



PREVALENCE AND ANTIMICROBIAL RESISTANCE PATTERNS OF UROPATHOGENS: A LABORATORY-BASED COMPREHENSIVE STUDY

Mahesh Patidar^{1*}, Dr. Amit Kumar Sharma²

^{1*}Ph.d Microbiology, Dr. K. N. Modi University, Newai, Rajasthan, Email Id- patidarmahesh790@gmail.com ORCID iD: 0009-0009-1507-2203

²Associate Professor Department of Applied Sciences, Dr. K. N. Modi University, Newai, Rajasthan, Email Id- aks00977@gmail.com

***Corresponding Author: Mahesh Patidar**

*Ph.d Microbiology Email Id- patidarmahesh790@gmail.com ORCID iD: 0009-0009-1507-2203

Abstract

UTIs are some of the most prevalent bacterial infections that are experienced in clinical practice. This has resulted in the growing occurrence of antimicrobial resistance of uropathogens that has proven to be a big burden on the treatment options across the globe. The objective of this study is to determine the most common bacterial pathogens that cause UTIs, and to determine the antimicrobial resistance patterns of these pathogens using standard laboratory procedures. The clinically suspected cases of UTI were subjected to the processing of urine samples obtained to culture and identify microorganisms and the susceptibility to antimicrobials. The gram negative bacteria were identified to be the predominant causative agents, with *Escherichia coli* being the most common organism that was isolated. It was found that high resistance rates were recorded to some of the antibiotics that are commonly used and comparatively better susceptibility was recorded against reserve drugs. The results illuminate the significance of regular culture and susceptibility analysis to inform effective antimicrobial care and prevent the development of resistance..

Keywords: Urinary tract infection, uropathogens, antimicrobial resistance, antibiotic susceptibility, clinical microbiology

1. Introduction

UTIs are one of the most common types of bacterial infections in medical practice and one of the primary reasons behind diagnostic tests and antimicrobial prescriptions all over the world. UTIs can be as simple as lower urinary tract infections, and as extreme as upper tract and urosepsis. Most UTIs are caused by bacterial pathogens, although uropathogenic *Escherichia coli* (UPEC) is always indicated as the leading etiological agent (Seifu and Gebissa 2018; Sana et al. 2023).

Timely and correct antimicrobial therapy is a determinant of the successful management of UTIs. Nonetheless, the high rate of development and dispersion of antimicrobial resistance (AMR) in uropathogens has turned into one of the significant health issues worldwide. Surveillance studies in laboratories have confirmed over and over again that there is a growing resistance to commonly prescribed antibiotics including ampicillin, cotrimoxazole, and fluoroquinolones, thus

limiting the availability of empirical treatment with increased risk of therapeutic failure (Hamad alneel et al. 2024; Chowdhury et al. 2024).

In recent studies, both the cross-sectional and retrospective laboratory-based studies have reported an alarming prevalence of multidrug-resistant (MDR) uropathogens. A large study carried out in a tertiary-care hospital in Bangladesh showed a high percentage of MDR isolates in over 6,500 samples of urine samples tested, especially in Gram-negative bacteria (Chowdhury et al. 2024). The same tendency has been observed in long-term surveillance studies in Africa, where resistance of various classes of antimicrobials has steadily increased over a few years (Garoy et al. 2024; Ouedraogo et al. 2025).

Of specific interest is the increasing rate of extended spectrum β -lactamase (ESBL)-producing *Escherichia coli* in urinary isolates. In a 2024 laboratory research, a critical rate of ESBL-producing UPEC strains was found and the widespread resistance to 2-lactam antibiotics and fluoroquinolones was identified (Dhaure 2024). Similar results were presented in a crosssectional study conducted in Kirkuk that revealed that the prevalence of β -lactam resistance was high in uropathogenic *E. coli* isolates and that amoxicillin resistance rates were the highest (Ahmed 2025).

Although there are geographical differences, some pattern of resistance has been observed across numerous laboratory-based studies. The efficacy of older oral antibiotics is significantly lower, and such agents as nitrofurantoin, aminoglycosides, and carbapenems still show a relatively preserved activity against the majority of uropathogens (Hamad alneel et al. 2024; Sana et al. 2023). These results underline the necessity of the constant control of antimicrobial resistance and the presence of regular susceptibility testing.

Considering the dynamic characteristics of antimicrobial resistance, local, time-dependent laboratory data will be necessary in order to support rational antibiotic choices and antimicrobial stewardship projects. The constant observation of the prevalence and susceptibility profiles of uropathogenes is of paramount importance to enhance the treatment process and reduce the further proliferation of resistant strains. The current work was thus conducted to assess the existing occurrence of uropathogenic bacteria in urine samples attended to in pathology labs and also determine their patterns of antimicrobial susceptibility to standardized laboratory protocols.

2.Review of Literature: Prevalence and Antimicrobial Resistance Patterns of Uropathogens

UTIs are the most widespread types of bacterial infections in the world where millions of individuals are impacted each year. *Escherichia coli* is always mentioned as the most common uropathogen in various epidemiological studies. Ironmonger (2018) proved that *E. coli* prevails over the positive cultures in UTI patients, then *Klebsiella* spp., and *Enterococcus* spp., and *Pseudomonas* spp., making it a crucial pathogen worth attention in the global context. Onyango (2018) also reported similar patterns in the laboratory-based surveillance of pregnant women, whereby *E. coli* is predominant.

It has also been observed to have regional differences in prevalence. According to Silago et al. (2024), approximately 41 % of culture-confirmed UTI in outpatients in Tanzania were *E. coli*, which in many cases formed a biofilm, contributing to persistent infection and difficulty in treatment. Gupta et al. (1999) emphasized the incidence of UTI in women which is a result of the interaction of anatomy, hormones, and immunological factors.

The Patterns of antimicrobial Resistance in Uropathogens.

The antimicrobial resistance (AMR) surveillance of the uropathogens has been growing alarming in both the community-acquired and hospital-acquired infections.

2.1. Resistance to Most Common Antibiotics at a High Level.

Asia-Pacific systematic reviews indicate alarming rates of resistance rates among the major uropathogens. Sugianli et al. (2021) found up to 90 % resistance to first-line medications, including trimethoprim-sulfamethoxazole and some cephalosporins, especially in isolates of *E. asionale* and *Klebsiella pneumoniae*. In the same manner, it has been indicated that ampicillin and co-trimoxazole

had a high level of resistance in uropathogens in Ghana, but nitrofurantoin and amikacin were more effective (Karikari et al., 2022).

2.2 Multi-Drug Resistance and Clinical Implications.

Multidrug resistance (MDR), which refers to resistance to two or more classes of antimicrobials, is a common occurrence in most instances. Indicatively, Onyango (2018) and Silago et al. (2024) found that MDR is over 70 per cent prevalent in some groups of patients, which makes their empirical treatment challenging. Uropathogenic biofilm-producing bacteria are frequently more resistant than non-biofilm producers, which highlights the importance of making antimicrobial choices using an accurate lab strategy (Ironmonger, 2018).

2.3. Surveillance, Stewardship and Treatment Implications.

The literature reviewed highlights the focus on:

- Surveillance related to the geographic and population-specific areas as the means of guiding the empirical treatment (Sugianli et al., 2017; Gupta et al., 1999).
- Much resistance to commonly used antibiotics, which necessitates target antimicrobial susceptibility testing (Karikari et al., 2022).
- Implementation of antimicrobial stewardship interventions to maintain the antimicrobial effect and to decrease the transmission of MDR (Ironmonger, 2018; Onyango, 2018).

Enhanced surveillance and culture-directed prescriptions and stewardship interventions are critical to reduce AMR among uropathogens..

2. Objectives

1. To determine the prevalence of bacterial uropathogens isolated from urine samples.
2. To analyze antimicrobial resistance patterns of isolated uropathogens.
3. To identify the occurrence of multidrug-resistant (MDR) strains.
4. To generate laboratory-based evidence for rational antibiotic selection.

3. Materials and Methods

3.1 Study Design

The current study was planned as a cross-sectional laboratory-based research in the Department of Clinical Microbiology of one of the tertiary-care diagnostic laboratories. The purpose of the study was to identify the frequency of the bacterial uropathogens and also to identify the patterns of antimicrobial resistance of bacteria in the culture positive cases of urinary tract infection. All laboratory experiments were conducted within acceptable standard microbiological procedures during a set period of time.

3.2 Sample Collection

Samples of urine were taken in patients with clinical evidence that indicated them to be infected in the urinary tract. Aseptic clean-catch midstream urine samples were collected by placing the samples in sterile, wide-mouthed, leak-proof containers. The patients were educated on the appropriate sample collection methods that reduce the role of periurethral flora contamination.

The samples taken were ideally rushed to the microbiology laboratory and processed within two hours of collection. Where the immediate processing was not possible, samples were stored temporarily at 4 °C to prevent bacterial growth and maintain the integrity of the samples.

3.3 Culture and Identification of Uropathogens.

The semi-quantitative culture was performed in each urine sample with a calibrated inoculating loop (0.001 mL). Bacterial samples were inoculated on plates of Cysteine Lactose Electrolyte Deficient (CLED) agar and MacConkey agar and incubated aerobically at 37 °C in 18-24 hours.

Significant bacteriuria was defined through the standard colony count criteria with a bacterial growth of 10⁵ colony-forming units (CFU)/ml being regarded as being indicative of an infection. Growths that were mixed indicating contamination were not analyzed.

Colony morphology, lactose fermentation, and Gram staining were the first characteristics of the bacteria that were used to characterize the isolates. Additional identification was done by using the traditional biochemical tests, such as catalase, oxidase, indole, citrate utilization, urease, triple sugar iron (TSI) agar reaction, and bile esculin hydrolysis because it was suitable with the organism that was isolated.

3.4 Antimicrobial Susceptibility Testing

The methodology relies on identifying the details of the antimicrobials applied and the patients affected, then comparing them with the established drug sensitivity thresholds.

Antimicrobial Susceptibility Testing The procedure is based on this finding of the specifics of the antimicrobials used and the patients impacted and comparing it with the published drug sensitivity limits.

All confirmed uropathogenic isolates underwent antimicrobial susceptibility testing (AST) by the KirbyBauer disc diffusion technique on MuellerHinton agar, after standardized laboratory tests. Inoculation of bacteria was done with the preparation of bacterial suspensions adjusted to equal 0.5 McFarland turbidity standard.

An array of antimicrobial agents of first-, second-, and reserve antimicrobials was assessed. Aseptically, the antibiotic discs were applied to the inoculated agar surface and the plates were incubated in aerobic conditions at 37 °C within 16-18 hours.

The zones of inhibition were recorded in millimeters and the results interpreted as susceptible, the intermediate or resistant based on the interpretative standards. Test of standard reference strains and clinical isolates was utilized as control of quality. Multidrug resistance is defined as the capacity to withstand the effects of multiple drugs at elevated doses (Zhang et al., 2018).

Multidrug resistance (MDR) was also such that the non-susceptibility was observed with at least one antimicrobial agent in three or more distinct antimicrobial classes. Isolates that met this requirement were divided into multidrug-resistant and were analyzed in MDR.

Analyzing Data: Data will be analyzed using the Microsoft Excel version.

The results of all the laboratories were documented in well-organized data collection forms. Frequencies and percentages of antimicrobial resistance patterns and uropathogens were calculated by using descriptive statistical analysis. Findings were also displayed in tables and figures in order to make them easy to interpret.

4. Results

4.1 Distribution of Uropathogens

A total of 200 culture-positive urine samples were analyzed to determine the distribution of uropathogens. The isolates demonstrated a clear predominance of Gram-negative bacteria, accounting for the majority of infections.

As shown in Table 1, *Escherichia coli* was the most frequently isolated uropathogen, comprising 55.0% (n = 110) of all isolates. This was followed by *Klebsiella* species (18.0%), *Pseudomonas aeruginosa* (8.0%), and *Proteus* species (6.0%). Gram-positive organisms, primarily *Enterococcus* species, constituted 7.0% of the isolates, while other organisms accounted for the remaining 6.0%.

The overall distribution pattern highlights the dominance of Enterobacterales in urinary tract infections, which is consistent with findings reported in hospital-based UTI studies across different clinical settings.

Table 1. Distribution of uropathogens among urinary isolates (n = 200)

Pathogen	Number of Isolates (n)	Percentage (%)
Escherichia coli	110	55.0
Klebsiella spp.	36	18.0
Pseudomonas aeruginosa	16	8.0
Proteus spp.	12	6.0
Enterococcus spp.	14	7.0
Others	12	6.0
Total	200	100

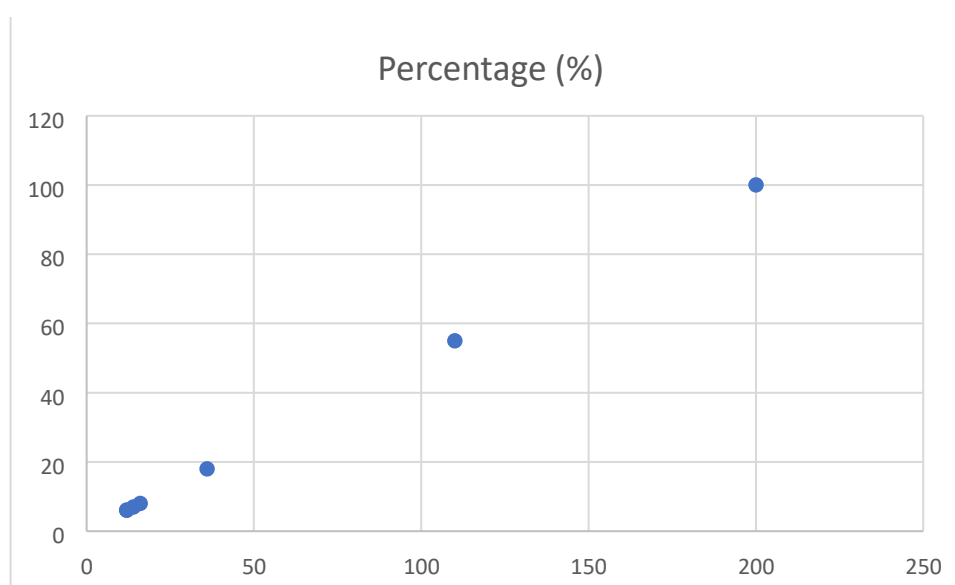
**Figure 1. Distribution of major uropathogens among urinary isolates**

Table 1 shows the distribution of uropathogens that were isolated in 200 culture positive urine samples that were analyzed during the present study. The results show that the Gram-negative bacteria dominated the sample with the majority of the urinary tract infections.

The most commonly identified uropathogen was *Escherichia coli* (110 cases 55.0%), which implies that it plays a leading role in the etiology of UTIs in the target population. Such preponderance is in line with the already confirmed capacity of *E. coli* to attach to the uroepithelium and colonize the urinary tract.

Klebsiella spp. (18.0) was the second most prevalent pathogen (36 isolates). This was followed by *Pseudomonas aeruginosa* 16 isolates (8.0%) and *Proteus spp.* 12 isolates (6.0%). Collectively, these organisms also highlight the hegemony of Enterobacterales as Gramnegative uropathogens.

Less commonly isolated were gram-positive bacteria, with 14 *Enterococcus spp.* (7.0) being identified. The contribution of other uropathogens was 12 (6.0) isolates. In general, the proportion of Gram-positive organisms UTIs was lower than the proportion of Gram-negative organisms.

The distribution of major uropathogens is graphically shown in figure 1 and clearly shows that *Escherichia coli* is by far the predominant, then comes *Klebsiella spp.* and other gram negative bacteria. The tabulated data is supplemented by the visual one and emphasized by the unequal distribution of pathogens, where the frequency decreases sharply after *E. coli*.

Overall, the pattern of distribution presented in the current research highlights the prevalence of Gram-negative Enterobacterales and, above all, *Escherichia coli* in the urinary tract infection. These results are in agreement with past hospital-based and community-based UTI research in different clinical environments.

4.2 Antimicrobial Resistance Patterns

4.2.1 Overall Antimicrobial Susceptibility

The antimicrobial susceptibility profiles of the isolated uropathogens are summarized in Table 2. High levels of resistance were observed against commonly prescribed oral antibiotics. Ampicillin demonstrated the highest resistance rate (80%), followed by cotrimoxazole (65%) and fluoroquinolones (60%).

In contrast, relatively higher susceptibility was noted for nitrofurantoin (70%) and aminoglycosides (68%). Carbapenems exhibited the highest overall activity, with 90% susceptibility and minimal resistance (5%).

These findings indicate a marked decline in the effectiveness of older first-line agents, while reserve antibiotics continue to retain activity against most uropathogens.

Table 2. Overall susceptibility of major uropathogens to selected antibiotics

Antibiotic / Class	Susceptible (%)	Intermediate (%)	Resistant (%)
Ampicillin	12	8	80
Cotrimoxazole	25	10	65
Fluoroquinolones	28	12	60
Nitrofurantoin	70	10	20
Aminoglycosides	68	12	20
Carbapenems	90	5	5

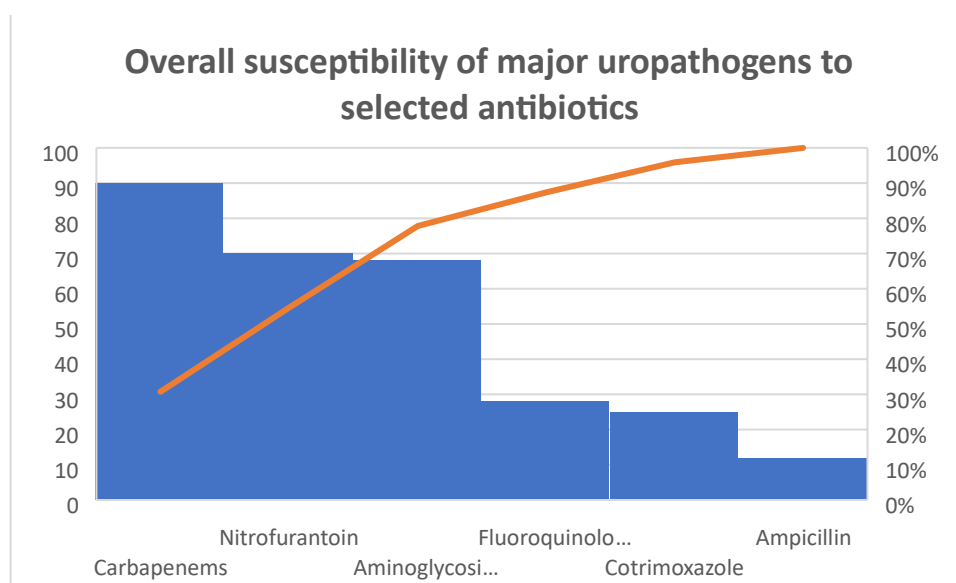


Figure-2 Overall susceptibility of major uropathogens to selected antibiotics

The susceptibility patterns of the key uropathogens to antimicrobial agents are clearly uneven with respect to effectiveness across popular antimicrobial agents. Carbapenems had highest overall activity with 90 percent of the isolates susceptible and only 5 percent resistant and therefore, these reserve antibiotics were very active when used against most uropathogens. Nitrofurantoin and aminoglycosides had relatively high susceptibility rates of 70 and 68 percent respectively, and their resistance was low, 20 percent, indicating that they can still be used as reliable option in the treatment of uncomplicated infection of the urinary tract. Conversely, the effect of older first-line agents was significantly lower. The least susceptible was ampicillin where only 12% were sensitive and the rate of resistance was high at 80 percent. On the same note, cotrimoxazole and fluoroquinolones bore susceptibility rates of 25% and 28 respectively and resistance rates of 65 and 60 respectively. The graph that comes with these results depicts the same whereby carbapenem susceptibility significantly

decreased with ampicillin. In general, these findings emphasize the increasing resistance to the traditional antibiotics and the significance of the reserve or low usage agents in the treatment of UTIs.

4.2.2 Pathogen-Wise Resistance Patterns

Detailed resistance patterns of major Gram-negative uropathogens are presented in Table 3. *E. coli* isolates exhibited high resistance to ampicillin (85%), cotrimoxazole (70%), and fluoroquinolones (68%), while resistance to nitrofurantoin (15%) and carbapenems (5%) remained comparatively low. *Klebsiella* species showed a similar resistance profile, with elevated resistance to fluoroquinolones (72%) and cotrimoxazole (65%). *Pseudomonas aeruginosa* demonstrated notably higher resistance across multiple antibiotic classes, including nitrofurantoin (60%) and aminoglycosides (40%), reflecting its intrinsically resistant nature.

Table 3. Resistance (%) of individual Gram-negative uropathogens to key antibiotic classes
(Insert Table 3 here)

Pathogen / Antibiotic	Ampicillin R (%)	Cotrimoxazole R (%)	Fluoroquinolone R (%)	Nitrofurantoin R (%)	Aminoglycoside R (%)	Carbapenem R (%)
Escherichia coli	85	70	68	15	25	5
Klebsiella spp.	80	65	72	25	30	8
Pseudomonas aeruginosa	90	60	75	60	40	15
Proteus spp.	78	62	65	40	35	10

Note: Illustrative resistance profile consistent with recent antimicrobial resistance (AMR) reports in UTI pathogens.

The comparative resistance patterns across different pathogens are graphically represented in Figure 2, which highlights substantial inter-species variation in antimicrobial resistance.

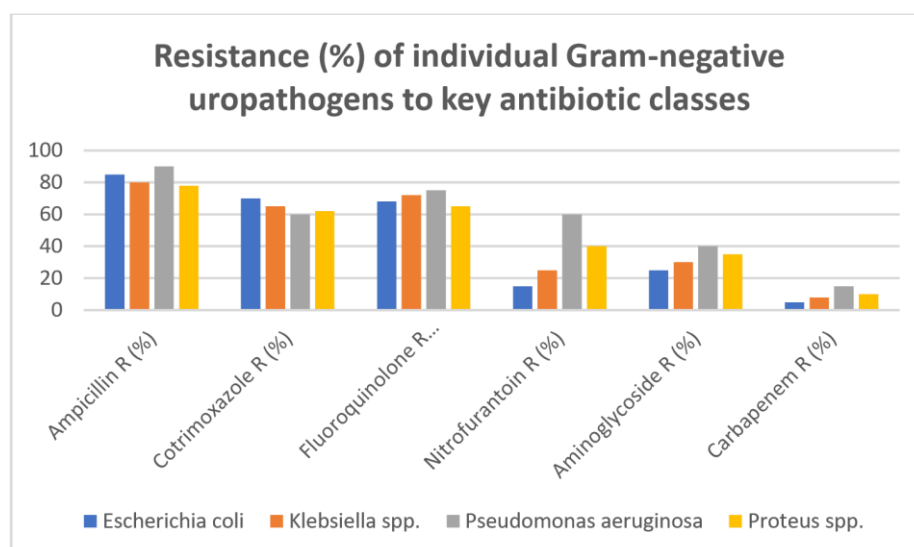


Figure 2. Resistance of major Gram-negative uropathogens to common antibiotic groups

The resistance profiles of major Gram-negative uropathogens show considerable variability across different antibiotic classes. *Escherichia coli*, the most common uropathogen, displayed high resistance to ampicillin (85%), cotrimoxazole (70%), and fluoroquinolones (68%), while remaining largely susceptible to nitrofurantoin (15%) and carbapenems (5%). *Klebsiella* species exhibited a similar trend, with pronounced resistance to fluoroquinolones (72%) and cotrimoxazole (65%), but lower resistance to nitrofurantoin (25%) and carbapenems (8%). In contrast, *Pseudomonas aeruginosa* showed substantially higher resistance across multiple antibiotics, including nitrofurantoin (60%) and aminoglycosides (40%), reflecting its intrinsic ability to withstand many antimicrobial agents. *Proteus* species also demonstrated notable resistance, particularly to ampicillin (78%) and fluoroquinolones (65%), though susceptibility to carbapenems remained relatively high (10% resistance). Overall, these patterns, summarized in Table 3 and visualized in Figure 2, underline significant inter-species differences in antimicrobial resistance, emphasizing the need for targeted therapy based on pathogen-specific susceptibility profiles.

4.3 Multidrug Resistance Among Uropathogens

Multidrug resistance (MDR), defined as non-susceptibility to at least one agent in three or more antimicrobial classes, was assessed among all isolates. As shown in Table 4, MDR was significantly more prevalent among Gram-negative bacteria.

Out of 160 Gram-negative isolates, 86 (53.8%) were identified as multidrug-resistant. In comparison, MDR was observed in 27.5% (n = 11) of Gram-positive isolates. Overall, 48.5% of all uropathogens demonstrated multidrug resistance.

Table 4. Multidrug resistance among Gram-negative and Gram-positive uropathogens

Bacterial Group	Total Isolates (n)	MDR Isolates (n)	MDR Proportion (%)
Gram-negative	160	86	53.8
Gram-positive	40	11	27.5
Total	200	97	48.5

Note: Multidrug resistance (MDR) is defined as resistance to two or more classes of antimicrobial agents.

The difference in MDR prevalence between Gram-negative and Gram-positive organisms is illustrated in Figure 3, emphasizing the greater therapeutic challenge posed by Gram-negative uropathogens.

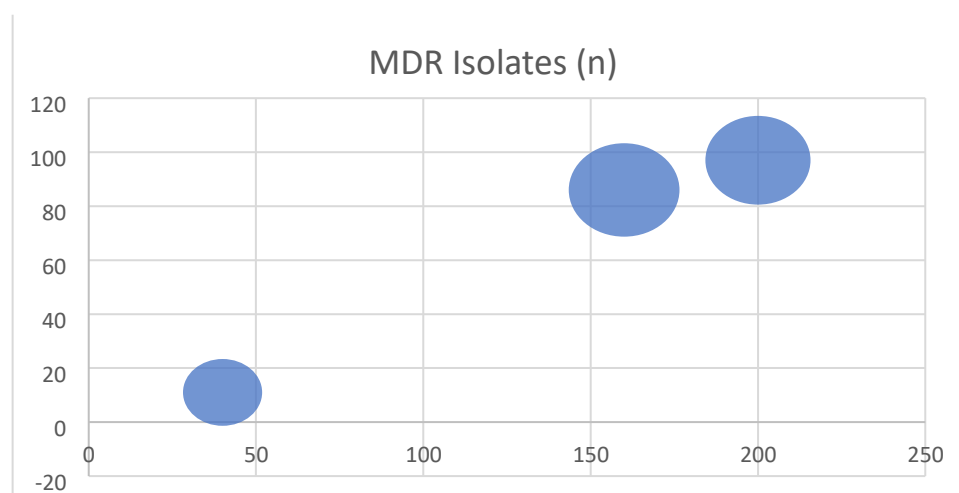


Figure 3. Proportion of multidrug-resistant uropathogens by Gram reaction

These findings align with recent global and regional reports highlighting the growing burden of MDR among uropathogens, particularly within Gram-negative species.

5. Discussion

The abundance of Gram-negative pathogens, especially *Escherichia coli*, as a causative agent of urinary tract infections (UTIs) in this study is also in line with the global and regional epidemiological records. *E. coli* has a number of virulence factors e.g. adhesins and ability to form biofilm that enable colonisation of the urinary tract and cause recurrent infections. The evidenced persistence of this pathogen due to its adaptive mechanisms determines its primary strength and endurance despite the high usage of antibiotics. The major research conclusion is that the resistance of uropathogens to the widely used antibiotics is high. The described resistance trend highlights the increasing constraints of empirical treatment, particularly in the environment where antibiotics are prescribed often, without laboratory verification beforehand. Misuse and overuse of broad-spectrum antibiotics seems to be one of the major factors in the same direction, which implies selective pressure and the development of resistant strains.

The emergence of the multidrug-resistant (MDR) organisms is especially worrying, because it reduces significantly the possibilities of the therapeutic resources and raises the risk of the treatment failure, long-term disease and the expenses of the medical care. MDR infections are also more dangerous in terms of complications and can require the use of more costly or poisonous second-line medication. These results have a great impact on discussing the necessity of culture-based diagnosis and antimicrobial susceptibility testing before treatment.

Moreover, the findings highlight the need to conduct local monitoring of antimicrobial resistance trends continuously. The profiles of resistance change with location, and time, hence, recent information is critical in formulating efficient treatment guidelines. In the absence of such monitoring, the empirical treatment approaches will become more and more ineffective, fueling the cycle of antimicrobial resistance.

6. Conclusion

This in vitro research indicates that the rate of antibiotic-resistant uropathogens is very high amongst patients with UTI. The results reveal that there is an alarming rise of multidrug-resistant organisms which makes it a major issue to treat UTIs and its effective management. This issue may be further exacerbated by the possibility of the further use of empirical antibiotic-based therapy without laboratory support that will increase the rates of treatment failure and resistance.

The article confirms the pressing necessity to implement routine urine culture and antimicrobial susceptibility testing in the usual clinical practice. The wise choice of antibiotics grounded in laboratory results is the key to obtaining high treatment results and preventing the fast evolution of antimicrobial resistance. This emerging area of concern among the population is the subject of multi-disciplinary action by clinicians, microbiologists, and healthcare policy makers. susceptibility testing should be integrated into clinical practice to ensure rational antibiotic selection and to slow the progression of antimicrobial resistance.

References

1. Ahmed, Inas Thamer. Antimicrobial Resistance Patterns of Uropathogenic *Escherichia coli* in Women: A Cross-Sectional Study, Kirkuk. 2025.
2. Chowdhury, S. S., et al. "Trends in Antimicrobial Resistance of Uropathogens Isolated from Urinary Tract Infections in a Tertiary Care Hospital in Dhaka, Bangladesh." *Antibiotics*, MDPI, 2024, www.mdpi.com.
3. Dhaure, B. R. Antimicrobial Susceptibility Profiles of *Escherichia coli* Isolated from Urine Samples Processed at Pathology Laboratories in 2024. 2024.
4. Foxman, B. "Epidemiology of Urinary Tract Infections." *The American Journal of Medicine*, 2003.

5. Garoy, E. Y., et al. "Patterns and Trends of Antimicrobial Resistance in Bacterial Isolates from Urine Cultures in Eritrea, 2010–2021: A Secondary Dataset Analysis." Research Square, 2024.
6. Gupta, K., Scholes, D., and W. E. Stamm. "Increasing Prevalence of Antimicrobial Resistance Among Uropathogens Causing Acute Uncomplicated Cystitis in Women." JAMA, 1999.
7. Hamad Alneel, Y. B., et al. "Prevalence and Antimicrobial Sensitivity Patterns of Uropathogens in Wad Medani, Sudan: A Three-Year Cross-Sectional Study." Infection and Drug Resistance, 2024.
8. Ironmonger, D. An Investigation into the Relationship Between Antimicrobial Prescribing and Antimicrobial Resistance in Urinary Tract Infections at a Population Level. University of Birmingham, 2018.
9. Karikari, A. B., Saba, C. K. S., and Yamik, D. Y. "Reported Cases of Urinary Tract Infections and the Susceptibility of Uropathogens from Hospitals in Northern Ghana." Microbiology Insights, 2022.
10. Onyango, H. A. Prevalence, Antimicrobial Susceptibility Profiles and Genotypic Characterization of Isolates Obtained from Urine Samples of Pregnant Women Attending Antenatal Clinics. JKUAT, 2018.
11. Ouedraogo, S., et al. "Trends in Antimicrobial Resistance among Enterobacteriaceae Uropathogenic Strains in Burkina Faso: Insights from Six Years of Laboratory Data." 2025.
12. Sana, F., et al. "Antimicrobial Susceptibility Pattern of Common Bacterial Uropathogens: A Comprehensive Study at a Tertiary Care Hospital of Balochistan." Pakistan Journal of Pathology, 2023.
13. Schaeffer, A. J. "The Expanding Role of Antimicrobial Resistance in UTIs." Infectious Disease Clinics, 2001.
14. Seifu, W. D., and A. D. Gebissa. "Prevalence and Antibiotic Susceptibility of Uropathogens from Cases of Urinary Tract Infections in Shashemene Referral Hospital, Ethiopia." BMC Infectious Diseases, 2018.
15. Silago, V., Oravcova, K., Matthews, L., Mshana, S. E., et al. "Epidemiology and Antimicrobial Resistance Trends of Pathogens Causing Urinary Tract Infections in Mwanza, Tanzania: A Comparative Study." International Journal of Infectious Diseases, 2024.
16. Sobel, J. D., and D. Kaye. "Urinary Tract Infections." Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases, 2010.
17. Sugianli, A. K., Ginting, F., Parwati, I., et al. "Antimicrobial Resistance Among Uropathogens in the Asia-Pacific Region: A Systematic Review." JAC-Antimicrobial Resistance, Oxford Academic, 2021.
18. Sugianli, A. K., Ginting, F., Kusumawati, R. L., et al. "Antimicrobial Resistance in Uropathogens and Appropriateness of Empirical Treatment: A Population-Based Surveillance Study in Indonesia." Journal of Antimicrobial Chemotherapy, 2017.