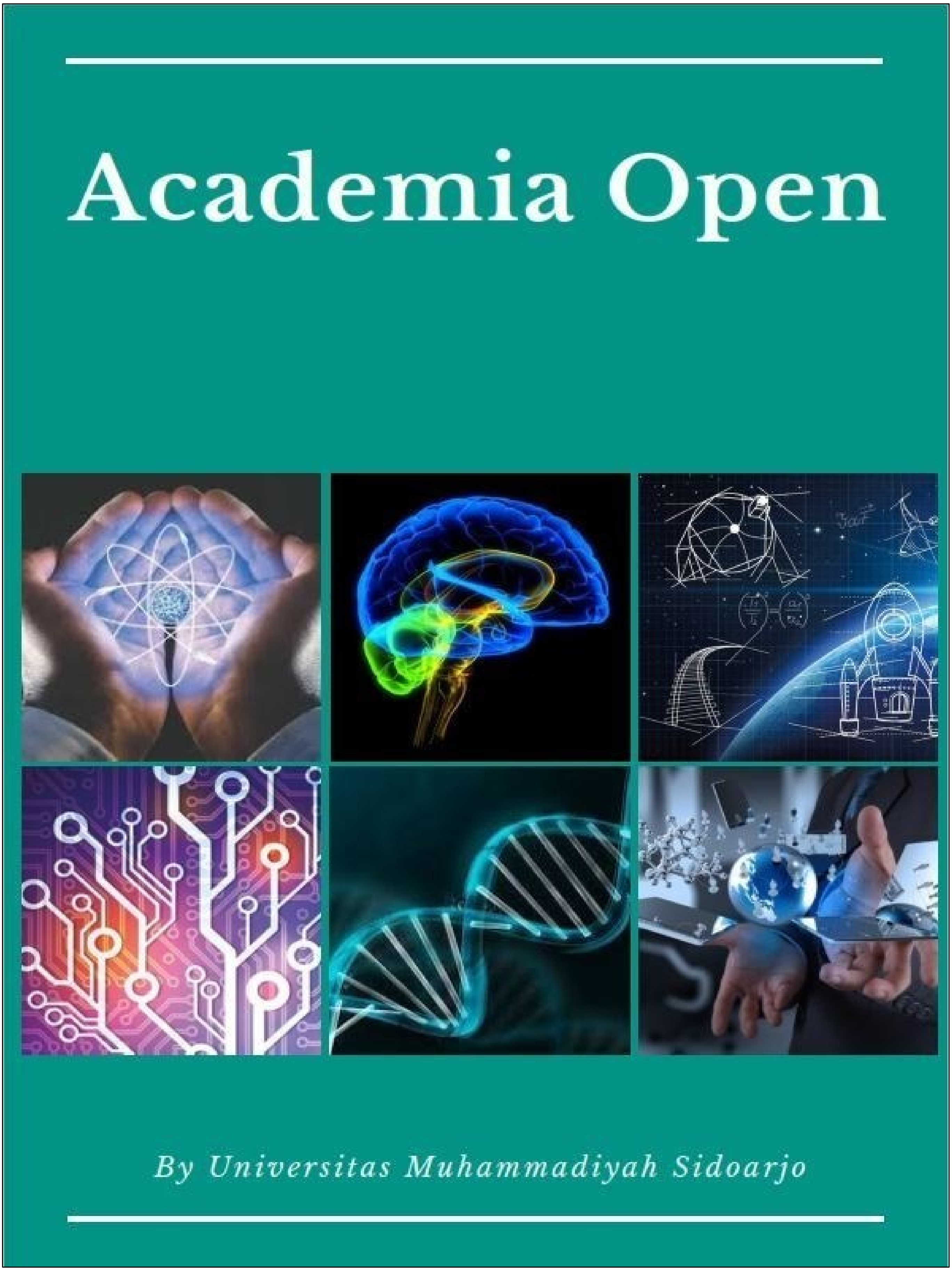
Academia Open

Vol. 10 No. 2 (2025): December
DOI: 10.21070/acopen.10.2025.12847



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Academia Open

Vol. 10 No. 2 (2025): December
DOI: 10.21070/acopen.10.2025.12847

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DOI: 10.21070/acopen.10.2025.12847

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Vol. 10 No. 2 (2025): December
DOI: 10.21070/acopen.10.2025.12847

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Academia Open
Vol. 10 No. 2 (2025): December
DOI: 10.21070/acopen.10.2025.12847

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Academia Open

Vol. 10 No. 2 (2025): December
DOI: 10.21070/acopen.10.2025.12847

Prevalence and Antibiotic Resistance Patterns of Uropathogens in Patients with Urinary Tract Infections

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Abstract

General Background: Urinary tract infections (UTIs) remain a significant global health concern, frequently complicated by the rise of antimicrobial resistance (AMR) among common uropathogens. Specific Background: In Iraq, increasing rates of multidrug-resistant bacterial strains, particularly Escherichia coli and Klebsiella pneumoniae, have limited therapeutic options and complicated clinical management. Knowledge Gap: Despite numerous studies on global AMR, region-specific data on uropathogen prevalence and susceptibility profiles in northern Iraq remain scarce. Aims: This study aimed to determine the prevalence and antibiotic resistance patterns of bacterial isolates from UTI patients in Mosul, Iraq, to guide empirical treatment and inform antimicrobial stewardship. Results: Among 173 isolates, E. coli (34.7%), K. pneumoniae (23.1%), and Pseudomonas aeruginosa (17.3%) were predominant. The highest susceptibility was observed with Meropenem (95.4%) and Imipenem (92.5%), while Ciprofloxacin resistance reached 42.2%, indicating restricted treatment options. Novelty: The study provides the most recent regional data on uropathogen distribution and resistance trends in Mosul, integrating microbiological surveillance with demographic analysis. Implications: These findings underscore the urgent need for continuous resistance monitoring, rational antibiotic use, and local antimicrobial stewardship programs to curb the spread of resistant uropathogens and improve clinical outcomes.

Highlight :

- E. coli remains the leading uropathogen in UTIs, followed by K. pneumoniae and P. aeruginosa.
- High resistance to Ciprofloxacin (42.2%) indicates limited treatment options.
- Regular surveillance of antibiotic resistance is essential for effective therapy and control.

Keywords : Ageing Population, Older Adults, Retirement, Life Transition, Demographic Changes

Published date: 2025-10-24

Introduction

Resistance to antimicrobials in human pathogens worldwide has become one of the most serious threats to public health. This emergence has wide-ranging implications in the field of infectious disease control. The urinary tract is still one of the most frequent sites of bacterial infection and the appearance of antibiotic resistant strains has complicated overall clinical care and patient outcome [1], [2].

In Iraq, particularly in Mosul city, antibiotic resistance of uropathogens is one of the important health problems. The occurrence of multidrug resistant (MDR) isolates is also a concern especially in Escherichia coli and Enterobacteriaceae that are the most common pathogens associated to UTIs in this setting. These bacteria have shown high rates of resistance to several groups of antibiotics, greatly reducing the choice of effective drugs and substantially raising the risk for serious complications. This resistance is frequently ascribed to the carriage of resistance genes and the formation of biofilms, which shield bacteria from antibiotics [3, 4].

The abuse and misuse of antibiotics, both in medical treatment and on farms, played a role to the rise of drug-resistant bacterial strains thus making an imperative public health action [5]. Of these, overprescribing, self-medication and lack of regulation of distribution of antibiotics are the main culprits fuelling this resistance. Of particular concern are pathogens such as Pseudomonas aeruginosa, Klebsiella pneumoniae and Acinetobacter baumannii, Enterococcus faecium and Staphylococcus aureus along with other Enterobacter spp. and Escherichia coli which are well-known to cause many nosocomial infections [6].

Antibiotic resistance is multi-faceted and strategies to combat it must be too: from antimicrobial stewardship, infection prevention, to rapid diagnostics and policy enforcement. Letting the old antimicrobials continue their work, requires more international co-operation and investment from both public and private side [7], [8].

Urinary tract infection is one of the most frequent bacterial infections in the human urinary system throughout the world, and it is generally a consequence of the genitourinary tract colonized by microbes, especially in people with structural or functional abnormality [9], [10]. It relates to over seven million outpatients visits and nearly one million emergency room visits each year with some 100,000 admissions into hospital [11], [12].

Symptomatic and asymptomatic UTIs Symptomatic versus asymptomatic UTI may be distinguished. Symptomatic infections are those causing significant bacteriuria and accompanied by symptoms, such as dysuria, urgency or flank pain, may be associated with inflammation of the bladder (cystitis) or kidneys (pyelonephritis). Asymptomatic bacteriuria, however, is described as a condition in which there are detectable amounts of bacteria in the urine without any symptoms [13].

The antibiotic resistance problem in the low-resource setting, to which some Iraqi regions may belong, is further complicated by a weak medical infrastructure, availability of counterfeit drugs and antibiotics misuse without a prescription. Antimicrobial resistance patterns can differ widely among bacterial species, antibiotic groups, geographical reasons and between hospitals [14].

A significantly increasing trend of resistance among uropathogens was reported in Nineveh, Iraq, where E. coli strains were the most resistant during a study period of 5 years [15]. In view of these disturbing trends, frequent evidence based surveillance is essential in order to monitor resistance pattern and implement rational empirical therapy [16].

The objectives of the present study are to determine the prevalence and antibiotic resistance profile pattern of bacterial isolates from patients with UTI in Mosul, Iraq. It aims to translate these findings and uncover the mechanisms behind resistance to guide clinicians when prescribing antibiotics, as well as inform policy makers and industry by providing a profile of resistant uropathogens and outline strategies for combating the rise in multidrug-resistant uropathogens.

Methodology

The current study was carried out to determine prevalence of bacterial uropathogens and their antibiotic susceptibility in the patients who presented in Ibn Sina Teaching Hospital, Mosul, Iraq from July to September 2024. A total of 173 patients, including 100 men and 73 women, whose ages ranged from 20 to 70 years were recruited. Patients were included based on clinical evidence of urinary tract infection (UTI), and midstream urine samples in a sterile container were collected for analysis within 2 hours. Standard culture methods were used, and a 1 μL loop (calibrated) was used to inoculate the urine onto three different agars: UriSelect 4 agar (a non-selective chromogenic medium that distinguishes Gram-negative pathogens),MacConkey (non-inhibitory selective cresol red agar with lactose for GNB), and 5% sheep blood agar(non-selective general purpose medium not inhibiting growth). The culture plates were aerobically incubated for 24 h at 35–37°C. Bacterial growth was examined for colony morphology and Gram color, and additional identification was made by biochemical tests or medium-dependent features. Entry criteria were clinical diagnosis of UTI where urine culture and sensitivity was indicated, recurrent UTIs (with or without history of antibiotic use), and both male/female patients of all ages. Patients recently hospitalized (within the last two months), urinary catheterized, received antibiotics within 2 weeks, structural urinary anomalies or having a diagnosis other than UTIs such as urinary tuberculosis or nosocomial infections were lowed to enter. Those who were unwilling to participate were also excluded. All patients received both urine culture and antibiotic susceptibility testing during the study period. Antimicrobial susceptibility testing began with 21 antibiotics, based on the availability and UTI-prescribing patterns in Hanzhong. Antibiotic discs were placed using standardized concentrations (μg) and interpreted according to the guidelines of CLSI. This is a part of a whole program designed to provide updated regional data on uropathogen distribution and resistance patterns for appropriate empirical treatment plans. (Table 1)

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DOI: 10.21070/acopen.10.2025.12847

Table 1: Antibiotic Symbol Table with Concentrations and Codes Used in the Current Study

No	Antibiotic	Concentration (µg)	Code
1.	Amikacin	30	AMK
2.	Co-amoxiclave (Amoxicillin/Clavulanic Acid)	30	CA
3.	Cefotaxime	30	CTX
4.	Cefalothin	30	CFN
5.	Cephalexin	30	CFX
6.	Cephadroxil	30	CPX
7.	Cefepime	30	FEP
8.	Cefaclor	30	CCL
9.	Ciprofloxacin	5	CIP
10.	Cotrimoxazole (Trimethoprim-Sulfamethoxazole)	25	TMP-SMX
11.	Gentamicin	10	GEN
12.	Imipenem	10	IMP
13.	Meropenem	10	MEM
14.	Nalidixic Acid	30	NA
15.	Nitrofurantoin	30	NIT
16.	Ofloxacin	5	OFX
17.	Ampicillin-Cloxacillin	20	ACL
18.	Ceftriaxone	30	CRO
19.	Levofloxacin	5	LVX
20.	Norfloxacin	10	NOR
21.	Streptomycin	10	STR

• The concentration of each antibiotic employed in the disk diffusion method is shown in the Concentration (µg) column.

• Each antibiotic is given a standardized abbreviation in the Code column that you can use for convenient reference in your research.

Analysis of statistics

The Statistical Package for the Social Sciences (SPSS) version 24 was used for analysis after current study administered the data using Microsoft Excel 2013. Using frequency and percentage to represent categorical variables. On the other hand, mean ± SD was used to represent continuous variables. For the non-parametric data frequencies, a chi-square test was engaged. A one-way ANOVA and a paired t-test were used to assess Escherichia coli antibiotic susceptibility and resistance. Using Tukey's post hoc analysis, the differences in values were deemed significant when the P-value was less than 0.001, 0.05, and 0.01. When using a Chi-square test, a P-value < 0.05 was regarded as a statistically significant difference.

Result

Sociodemographic Features of Research Participants

There were 173 patients enrolled in the study, with a mean age of 45.3 years (± 15.4). Among the total population, males constituted 57.8%, while females accounted for 42.2%. The majority of participants (63.5%) were from rural areas. Regarding employment status, 40.5% of the patients

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were unemployed, 46.2% were employed, and 13.3% were students. In terms of educational level, 26.0% of the participants had completed primary education, 52.0% had completed secondary education, and 11.5% had no formal education, as shown in table 2.

Table 2: Socio-Demographic Appearances of Study Patients

Characteristic	**Total Patients (N = 173)**	**Male (N = 100)**	**Female (N = 73)**
Age (Years)			
Mean ± SD	45.3 ± 15.4	46.1 ± 14.7	43.9 ± 16.3
Age Range	20 - 70	20 - 70	20 - 68
Gender			
Male	100 (57.8%)	100 (100%)	-
Female	73 (42.2%)	-	73 (100%)
***P*- value**	0.000***		
Residence			
Rural	110 (63.5%)	65 (65%)	45 (61.6%)
Urban	63 (36.5%)	35 (35%)	28 (38.4%)
***P*- value**	0.000**		
Occupation			
Unemployed	70 (40.5%)	45 (45%)	25 (34.2%)
Employed	80 (46.2%)	50 (50%)	30 (41.1%)
Student	23 (13.3%)	5 (5%)	18 (24.7%)
***P*- value**	0.000**		
Educational Level			
No Formal Education	20 (11.5%)	10 (10%)	10 (13.7%)
Primary	45 (26.0%)	30 (30%)	15 (20.5%)
Secondary	90 (52.0%)	50 (50%)	40 (54.8%)
Higher Education	18 (10.4%)	10 (10%)	8 (10.9%)
	0.000**		

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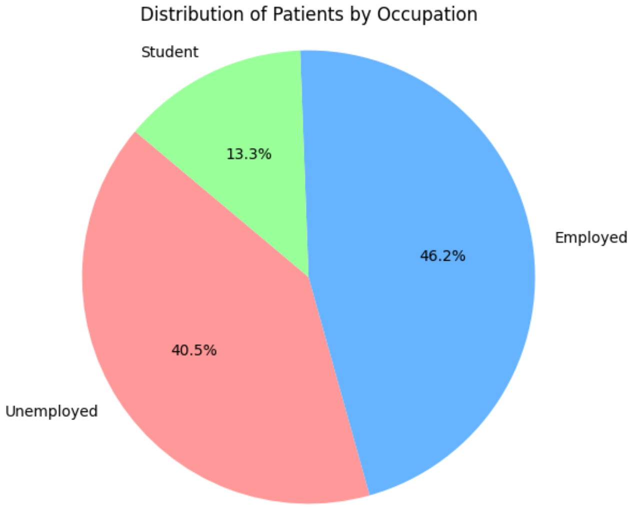

Figure 1: Socio-Demographic Appearances of Study Patients

This figure 1 provides a visual representation of the sociodemographic characteristics of the study participants, including age, gender, residence, occupation, and educational level, highlighting key differences between male and female participants and their respective backgrounds.

Occurrence of Uropathogens Between Urinary Isolates

The most prevalent urinary pathogens isolated from urine samples are prepared down in this table 3 . Escherichia coli accounted for 34.7% of the isolates, making it the most common.

Table 3: Occurrence of Uropathogens Among Urinary Isolates

Uropathogen	Number of Isolates (N)	Percentage
Escherichia coli	60	34.7%
Klebsiella pneumoniae	40	23.1%
Pseudomonas aeruginosa	30	17.3%
Proteus mirabilis	20	11.5%
Staphylococcus saprophyticus	10	5.8%
Enterococcus faecalis	8	4.6%
Others	5	2.9%
P. value	**0.000****	

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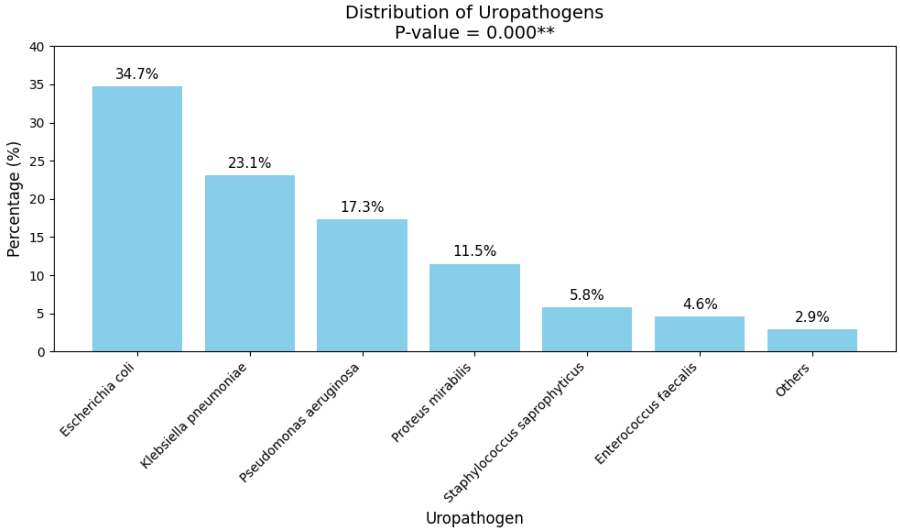

Figure 2: Occurrence of Uropathogens Between Urinary Isolates

Figure 2 illustrates the distribution of the most prevalent uropathogens isolated from urine samples, with Escherichia coli being the most frequent, followed by Klebsiella pneumoniae and Pseudomonas aeruginosa.

Susceptibility of Antibiotic

By investigative their patterns of antibiotic susceptibility, the resistance outlines of the bacterial isolates from the research participants were controlled. The results demonstrate varying levels of susceptibility and resistance to commonly used antibiotics. Escherichia coli showed a high level of susceptibility to Meropenem (95.4%) and Imipenem (92.5%), based on patterns of antibiotic susceptibility . Co-amoxiclave (80.9%) and cefotaxime (75.1%) demonstrated moderate susceptibility .

The data highlights how important it is to routinely monitor for antibiotic susceptibility in order to advise the appropriate course of action. Ciprofloxacin resistance was much higher (42.2%), indicating a concerning tendency in antibiotic resistance as showed in table 4.

Table 4: Antibiotic Susceptibility Patterns of Bacterial Isolates

Antibiotic	Susceptible (N = 173)	Resistant (N = 173)	% Susceptible	% Resistant
Amikacin	150	23	86.7%	13.3%
Co-amoxiclave (Amoxicillin/Clavulanic Acid)	140	33	80.9%	19.1%
Cefotaxime	130	43	75.1%	24.9%
Ciprofloxacin	100	73	57.8%	42.2%
Gentamicin	120	53	69.4%	30.6%
Imipenem	160	13	92.5%	7.5%
Meropenem	165	8	95.4%	4.6%
Ceftriaxone	135	38	78.0%	22.0%
Nitrofurantoin	110	63	63.6%	36.4%
Levofloxacin	125	48	72.3%	27.7%

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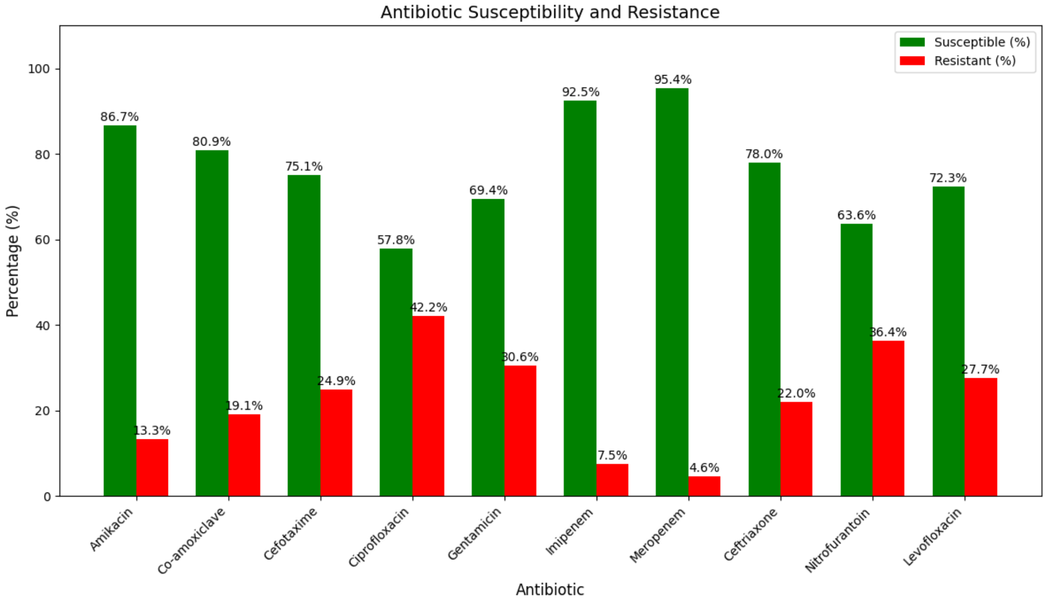

Figure 3: Antibiotic Susceptibility Patterns

This figure 3 presents the antibiotic resistance profiles of the bacterial isolates from the study, showing varying susceptibility levels to commonly used antibiotics, with Meropenem and Imipenem demonstrating the highest effectiveness.

Influences of Escherichia coli Antibiotic Susceptibility and Resistance in Urine Cultures

The analysis shows that Escherichia coli is highly susceptible to imipenem (92.5%) and Meropenem (95.4%). At 80.9% and 75.1%, respectively, co-amoxiclave and cefotaxime also showed good susceptibility rates. \ Ciprofloxacin resistance was found to be alarming, with 42.2% of isolates exhibiting resistance, indicating a pattern of rising antibiotic resistance as seen in table 5.

Table 5: Determinants of Escherichia coli Antibiotic Susceptibility and Resistance in Urine Cultures

Antibiotic	Susceptible (N)	Resistant (N)	% Susceptible	% Resistant
Amikacin	150	23	86.7%	13.3%
Co-amoxiclave (Amoxicillin/Clavulanic Acid)	140	33	80.9%	19.1%
Cefotaxime	130	43	75.1%	24.9%
Ciprofloxacin	100	73	57.8%	42.2%
Gentamicin	120	53	69.4%	30.6%
Imipenem	160	13	92.5%	7.5%
Meropenem	165	8	95.4%	4.6%
Nitrofurantoin	110	63	63.6%	36.4%
Levofloxacin	125	48	72.3%	27.7%
Ceftriaxone	135	38	78.0%	22.0%

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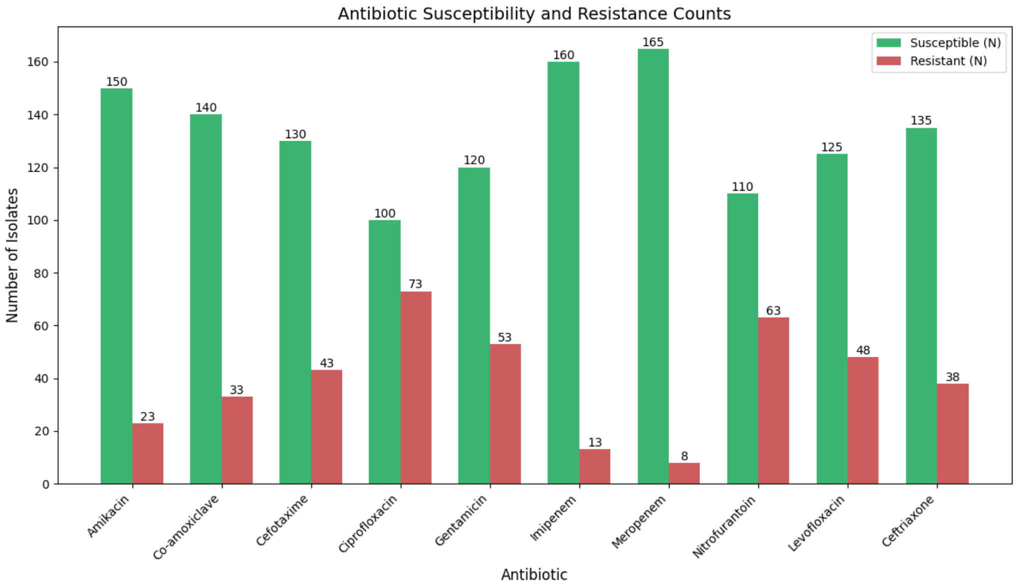

Figure 4: Influences of Escherichia coli Antibiotic Susceptibility and Resistance in Urine Cultures

This figure specifically highlights the antibiotic susceptibility and resistance patterns of Escherichia coli, a key finding that demonstrates the challenges in treating UTIs due to rising resistance rates, particularly to Ciprofloxacin.

Discussion

The demographic characteristics of the study participants may influence both the generalizability and interpretation of the findings. The study included 173 patients with a mean age of 45.3 years (±15.4), of whom 57.8% were male and 42.2% were female. A majority (63.5%) resided in rural areas, which may affect healthcare accessibility and participation in clinical trials, as rural populations often face barriers such as distance from healthcare facilities and limited resources. Regarding employment status, 46.2% were employed, 40.5% unemployed, and 13.3% were students. As for educational level, 26.0% had completed primary school, 52.0% had completed secondary education, while 11.5% had no formal education, highlighting the impact of education on health awareness and access to medical care [17], [18]. In comparison, other studies have reported different gender distributions, such as a chronic disease survey where 87.5% of participants were female, suggesting possible gender-related predispositions in certain conditions [19]. Similarly, a study by [20], emphasized the importance of residence, employment, and education as social determinants affecting health outcomes and clinical engagement. In terms of microbiology, Escherichia coli remains the predominant uropathogen in UTIs, accounting for 37.3% to 76.28% of isolates in different series [21].

Other notable isolates include Pseudomonas aeruginosa (8.4–17.3%), and Klebsiella pneumoniae, each necessitating targeted treatment strategies. Despite E. coli being the most common, the emergence of resistant strains such as Klebsiella and Pseudomonas demands broader antimicrobial planning. This study also aligns with previous findings reporting E. coli as the leading uropathogen, followed by K. pneumoniae, as seen in Duhok Province [22]. A meta-analysis by noted a rising trend in drug-resistant E. coli from diverse sources. Concerning antimicrobial susceptibility, Ciprofloxacin demonstrated the highest resistance, while Meropenem and Imipenem showed the highest susceptibility, confirming their role as last-resort treatments [23].The mechanisms of resistance, including acquired resistance via plasmids, bacteriophages, or integrons, are well-documented in Gram-negative bacteria [24]. Regional data from Nasiriyah showed high resistance to Ampicillin (95%) and Amoxicillin-Clavulanate (80%), with low resistance to Imipenem (5%) and Meropenem (10%) [25] .Similarly, Iraqi hospital studies found Staphylococcus aureus to be highly resistant to penicillins [26]. Despite the high resistance rates to antibiotics such as Cefepime, the study emphasizes the need for effective antimicrobial stewardship, surveillance, and alternative therapeutic strategies to mitigate risks associated with resistant pathogens in Iraq [27].

Conclusion

The results of this study indicated the need for continuous monitoring of uropathogens, especially E. coli which is still the predominant uropathogen in UTI episodes. The good susceptibility of E. coli to Meropenem and Imipenem coupled with the moderate sensitivity to Co-amoxiclave and Cefotaxime, well justifies use of these antibiotics in UTIs. But the high resistance rate of Ciprofloxacin (42.2%) reflects already a growing problem on treating UTIs. These results underscore the importance of establishing antimicrobial stewardship programs, updated surveillance of antibiotic drug susceptibility data and clinical specimen collection to guide treatment in order to address the increased risk due to the spread of AMR. The prevalence proportions indicate that E. coli remains the predominant etiologic agent of UTIs and are followed by K. pneumoniae, and P. aeruginosa which have also displayed a high rate of susceptibility to various antibiotics. This highlights the increased demand for new therapeutic approaches and secondary lines of treatment (vaccines, bacteriophage therapy) to fight wRUs. The study also highlights the need to address social determinants of health which includes education, healthcare access and misuse of antibiotics that are critical for resistance emergence and spread.

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

References

1. R. V. Sionov and D. Steinberg, "Targeting the Holy Triangle of Quorum Sensing, Biofilm Formation, and Antibiotic Resistance in Pathogenic Bacteria," Microorganisms, vol. 10, no. 6, p. 1239, 2022. Available: https://doi.org/10.3390/microorganisms10061239

2. G. Mancuso, M. Midiri, C. Gerace, and G. Teti, "Bacterial Antibiotic Resistance: The Most Critical Pathogens," Pathogens, vol. 10, no. 10, p. 1310, 2021. Available: https://doi.org/10.3390/pathogens10101310

3. S. M'Aiber, N. H. Jaff, and M. Al-Ibrahimi, "The Challenge of Antibiotic Resistance in Post-War Mosul, Iraq: An Analysis of 20 Months of Microbiological Samples from a Tertiary Orthopaedic Care Centre," Journal of Global Antimicrobial Resistance, vol. 30, pp. 311–318, 2022.

4. M. A. Oudah, "Antibiotic Resistance Profile of Pathogenic Bacteria Isolated from Healthcare Rooms in the Mosul Government Hospital, Iraq," Medical Journal of Babylon, vol. 21, Suppl. 1, pp. S70–S80, 2024.

5. B. Singh, A. Bhat, and K. Ravi, "Antibiotics Misuse and Antimicrobial Resistance Development in Agriculture: A Global Challenge," Environmental Health, vol. 2, no. 9, pp. 618–622, 2024.

6. G. Muteeb, M. Khalid, and S. W. Siddiqui, "Origin of Antibiotics and Antibiotic Resistance, and Their Impacts on Drug Development: A Narrative Review," Pharmaceuticals, vol. 16, no. 11, p. 1615, 2023.

7. T. O. Kolawole, J. M. Olayinka, and P. S. Nwachukwu, "Innovative Strategies for Reducing Antimicrobial Resistance: A Review of Global Policy and Practice," Global Health Research and Policy, vol. 8, no. 1, p. 55, 2023.

8. S. Mudenda, J. M. Banda, and A. Chileshe, "Global Strategies to Combat Antimicrobial Resistance: A One Health Perspective," Pharmacology and Pharmacy, vol. 14, no. 8, pp. 271–328, 2023.

9. X. Yang, Z. Li, and Y. Zhao, "Disease Burden and Long-Term Trends of Urinary Tract Infections: A Worldwide Report," Frontiers in Public Health, vol. 10, p. 888205, 2022.

10. X. Li, M. Zhang, and J. Liu, "Global and Regional Burden of Bacterial Antimicrobial Resistance in Urinary Tract Infections in 2019," Journal of Clinical Medicine, vol. 11, no. 10, p. 2817, 2022.

11. S. von Vietinghoff, L. Bergman, and H. Haller, "The Global Burden of Antimicrobial Resistance–Urinary Tract Infections," Nephrology Dialysis Transplantation, vol. 39, no. 4, pp. 581–588, 2024.

12. Y. Zhou, L. Wang, and P. Chen, "Urinary Tract Infections Caused by Uropathogenic Escherichia coli: Mechanisms of Infection and Treatment Options," International Journal of Molecular Sciences, vol. 24, no. 13, p. 10537, 2023.

13. R. Kaur and R. Kaur, "Symptoms, Risk Factors, Diagnosis and Treatment of Urinary Tract Infections," Postgraduate Medical Journal, vol. 97, no. 1154, pp. 803–812, 2021.

14. H. Ehsan, M. Khan, and A. Rahimi, "Comprehensive Narrative Analysis of Antimicrobial Resistance in Afghanistan: Key Drivers, Challenges, and Strategic Interventions," Journal of Health, Population and Nutrition, vol. 44, p. 265, 2025.

15. R. N. Al-Zidan, S. M. Mahmood, and Z. M. Younus, "The Antibiotic Susceptibility Patterns of Uropathogens Among Adults with Recurrent Urinary Tract Infection in Mosul, Iraq," Pharmakeftiki, vol. 36, no. 2, 2024.

16. M. Iftikhar, T. Ullah, and N. Javed, "Antibiogram and Antibiotic Resistance Patterns in Bacterial Isolates from Hayatabad Medical Complex, Peshawar," Cureus, vol. 16, no. 10, 2024.

17. R. O. Chimezie, "Health Awareness: A Significant Factor in Chronic Diseases Prevention and Access to Care," Journal of Biosciences and Medicine, vol. 11, no. 2, pp. 64–79, 2023.

18. J. Rosário, M. Martins, and A. Silva, "Exploring Perceptions of Health Literacy, Healthcare Access, and Utilisation Among Higher Education Students in Alentejo, Southern Portugal: A Qualitative Study," PLoS One, vol. 20, no. 6, p. e0326575, 2025.

19. S. Ajabshir, N. Patel, and M. Khan, "Rate of Nutrition-Related Chronic Diseases Among a Multi-Ethnic Group of Uninsured Adults," Cureus, vol. 14, no. 9, 2022.

20. O. A. Alzomor, "Community Acquired Urinary Tract Infections in Children: Prevalence and Predictive Factors for ESBL Status of Uropathogen in a Tertiary Care Center in Saudi Arabia," M.S. thesis, Alfaisal University, Riyadh, Saudi Arabia, 2024.

21. R. J. Nhoro, "Aetiology and Antimicrobial Resistance Patterns of Urinary Tract Infections (UTIs) in Pregnant Women Attending Masvingo Provincial Hospital in 2023," Dissertation, University of Zimbabwe, Harare, 2024.

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

Vol. 10 No. 2 (2025): December
DOI: 10.21070/acopen.10.2025.12847

22. D. R. Ibrahim, "Prevalence of Plasmid Mediated QNRA, QNRB and QNRS Among Clinical Escherichia coli Isolated from Urinary Tract Infections in Duhok, Kurdistan Region of Iraq," Scientific Journal of University of Zakho, vol. 11, no. 4, pp. 523–531, 2023.

23. T. Ramatla, M. A. Kachigunda, and B. Molefe, "A Systematic Review and Meta-Analysis on Prevalence and Antimicrobial Resistance Profile of Escherichia coli Isolated from Water in Africa (2000–2021)," Heliyon, vol. 9, no. 6, 2023.

24. N. J. Verkaik, S. M. Kolesnyk, and M. K. Tokar, "Antimicrobial Susceptibility to Last-Resort Antibiotics in Carbapenemase-Producing Bacteria from Ukrainian Patients," Microbiology Spectrum, vol. 12, no. 11, p. e01142-24, 2024.

25. M. M. Rahman, A. H. Hossain, and K. Islam, "An Overview of Antimicrobial Stewardship Optimization: The Use of Antibiotics in Humans and Animals to Prevent Resistance," Antibiotics, vol. 11, no. 5, p. 667, 2022.

26. S. N. Khadse, S. Ugemuge, and C. Singh, "Impact of Antimicrobial Stewardship on Reducing Antimicrobial Resistance," Cureus, vol. 15, no. 12, 2023.

27. M. Oliveira, R. Pereira, and D. Costa, "An Overview of the Recent Advances in Antimicrobial Resistance," Microorganisms, vol. 12, no. 9, p. 1920, 2024.

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo