare expenditure, and the continued dissemination of resistant pathogens [4].

The distribution of uropathogens and their antimicrobial susceptibility profiles varies considerably across geographical regions, healthcare settings, patient populations, and time periods [1]. Factors such as local prescribing practices, infection control measures, healthcare infrastructure, and socioeconomic conditions influence the epidemiology of urinary tract infections [2]. Therefore, susceptibility data generated from one institution may not be directly applicable to another [5]. Continuous local surveillance is essential for developing institution-specific antibiograms, guiding empirical antibiotic therapy, supporting antimicrobial stewardship programs, and improving patient outcomes [8].

Considering the increasing burden of urinary tract infections and the growing challenge of antimicrobial resistance, regular monitoring of urinary pathogens and their susceptibility patterns is necessary to support evidence-based clinical decision-making. Therefore, the present study was undertaken to determine the prevalence of uropathogens isolated from urine samples and to evaluate their antimicrobial susceptibility patterns among patients attending a tertiary care teaching hospital in North India over a three-year period.

MATERIALS & METHODS

Study Design

This retrospective observational study involved analysis of microbiological laboratory records over a three-year period.

Study Setting and Duration

The study was carried out in the Department of Microbiology at a tertiary care hospital in North India. Laboratory records of urine specimens received between January 2021, and December 2023 were reviewed and analysed.

The microbiology laboratory functions as a tertiary care diagnostic center catering to both outpatient (OPD) and inpatient (IPD)

services, receiving specimens from various clinical departments including General Medicine, Surgery, Obstetrics and Gynecology, Pediatrics, Urology, Nephrology, and Intensive Care Units.

Study Population

The study included urine specimens received from patients of all age groups and both sexes who were clinically suspected of having urinary tract infection and were advised to undergo urine culture and antimicrobial susceptibility testing by the treating physician.

Inclusion Criteria

- Urine samples received for culture and antimicrobial susceptibility testing during the study period.
- Samples from patients of all age groups and both genders.
- Samples showing significant microbial growth on culture.

Exclusion Criteria

- Duplicate isolates obtained from the same patient during a single episode of infection.
- Samples with insignificant bacterial growth.
- Mixed growth suggestive of contamination.
- Incomplete laboratory records lacking essential demographic or microbiological information.

Sample Collection and Transportation

Urine specimens were collected using standard aseptic precautions. Midstream clean-catch urine samples were preferred for ambulatory patients, while catheterized urine samples were collected aseptically whenever indicated. Samples were transported promptly to the microbiology laboratory and processed without undue delay to minimize bacterial overgrowth and ensure reliability of culture results.

Culture and Identification of Isolates

Urine specimens were cultured using a calibrated sterile loop delivering 0.01 mL of urine onto Cysteine Lactose Electrolyte Deficient (CLED) agar using the T-streak method. The inoculated plates were incubated aerobically at 37°C for 18–24 hours.

Following incubation, colony counts were performed and interpreted quantitatively. Significant bacteriuria was defined as growth of a single organism at a concentration of $\geq 10^5$ colony-forming units (CFU)/mL of urine. **[9]** Samples demonstrating mixed bacterial growth were considered contaminated and excluded from analysis.

Microbial identification was carried out using standard microbiological techniques including assessment of colony morphology, Gram staining characteristics, motility testing where appropriate, and conventional biochemical reactions. Organisms were identified to the species level whenever possible.

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing was performed using the Kirby–Bauer disk diffusion. **[9]** A standardized bacterial suspension equivalent to 0.5 McFarland turbidity standard (Leber, 2016) was prepared from pure colonies. The suspension was inoculated uniformly onto Mueller–Hinton agar plates and antibiotic disks were applied using sterile forceps. Plates were incubated aerobically at 37°C for 16–18 hours.

Zone diameters were measured and interpreted as susceptible, intermediate, or resistant according to the Clinical and Laboratory Standards Institute (CLSI) guidelines applicable during the respective year of testing **[10]**.

The antibiotic panel varied according to the organism isolated as per CLSI guidelines.

Quality Control

Quality control for culture media, biochemical identification procedures, and antimicrobial susceptibility testing was performed in accordance with Clinical and Laboratory Standards Institute (CLSI) recommendations. **[10]** Standard American Type Culture Collection (ATCC) reference strains were used to ensure the accuracy and

reliability of antimicrobial susceptibility testing. The quality control strains included *Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853, *Staphylococcus aureus* ATCC 25923, and *Enterococcus faecalis* ATCC 29212 (Yechouron, Dascal, Stevenson, & Mendelson, 1991). Zone diameters obtained for these control strains were monitored regularly and interpreted according to CLSI quality control ranges before reporting patient results.

Data Collection

Demographic variables including age and gender were retrieved from laboratory records. Microbiological variables included culture positivity, isolated organisms, and antimicrobial susceptibility profiles.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics version 26.0. For statistical presentation, organisms with low individual frequencies were grouped according to microbiological characteristics for antimicrobial susceptibility analysis. Categorical variables were expressed as frequencies and percentages. The chi-square goodness-of-fit test was applied to assess whether the sex distribution of culture-positive cases differed from an expected 1:1 ratio. A p-value <0.05 was considered statistically significant

Ethical Considerations

The study was approved by the Institutional Ethics Committee, Integral Institute of Medical Sciences & Research (IIMS&R), Integral University, Lucknow (Approval No. IEC/IIMSR/2023/37, approved on 17 October 2023). As this was a retrospective study using anonymous laboratory records, the requirement for informed consent was waived by the Institutional Ethics Committee. Patient confidentiality was maintained throughout the study.

RESULT

Demographic characteristics (Table 1)

During the study period, a total of 801 urine samples were processed for culture and antimicrobial susceptibility testing, of which 298 yielded significant microbial growth, corresponding to an overall culture positivity rate of 37.2%.

Of the 298 culture-positive patients, females constituted the majority, accounting for 186 (62.4%) cases, whereas males represented 112 (37.6%), giving a female-to-male ratio of approximately 1.7:1 ($\chi^2 = 18.06$, $p < 0.001$). Age-wise analysis demonstrated the highest proportion of infections in the 21–30 years age group (75; 25.2%), followed by 31–40 years (48; 16.1%), 0–10 years (46; 15.4%), 11–20 years (43; 14.4%), 41–50 years (32; 10.7%), 51–60 years (29; 9.7%), and >60 years (25; 8.4%).

Distribution of uropathogens (Table 2)

A total of 298 organisms were recovered from the 298 culture-positive urine samples. *Escherichia coli* was the predominant uropathogen, accounting for 117 (39.3%) isolates, followed by *Enterococcus* spp. with 86 (28.9%) isolates, comprising *Enterococcus faecalis* (62; 20.8%) and *Enterococcus faecium* (24; 8.1%). Coagulase-negative staphylococci accounted for 27 (9.1%) isolates and *Klebsiella* spp. for 21 (7.0%). The remaining isolates included MRSA (11; 3.7%), *Pseudomonas* spp. (8; 2.7%), *Citrobacter* spp. (7; 2.3%), *Acinetobacter* spp. (5; 1.7%), *Streptococcus* spp. (5; 1.7%), *Candida* spp. (4; 1.3%), *Proteus mirabilis* (3; 1.0%), methicillin-sensitive *Staphylococcus aureus* (2; 0.7%), *Proteus vulgaris* (1; 0.3%), and *Moraxella* spp. (1; 0.3%). Of the 298 isolates, 294 were bacterial and 4 were yeasts; among the bacterial isolates, Gram-negative bacilli constituted 163 (55.4%) and Gram-positive cocci 131 (44.6%).

Antimicrobial susceptibility pattern of Gram-positive uropathogens (Table 3)

Enterococcus faecalis (N= 62) showed 100% susceptibility to linezolid and nitrofurantoin, followed by fosfomycin (97%), vancomycin (97%), teicoplanin (96%), and doxycycline

(95%). *Enterococcus faecium (N= 24)* showed poor susceptibility to ampicillin (21%) and penicillin (60%), and moderate susceptibility to nitrofurantoin (64%), with excellent activity retained by linezolid (99%), doxycycline (99%), levofloxacin (97%), teicoplanin (96%), and vancomycin (95%). High-level gentamicin susceptibility was 62% for *E. faecium* and 55% for *E. faecalis*. *Streptococcus* spp. was fully susceptible to vancomycin (100%), with good activity of cotrimoxazole (96%), ampicillin (78%), and penicillin (70%). All MRSA isolates were susceptible to linezolid, vancomycin, teicoplanin, and doxycycline, with 97% susceptibility to cotrimoxazole, whereas susceptibility to penicillin and cefoxitin was 0%. Coagulase-negative staphylococci showed highest susceptibility to teicoplanin (100%), followed by cotrimoxazole (99%), vancomycin (96%), doxycycline (95%), and linezolid (93%), with low susceptibility to cefoxitin (55%) and penicillin (24%).

Antimicrobial susceptibility pattern of *E. coli* and *Klebsiella* spp. (Table 4)

For *E. coli* (n = 117), fosfomycin was the most active agent (96%), followed by cotrimoxazole (89%), amikacin (88%), nitrofurantoin (78%), tobramycin (77%), ertapenem (74%), gentamicin (72%), and imipenem (70%). Piperacillin-tazobactam (58%) and ampicillin-sulbactam (44%) showed moderate activity, whereas cephalosporins and fluoroquinolones showed poor activity (cefazolin 15%, ceftriaxone 17%, ciprofloxacin 21%, levofloxacin 27%, ceftazidime 29%, cefepime 30%, aztreonam 34%).

For *Klebsiella* spp. (n = 21), cotrimoxazole was the most active agent (84%), followed by amikacin (75%), tetracycline (68%), tobramycin (67%), piperacillin-tazobactam (65%), and imipenem and ertapenem (65% each). Susceptibility was lowest for cefazolin (16%), ampicillin-sulbactam (33%), nitrofurantoin (33%), levofloxacin (33%), ciprofloxacin (35%), aztreonam (38%), cefepime (42%), and ceftriaxone and ceftazidime (45% each).

Antimicrobial susceptibility pattern of non-fermenters and other Gram-negative uropathogens (Table 5)

For *Pseudomonas aeruginosa*, activity was highest for amikacin and aztreonam (75% each), piperacillin-tazobactam (71%), and meropenem (71%), followed by tobramycin (63%) and imipenem (57%); susceptibility was poor for cefepime (43%), ceftazidime (25%), and ciprofloxacin and levofloxacin (13% each). For the *Citrobacter*/Moraxella/ *Proteus* group and other Gram-negatives, cotrimoxazole was the most active agent (87%), followed by imipenem (69%) and tetracycline (68%), with moderate activity of amikacin and gentamicin (55% each) and tobramycin (54%). For *Acinetobacter* spp., ampicillin-sulbactam retained the best activity (74%), followed by tobramycin (62%), meropenem (56%), imipenem (54%), and cotrimoxazole (48%), with all other agents showing ≤38% susceptibility.

Comparative susceptibility profile

Overall, fosfomycin demonstrated the highest activity against *E. coli* (96%), linezolid was the most effective agent against enterococci (99–100%), and vancomycin was most active against *Streptococcus* spp. (100%). *Klebsiella* spp. showed maximum susceptibility to cotrimoxazole (84%), and cotrimoxazole was likewise the most active agent against the *Citrobacter*/Moraxella/ *Proteus* group (87%), whereas ampicillin-sulbactam was most active against *Acinetobacter* spp. (74%). All MRSA isolates were susceptible to linezolid, vancomycin, teicoplanin, doxycycline, and nitrofurantoin. In contrast, fluoroquinolones exhibited consistently poor activity across both Gram-positive and Gram-negative uropathogens.

Table 1. Demographic characteristics of culture-positive UTI patients (n=298)

Variable	Frequency (n)	Percentage (%)
Gender		
Male	112	37.6
Female	186	62.4
Age Group (years)		
0–10	46	15.4
11–20	43	14.1
21–30	75	25.2
31–40	48	16.1
41–50	32	10.7
51–60	29	9.7
>60	25	8.4
Total	298	100

Table 2. Distribution pathogen isolated from urine cultures (n=298)

Organism	Frequency (n)	Percentage (%)
Escherichia coli	117	39.3
Enterococcus faecalis	62	20.8
Enterococcus faecium	24	8.1
CONS	27	9.1
Klebsiella spp.	21	7
MRSA	11	3.7
Pseudomonas spp.	8	2.7
Citrobacter spp.	7	2.3
Acinetobacter spp.	5	1.7
Streptococcus spp.	5	1.7
Candida spp.	4	1.3
Proteus mirabilis	3	1
Staphylococcus aureus	2	0.7
Proteus vulgaris	1	0.3
Moraxella spp.	1	0.3.
Total	298	100

"All percentages calculated with n = 298 (all isolates, including fungi) as denominator."

Table 3. Antimicrobial susceptibility pattern of major Gram-positive uropathogens (% susceptible)

Antibiotic	Enterococcus faecium	Enterococcus faecalis	Streptococcus spp.	MRSA	CONS
Penicillin	60	54	70	0	24
Ampicillin	21	62	78	NA	NA
Linezolid	99	100	NA	100	93
Vancomycin	95	97	100	100	96
Teicoplanin	96	96	NA	100	100
Nitrofurantoin	64	100	NA	NA	NA
Doxycycline	99	95	NA	100	95
H LG	62	55	NA	NA	NA
Ciprofloxacin	84	79	NA	NA	NA
Levofloxacin	97	94	NA	NA	NA
Fosfomycin	NA	97	NA	NA	NA
SXT-TMP	NA	NA	96	97	99
Cefoxitin	NA	NA	NA	0	55

Table 4. Antimicrobial susceptibility pattern of major Gram-negative uropathogens (% susceptible)

Antibiotic	E. coli (n= 117)	Klebsiella spp.(n=21)
Ampicillin/Sulbactam	44	33
Piperacillin/Tazobactam	58	65
Gentamicin	72	58
Amikacin	88	75
Tobramycin	77	67

Ceftriaxone	17	45
Ceftazidime	29	45
Cefepime	30	42
Aztreonam	34	38
Ciprofloxacin	21	35
Levofloxacin	27	33
Imipenem	70	65
Ertapenem	74	65
Cefazolin	15	16
Nitrofurantoin	78	33
Tetracycline	54	68
Fosfomycin	96	NA
Cotrimoxazole	89	84

Table 5. Antimicrobial susceptibility pattern of non-fermenters and other Gram-negative Uropathogens (% susceptible)

Antibiotic	Pseudomonas Aeruginosa	Citrobacter/Moraxella/ Proteus spp. etc.	Acinetobacter
Piperacillin/Tazobactam	71	46	38
Gentamicin	NA	55	38
Amikacin	75	55	32
Tobramycin	63	54	62
Cefepime	43	20	28
Ceftazidime	25	31	34
Aztreonam	75	40	NA
Ciprofloxacin	13	33	34
Levofloxacin	13	38	33
Imipenem	57	69	54
Meropenem	71	46	56
Ampicillin- sulbactam	NA	NA	74
Tetracycline	NA	68	NA
Cotrimoxazole (SXT-TMP)	NA	87	48
Ceftriaxone	NA	46	15

DISCUSSION

Although the reported prevalence of urinary tract infections varies widely depending on the study population, healthcare setting, urine collection techniques, and previous antibiotic exposure, community-based studies generally report lower positivity rates [11]. Urinary tract infection remains one of the most frequently encountered bacterial infections worldwide and continues to place a substantial burden on healthcare systems [1,12]. The management of complicated UTIs remains particularly challenging because of increasing antimicrobial resistance and limited therapeutic options [2,7]. These findings highlight the continued importance of urine culture in confirming the diagnosis and providing reliable antimicrobial susceptibility data to guide empirical treatment, rather than relying solely on clinical symptoms.

Female patients accounted for nearly two-thirds of all culture-positive cases, reflecting the well-established epidemiology of urinary tract infections. Anatomical and physiological factors, including a shorter urethra, its close proximity to the anal region, sexual activity, pregnancy, and hormonal changes, contribute to the increased susceptibility of women to UTIs [12,13]. A similar female predominance has also been reported in studies from South India [14]. The highest frequency of infection was observed in the 21–30-year age group, which may be associated with greater sexual activity, pregnancy-related healthcare visits, and increased healthcare utilization among young adults [13,14]. However, as these variables were not available in the present

retrospective study, these explanations remain speculative. From a clinical perspective, this age group frequently receives outpatient oral antimicrobial therapy, making the susceptibility patterns of oral antibiotics observed in our study particularly relevant for empirical management.

Escherichia coli was the predominant uropathogen in the present study, accounting for 39.3% of all isolates. This finding is consistent with reports from other Indian hospital-based studies **[15,20]** as well as international studies that have described a similar distribution of uropathogens **[9,16,17].** The ability of E. coli to remain the leading cause of urinary tract infections is largely attributed to its diverse virulence mechanisms, including adhesins, fimbriae, biofilm formation, and iron-acquisition systems. These factors facilitate colonization of the periurethral region, persistence within the bladder epithelium, and subsequent ascending infection **[3,18,19]**. The pathogenic mechanisms of uropathogenic E. coli have been extensively described in systematic reviews **[20]**. From a clinical perspective, the predominance of E. coli is particularly important because it largely determines the overall antibiogram of the study population, making its antimicrobial susceptibility profile central to empirical treatment decisions. However, the proportion of E. coli observed in our study (39.3%) was lower than the 68.3% reported in Indian community-based studies **[11]**. This difference is likely related to the tertiary care setting of our hospital, where patients with catheter-associated, recurrent, previously treated, and complicated urinary tract infections are more frequently encountered, resulting in a broader spectrum of uropathogens.

Among Gram-negative isolates, fosfomycin (96%) and nitrofurantoin (78%) were the most active oral agents against *E. coli*, closely mirroring national Indian surveillance figures (fosfomycin 92.2%; nitrofurantoin 80.8%) **[5]** and the high fosfomycin (97.7%) and nitrofurantoin (98.1%) susceptibility reported among community-acquired isolates in the DARMIS-2018 study **[21]**. These findings reinforce international guideline positions that reserve these agents as first-line oral therapy for uncomplicated cystitis **[21,22]** and the pharmacological literature supporting fosfomycin's concentrated urinary activity **[6]**

In contrast, *E. coli* showed poor susceptibility to fluoroquinolones, with only 21% of isolates susceptible to ciprofloxacin and 27% to levofloxacin. These findings are consistent with the progressive increase in fluoroquinolone resistance reported over the past two decades in longitudinal surveillance studies of *E. coli* isolated from female outpatients in the United States. **[23]** and is aligned with Indian data demonstrating poor fluoroquinolone susceptibility among community-acquired Enterobacterales **[24, 25]** as well as by a tertiary care study from Delhi reporting 70.2% fluoroquinolone resistance among uropathogens **[26]**. Pooled meta-analysis of uropathogenic *E. coli* likewise demonstrates high ciprofloxacin resistance (44.5%) alongside comparatively low nitrofurantoin resistance (20.0%) **[20]**, positioning fluoroquinolone resistance as a global rather than merely local phenomenon though the markedly worse figures in our cohort compared with the 60.6% ciprofloxacin susceptibility reported among adults in DARMIS-2018 **[21]** suggest that the higher antibiotic pressure in Indian tertiary care settings has accelerated the decline.

Among Gram-positive isolates, linezolid, vancomycin, teicoplanin, and doxycycline retained excellent activity against MRSA (100% each), a reassuring profile consistent with the predictable susceptibility of MRSA to these last-line agents described in the clinical literature **[27]**; coagulase-negative staphylococci showed 99% susceptibility to cotrimoxazole. The comparatively high proportion of *Enterococcus* spp. (28.9%) observed here - considerably higher than the 5.6% reported from Indian community settings **[11]** - aligns with the increasing recognition of Gram-positive cocci in urinary

infection documented in long-term prevalence analyses **[16]**.The most plausible explanation is the tertiary care setting of our institution, where urinary catheterisation, prolonged hospitalisation, prior broad-spectrum antibiotic exposure, recurrent infection, and multiple comorbidities predispose patients to infection with these well-recognised opportunistic and hospital-associated uropathogens **[27,28]** since catheterisation and prior antibiotic exposure data were not available to us, this explanation remains speculative. Enterococcal pathogenicity is underpinned by intrinsic and acquired resistance mechanisms and by biofilm-mediated persistence on catheters and uroepithelium **[27,29]** and resistance is highly species-dependent, with *E. faecium* consistently more resistant than *E. faecalis* **[15]**. Accordingly, *E. faecalis* was more susceptible than *E. faecium* to nitrofurantoin (100% vs 64%) and ampicillin (62% vs 21%), whereas the 95% vancomycin susceptibility of *E. faecium* contrasted with the approximately 40% vancomycin resistance reported in national surveillance **[5]**; high-level gentamicin susceptibility was low in both species (faecalis 55%; faecium 62%), signalling substantial aminoglycoside resistance in enterococci **[29]**.

Klebsiella spp. showed maximum susceptibility to cotrimoxazole (84%), with moderate carbapenem activity (65%). Our carbapenem figures were more favourable than national surveillance, where carbapenem susceptibility among *K. pneumoniae* isolates has declined (imipenem 70.8% in 2017 to 42.8% in 2024; meropenem 56.3% to 48.6%) **[5]**; this discrepancy plausibly reflects single-centre sampling, the smaller number of *Klebsiella* isolates in our cohort, and variable local prescribing pressure. Nevertheless, the overall multidrug-resistant profile of our *Klebsiella* isolates parallels the global dissemination of resistant *K. pneumoniae* clones, in which a limited number of successful lineages carrying multiple resistance determinants have spread across healthcare networks worldwide **[30]** Among non-fermenting Gram-negative bacilli, *P. aeruginosa* and *Acinetobacter* spp. demonstrated poor susceptibility to most classes - ciprofloxacin and levofloxacin were active against only 13% of *Pseudomonas* isolates, and meropenem susceptibility of *Acinetobacter* spp. was 56% - mirroring the national picture, in which meropenem resistance in *A. baumannii* reached 91.0% in 2024 **[5]**; the suboptimal carbapenem activity against *P. aeruginosa* is likewise consistent with national surveillance in which carbapenem resistance is driven predominantly by metallo-β-lactamase genes, notably NDM and VIM **[5]**. The low imipenem susceptibility of our *E. coli* isolates (70%) also tracks the declining national trend (88.3% in 2017 to 68.8% in 2024) **[5]**.

Comparison with parallel studies reinforces several of these observations. A recent bacteriological profile of uropathogens reported broadly comparable organism distributions and resistance patterns **[9]**, while regional data from Jiaxing documented similar pathogen hierarchies with rising drug resistance over successive years **[31]** Comparative series of uropathogenic *E. coli* and *Enterobacter cloacae* have likewise reported fluoroquinolone and cephalosporin susceptibility below the thresholds recommended for empirical confidence **[17]**. The convergence of these findings across geographically distinct settings supports the view that the patterns documented here form part of a broader epidemiological shift rather than an institutional artefact.

Taken together, these findings argue for institution-specific antibiograms to guide empirical therapy, an approach shown to meaningfully influence prescriber behaviour even in resource-constrained settings **[31]** Concretely, this means prescribing fosfomycin and nitrofurantoin preferentially for uncomplicated cystitis, reserving fluoroquinolones and third-generation cephalosporins for settings with documented susceptibility, and embedding continuous surveillance through structured national resistance networks **[5,23]**. Personal clinical history - prior antibiotic exposure and

previous resistant isolates - should additionally be incorporated into empirical decision-making, as it is a documented predictor of resistance in individual patients **[4]**. Emerging management strategies, including re-evaluation of older agents and novel therapeutic pathways, may offer additional options as the oral armamentarium narrows **[2,6,8]**. The overarching objective remains preservation of the remaining oral options and containment of further escalation of multidrug resistance.

The present study has several strengths. Three years of continuous data provided adequate sample volume to characterise pathogen distribution and resistance trends. Standardised microbiological techniques were used throughout, with culture on validated media and susceptibility testing performed according to CLSI guidelines **[10,32]**, supported by appropriate quality control strains **[33]**. Institution-specific data of this kind directly support evidence-based prescribing for the population the laboratory serves.

Certain limitations should be acknowledged. This was a retrospective, single-centre study, limiting generalisability to other settings. Detailed clinical information — catheterisation status, specimen type, prior antibiotic exposure, comorbidities, and treatment outcomes — was unavailable for analysis, even though such history is a documented predictor of resistance **[4]**. Molecular characterisation of ESBL and carbapenemase production was not performed, so resistance mechanisms were inferred phenotypically rather than genotypically. Future multicentre prospective studies incorporating clinical risk-factor analysis, molecular resistance profiling, and outcomes data would provide a more comprehensive understanding of the evolving epidemiology and resistance patterns of uropathogens.

CONCLUSION

In conclusion, our three-year surveillance confirms the enduring predominance of *E. coli* alongside a substantial burden of *Enterococcus*, documents the retention of fosfomycin and nitrofurantoin as the most reliable oral agents, and demonstrates fluoroquinolone susceptibility too low to support empirical use. Institution-specific, regularly updated antibiograms supported by continuous surveillance and disciplined stewardship remain the most defensible strategy for preserving effective therapy for urinary tract infection in this setting.

Declaration by Authors

Ethical Approval: Approved by institutional ethics committee IIMS&R Integral university Lucknow with approval certificate no. IEC/IIMSR/2023/37

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