Original Article

Exploring the Trends and Spectrum of UTI-Causing Uropathogenic Bacterial Profiles and Their Antibiotic Susceptibility Patterns: A 4-Year Retrospective Study in Western Maharashtra

Amol Bausakar[1,*], Neha Singh[1], Preeti Rai[2], Pallavi Sharma[1], R Mahesh Reddy[1]

[1]Department of Microbiology, Armed Forces Medical College, Pune, Maharashtra, India.
[2]Department of Microbiology, Military Hospital Jalandhar, India.

***Correspondence:** amolbausakar@gmail.com

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Abstract

Background: Urinary tract infections (UTIs) are one of the most common and prevalent healthcare challenges worldwide, caused by uropathogens. This abstract summarizes recent research on UTI-causing uropathogens and their antibiotic susceptibility trend in a tertiary hospital over the period of four years. The study will help improve resistance surveillance and antibiotic policies, ultimately enhancing patient outcomes.
Methods: A retrospective study was conducted in a tertiary care hospital for a period of 4 years (2020-2023). 21,330 urine samples of patients with UTI-like symptoms were subjected to bacterial cultures. Samples with significant bacteriuria were subjected to identification and antibacterial susceptibility testing using the VITEK® 2 COMPACT System.
Result: Of 21,330 samples, 5,211 (24.43%) showed significant bacteriuria, with *Escherichia coli* (49.75%) being the most common uropathogen, followed by *Klebsiella pneumoniae* (24.69%), *Pseudomonas aeruginosa* (8.01%), and *Enterococcus* spp. (5.49%). Carbapenem-resistant *K. pneumoniae* isolates increased significantly from 33.21% (2020) to 59.96% (2023), while no significant rise was observed in Carbapenem-resistant *E. coli* and *P. aeruginosa* isolates. Resistance to Vancomycin (13.75%), Linezolid (9.99%), and Teicoplanin (8.12%) in *Enterococcus* species remained stable over four years. Resistance rates in ICU isolates were higher than those in outpatients and non-ICU inpatients.
Conclusion: *E. coli*, *K. pneumoniae*, *Enterococcus* spp., and *P. aeruginosa* were the most common pathogens causing UTIs in our region. The bacterial species and antimicrobial resistance patterns seen in uropathogens varied across different patient populations that visited the tertiary care hospital. Strengthening and improving the monitoring and surveillance of bacterial resistance is very essential to minimize the spread and evolution of multi-drug-resistant organisms.

Keywords: Uropathogens; Antibiotic susceptibility; Carbapenem-Resistant Enterobacterales (CRE)

Introduction

Urinary tract infections (UTIs) are one of the most prevalent bacterial infections globally. They are the most common type of infections along with respiratory tract and gastrointestinal tract infections. They are also one of the most common causes of community-acquired infections and also in hospital-acquired infections, i.e., in patients admitted to hospitals for longer durations. Each year, around 150 million individuals are affected by UTIs, leading to significant health issues and economic challenges [1]. The data on the antibiotic susceptibility of uropathogens that cause UTIs varies from one location to another and from time to time.

A Urinary tract infection (UTI) can be defined as significant bacteriuria, characterized by the growth of a single pathogen: at least 10 colony-forming units (CFU) per millilitre in catheter specimens, at least 10 CFU per millilitre in midstream clean-catch specimens, or 5×10 CFU accompanied by significant pyuria in a patient presenting with fever or other clinical symptoms [2]. UTIs can be classified as complicated and uncomplicated based on the severity of the symptoms, age, gender, pregnancy, and most importantly, the site of the infection in the urinary tract.

Escherichia coli (*E. coli*) is one of the most prevalent pathogenic organisms responsible for urinary tract infections, followed by *Klebsiella pneumoniae* (*K. pneumoniae*), *Pseudomonas aeruginosa* (*P. aeruginosa*), etc., amongst Gram-negative organisms, followed by *Enterococcus* spp. amongst Gram-positive organisms [3, 4].

Urinary tract infections (UTIs) usually require antibiotic treatment. However, the inappropriate use of antibiotics, including self-medication, has highly contributed to the growing issue of antibiotic resistance, reducing the effectiveness of many of the available treatments. The spread of antibiotic resistance varies depending on factors such as geographic location, differences in antibiotic use, and the availability of antibiotics over time [5]. In most cases, initial antibiotic therapy is given empirically. Additionally, many patients self-medicate, fail to follow prescribed dosage instructions, or stop taking antibiotics once symptoms subside. These practices, combined with the inherent susceptibility of UTI-causing pathogens to develop resistance, exacerbate the problem. As a result, high levels of antibiotic-resistant bacteria are making effective treatment options increasingly scarce [6].

Therefore, it is crucial to consistently monitor and record the prevalence of uropathogens causing UTIs and their evolving antimicrobial resistance to have an effective antibiotic policy in any healthcare setup. This study's objectives are to ascertain the prevalence of uropathogens causing UTIs and to determine the recent trends in uropathogen susceptibility patterns, which could aid physicians in providing empirical treatment.

Materials and Methods

The research employed a retrospective analysis spanning four years (2020-2023) from our tertiary care facility under the ICMR AMR Surveillance Network (ICMRASN). The included organisms in the study comprised uropathogens like *E. coli*, *K. pneumoniae*, *P. aeruginosa*, and *Enterococcus* spp., as these were the most commonly isolated uropathogens at this centre. A total of 21,330 urine samples from patients exhibiting UTI-like symptoms underwent bacterial cultures, of which samples with significant bacteriuria on growth were subsequently subjected to identification and their antimicrobial susceptibility testing using the Kirby Bauer disc diffusion method and also the VITEK® 2 COMPACT System, both as primary methods. This investigation was centred around the analysis of aggregated yearly data and did not aim to identify individual patients.

Results

21,330 midstream urine samples collected between 2020 and 2023 were examined, with a positivity rate of 24.43% (5,211). The most common uropathogen isolated was *E. coli* at 49.75% (2,593/5,211), followed by *K. pneumoniae* at 24.69% (1,287/5,211), *P. aeruginosa* at 8.01% (417/5,211), and *Enterococcus* spp. at 5.49% (286/5,211) (Figure 1).

Multidrug resistance (MDR) of commonly isolated uropathogens was observed to be higher in the Intensive Care Unit (ICU) overall as compared to Wards, followed by Out-Patient Departments (OPDs) during the period of study (Figure 2).

E. coli showed the highest overall antibiotic resistance to Ciprofloxacin (75.25%), followed by Cefazolin (68.25%) and Cotrimoxazole (57%). While the lowest rate of resistance was to Fosfomycin (6.75%) and Nitrofurantoin (21.5%). The overall antibiotic resistance trends show an increase in the resistance pattern throughout the study (Figure 3).

In the case of *K. pneumoniae*, the highest overall antibiotic resistance was to Nitrofurantoin (76.75%), followed by Cefazolin (61%) and Ciprofloxacin (66%). While a relatively low rate of resistance was to Amikacin (42%), Meropenem (48%), and Cotrimoxazole (54%). The organism has shown an increasing trend in the resistance pattern throughout the study (Figure 4).

However, *P. aeruginosa* has shown a decreasing trend in resistance over the years, with the highest resistance observed for Cefepime (63.5%), Ceftazidime (62.75%), and Piperacillin-Tazobactam (61.75%), with the least resistance to Tobramycin (37%), followed by Meropenem (53.75%) and Imipenem (54.25%) (Figure 5).

In Gram-positive *Enterococcus* spp., very high resistance was observed in Ciprofloxacin (80.75%), succeeded by Ampicillin (57.75%) and High-Level Gentamicin (50.75%), while the least resistance was given by Linezolid (8.5%), Vancomycin (13.75%), and Teicoplanin (16.5%) (Figure 6).

The year-wise data (2020 to 2023) indicates that Carbapenem resistance has almost remained the same for *E. coli* (21.47% in 2020, 22.12% in 2023) and *P. aeruginosa* (57.45% in 2020, 52.17% in 2023), whereas it has significantly increased for *K. pneumoniae* (33.21% in 2020, 59.96% in 2023) (Figure 7).

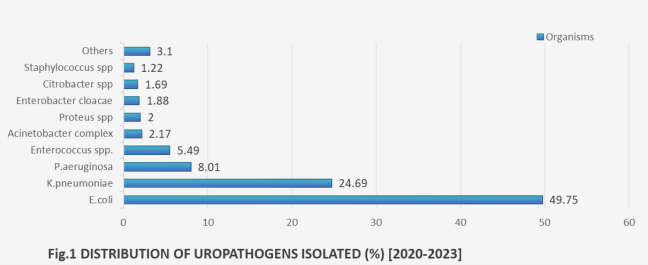

Figure 1: Distribution of Uropathogens Isolated (%) [2020-2023]

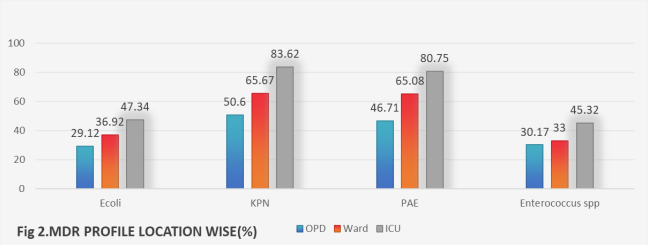

Figure 2: MDR Profile Location Wise (%)

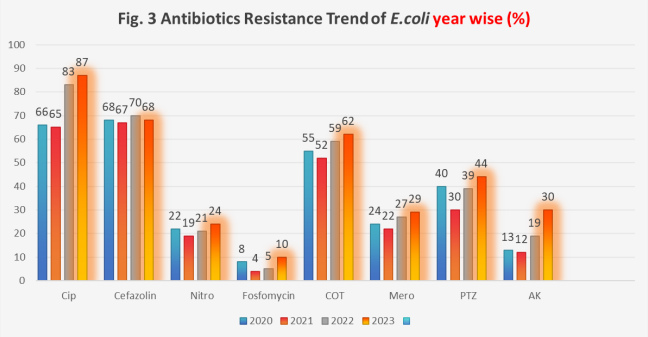

Figure 3: Antibiotics Resistance Trend of *E. coli*

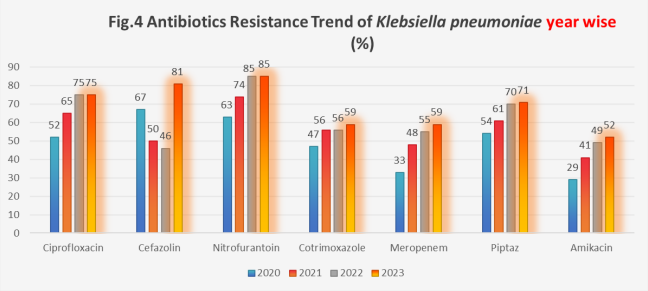

Figure 4: Antibiotics Resistance Trend of *Klebsiella pneumoniae* (%)

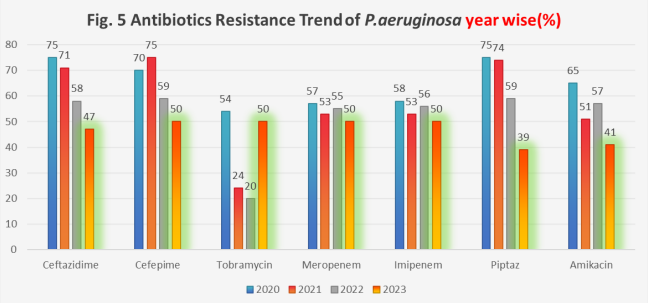

Figure 5: Antibiotics Resistance Trend of *P. aeruginosa*

Discussion

The most common cause of UTI is microorganisms from the Enterobacterales family (91%), followed by Gram-positive bacteria (7%). The most common uropathogen isolated is *E. coli* (49.75%), followed by *K. pneumoniae* (24.69%), *P.*

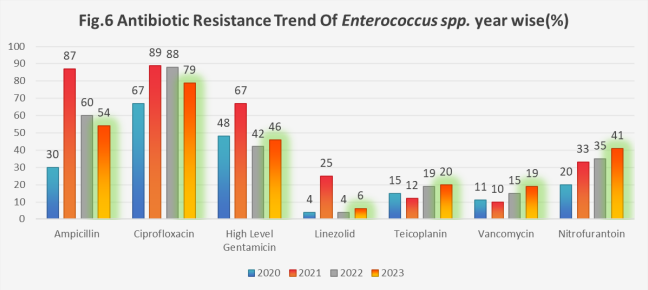

Figure 6: Antibiotic Resistance Trend of *Enterococcus* spp.

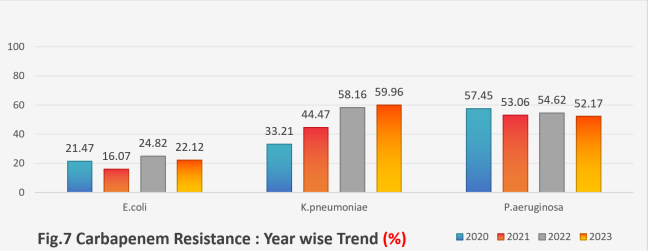

Figure 7: Carbapenem Resistance: Year-wise Trend

aeruginosa (8.01%), and *Enterococcus* spp. (5.49%), which is similar to a study conducted by Bhonsle KS et al. at Ujjain in the year 2022 [3] and similarly, Gandhi et al. in Gujarat reported *E. coli* (53.6%) and *K. pneumoniae* (20.5%) as dominant uropathogens [4]. A higher incidence of Enterobacterales in causing UTI is due to many factors which are responsible and essential for their attachment in the urogenital mucosa with adhesins, pili, fimbriae, and P-1 blood group phenotype receptor [7].

Gram-negative bacilli showed a rather high resistance rate to beta-lactam antibiotics, an expected result in the context of overprescribing and self-medication practices. Resistance to Cephalosporins for uropathogens isolated and further tested as recommended by CLSI guidelines is 68% for *E. coli* and 81% for *Klebsiella* spp., which is concerning.

Fluoroquinolones cannot be catabolized in vivo easily and are mainly excreted in urine, so they are often used as empirical drugs for UTIs. Results in this study showed that the resistance rates to fluoroquinolones in *E. coli* and *K. pneumoniae* were approximately 75%, which is similar to a study conducted by Hassan et al. in Somalia [8] and higher as compared to the study conducted by Li et al. in China [9], which indicates that the resistance rate varies among different populations in different regions and also according to the type of presentation of patients to the hospital. Similar resistance patterns were documented in a study by Prakash and Saxena in North India, where ciprofloxacin resistance in *E. coli* exceeded 70% and nitrofurantoin resistance remained below 25% [10]. *Enterococcus* spp. has shown very high resistance to penicillin and Fluoroquinolones, while preserved susceptibility to high-potency drugs like Linezolid and Vancomycin, probably since they are reserved for use in tertiary care centres and are not routinely used. This finding aligns with findings from Vignesh et al., who reported similar vancomycin susceptibility in *Enterococcus faecalis* and *E. faecium* isolates [11].

The prevalence of nosocomial infections caused by multi-drug resistant pathogens is increasing and has garnered widespread attention, with a complex treatment course and high mortality rates. Considering their efficacy against many bacteria and effectiveness against extended-spectrum β-lactamases (ESBL) producing organisms, Carbapenems are considered the most reliable last-resort treatment method [12]. This is why the rapid spread of carbapenem resistance throughout all continents, primarily among GNRs, is a major issue in public health worldwide. In this study, we observed an increasing trend in Carbapenem resistance in *K. pneumoniae*, which ranges from 33.21% in 2020 to 59.96% in 2023 (Figure 7), whereas it has remained almost stable for *E. coli* and *P. aeruginosa*. These findings are alarming and consistent with the ICMR-AMRSN surveillance data [13], which have reported increasing carbapenem resistance trends in *K. pneumoniae*, particularly in high-burden tertiary care hospitals. The Infectious Diseases Society of America [14] recommends antimicrobials like ciprofloxacin, levofloxacin, trimethoprim-sulfamethoxazole, nitrofurantoin, or a single dose of an aminoglycoside as preferred treatment options and Ceftazidime-avibactam, Meropenem-Vaborbactam, Imipenem-Cilastatin-Relebactam, or Cefiderocol as alternative options for UTIs caused by CRE.

The MDR property of microorganisms is on a steep rise, with the highest resistant organisms isolated from the ICU, followed by wards, and least in the OPD. This can be because hospitalized patients are more likely to use antibacterial drugs, which have a likely screening effect on antibiotic-resistant bacteria. ICU patients usually have a lengthier time of hospitalization and are at higher risk of exposure to immunosuppressants, chemotherapy drugs, and antibiotics, thus making them more exposed to drug-resistant pathogens [15].

This study involved data from 4 years and was extensively representative; however, there were some limitations in the analysis. Clinical data in terms of gender, age, and severity of presentation of the patient was not considered. Lastly, we could not obtain more detailed information to associate the total duration of UTIs and the patient outcome parameters, which could have provided more reference value for clinical treatment modification. Despite this, the findings obtained provide a valuable reference for the empiric treatment of UTIs.

Conclusion

This study provides a comprehensive analysis of the trends and spectrum of uropathogenic bacterial profiles responsible for urinary tract infections (UTIs) in Western Maharashtra over a four-year period. The findings underscore the dominance of *E. coli* as the most prevalent uropathogen, followed by *K. pneumoniae*, *P. aeruginosa*, and *Enterococcus* species. The investigation highlights significant concerns regarding antibiotic resistance, particularly among *E. coli* and *K. pneumoniae*, which exhibited alarming resistance rates to commonly used antibiotics such as fluoroquinolones, Cephalosporins, and beta-lactams.

Of particular note is the increasing trend of multidrug resistance (MDR), especially within Intensive Care Units (ICUs), where the highest resistance rates were observed. Carbapenem resistance, in particular, has emerged as a growing challenge, especially for *K. pneumoniae*. While some pathogens, like *P. aeruginosa*, showed a decrease in resistance over time, the overall pattern suggests a troubling rise in resistance that complicates empirical treatment strategies.

This study highlights the critical need to adopt stricter antibiotic stewardship practices and implement comprehensive infection control measures to curb the rise of resistant strains. This will ensure better clinical outcomes and preserve the efficacy of current therapeutic options for UTIs.

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