Antibiotic Resistance Pattern of Urinary Tract Infections Among Patients with Recent Antibiotic Use: A Cross-sectional Study

Behzad Yousefi Yeganeh [1], Golnaz Mahmoudvand [2], Reza Nejad Shahrokh Abadi [3], Majid Heidarian [4] and Arian Karimi Rouzbahani [2, 4, *]

[1]Department of Urology, School of Medicine, Lorestan University of Medical Sciences, Khorramabad, Iran
[2]USERN Office, Lorestan University of Medical Sciences, Khorramabad, Iran
[3]Mashhad University of Medical Sciences, Mashhad, Iran
[4]Student Research Committee, Lorestan University of Medical Sciences, Khorramabad, Iran

[*] *Corresponding author*: USERN Office, Lorestan University of Medical Sciences, Khorramabad, Iran. Email: ariankarimi1998@gmail.com

Abstract

Background: With the increasing rate of bacterial resistance and the emergence of multidrug-resistant pathogens, urinary tract infections (UTIs) are now among the most important public health problems worldwide.

Objectives: This study aimed to investigate the antibiotic resistance patterns of UTIs in Shahid Rahimi and Shohada-ye Ashayer hospitals of Khorramabad, Iran, in 2021.

Methods: In this cross-sectional study, 250 patients with UTI were included. Demographic characteristics and data related to the pathogen types and antibiogram were collected from their medical files and recorded in a researcher-made checklist. The collected data were analyzed by Stata software version 14 at a 5% significance level.

Results: The study population consisted of 163 women (65.2%) with a mean age of 54.52 ± 10.12 and 87 men (34.8%) with a mean age of 51.87 ± 12.01. The most common pathogens reported were *Escherichia coli* (41.20%), followed by *Staphylococcus saprophyticus* (20.80%), and *Klebsiella pneumonia* (18.40%). The most frequently reported resistances were against Amoxicillin (59.2%), followed by Ampicillin (53.6%), while the least reported were Imipenem (11.6%), followed by Amikacin (17.6%).

Conclusions: A high rate of resistance was observed against the commonly used antibiotics. It is crucial to prescribe antibiotics, particularly those with relatively low resistance rates (such as imipenem and amikacin), cautiously to prevent bacterial resistance against antimicrobial agents.

Keywords: Urinary Tract Infection, Antibiotic Drug Resistance, Antibacterial Agents

1. Background

Urinary tract infections (UTIs) are caused by a wide range of pathogens, constituting one of the most important public health problems worldwide (1). UTIs can affect both genders in all age groups. However, some individuals are at higher risk. In general, adult women are 30 times more likely to develop UTI, with 40% of all of them experiencing it at some point in their lives (2, 3). UTIs are reported to be the second most commonly treated infection in primary care and are the most common infection seen in a hospital setting, encompassing 40% of all hospital-acquired infections (4, 5). Microbial agents can infect any part of the genitourinary system and are clinically categorized as complicated or uncomplicated. In healthy patients and in the absence of structural abnormalities, uncomplicated UTIs are further differentiated as either upper or lower, typically seen as pyelonephritis and cystitis, respectively (6). These patients typically present with dysuria, urgency, urinary frequency, fever, and flank pain (7). Complicated UTIs are those seen during pregnancy, in patients with renal failure or transplantation, or in immunosuppressed patients but are most commonly associated with indwelling catheters (8). Diagnosis is based on signs and symptoms of infection and urine analysis (UA), with urine culture (UC) typically being reserved for complicated UTIs (9). The treatment of choice in UTIs depends on whether it is complicated or not, with antibiotics such as ciprofloxacin and ampicillin being the most commonly prescribed (2, 10). However, treatment is complicated with increasing rates of antibiotic resistance

and the emergence of multidrug-resistant pathogens. Thus, it is important to evaluate the frequency of these resistances in different microbial agents, to further understand their mechanism and to provide adequate treatment (11).

2. Objectives

In this study, the frequency of bacterial agents and the pattern of their antibiotic resistance were evaluated in UTI patients referred to teaching hospitals in Khorramabad in 2021.

3. Methods

3.1. Study Design and Participants

This cross-sectional study was conducted at Shahid Rahimi and Shohada-ye Ashayer hospitals in Khorramabad, Iran, in 2021. The sampling method was a census, and all patients who met the inclusion criteria were recruited. The inclusion criteria for this study were: (1) diagnosis of UTI in 2021, (2) recorded Urine Culture and antibiogram, and (3) age 16 years or older. The patients were excluded if their medical records were incomplete or did not consent to participate in the study. Finally, 250 patients were enrolled in the study.

3.2. Data Collection

After obtaining written consent, demographic information including age, gender, place of residence, occupation, educational level, history of underlying diseases, and history of antibiotic use as well as information relating to the type of pathogen and the antibiotic resistance and sensitivity, were collected through reports of UC results and antibiograms recorded in the patient's medical files and registered into a researcher-made checklist.

3.3. Data Analysis

The collected data were analyzed by Stata software (version 14) using chi-square and independent t-tests. Furthermore, multivariable logistic regression was used to investigate the prevalence of pathogens and their antibiotic resistance, with results being reported at a significance level of 5%.

3.4. Ethical Considerations

This study was conducted with the permission of the Research Ethics Committee of Lorestan University of Medical Sciences with the ethical code IR.LUMS.REC.1401.076. Written, informed, and voluntary consent was obtained from all participants. All details regarding the medical records of the patients were kept confidential. Hence, the principles of medical ethics, The Helsinki Declaration, were observed.

4. Results

The study population consisted of 163 women (65.2%) with a mean age of 54.52 ± 10.12 and 87 men (34.8%) with a mean age of 51.87 ± 12.01. Data regarding the history of the underlying disease and recent antibiotic use were recorded, with 18.4% and 96.4% having a positive history, respectively. Table 1 shows the frequency distribution of pathogens reported from the urine culture in the study population. The highest reported frequency of pathogens was related to *Escherichia coli* (41.20% or 103 patients), followed by *Staphylococcus saprophyticus* (20.80% or 52 patients) and *Klebsiella pneumoniae* (18.40% or 46 patients). The least frequently reported pathogens were *Citrobacter* and *Proteus*, with each consisting of 2% of the study population. Antibiotic resistance in these pathogens is shown in Table 2, with amoxicillin and ampicillin being the most frequently reported (59.2% and 53.6%, respectively). The least frequently reported antibiotic resistance among all pathogens was imipenem (11.6%), followed by amikacin (17.6%). Tables 3 and 4 display the frequency of resistance of different antibiotics by gender and age, respectively, and the chi-square test was used to determine statistical significance (P-value of < 0.05). This study also showed that there was no significant relationship between antibiotic resistance and gender in the different drug classes. Additionally, antibiotic resistance among patients was also evaluated based on the history of the underlying disease and was found to be insignificant (P-value > 0.05) among the different drug classes (Table 5).

5. Discussion

The inappropriate use of antibiotics for the treatment of infections can impose negative effects on public health economically and lead to drug resistance. Thus, it is crucial to incessantly monitor antimicrobial resistance patterns in all regions (12). In this cross-sectional study, the prevalence of microbial pathogens amongst UTI patients as well as their antibiotic resistance condition

Table 1. Frequency Distribution of Pathogens Seen in UCs

Pathogen	Prevalence, No. (%)
Escherichia coli	103 (41.2)
Staphylococcus saprophyticus	52 (20.8)
Klebsiella pneumoniae	46 (18.4)
Enterobacter	24 (9.6)
Staphylococcus epidermis	8 (3.2)
Proteus	5 (2)
Citrobacter	5 (2)
Others	7 (2.8)
Total	250 (100)

was evaluated. The results showed that *E. coli* was the most commonly reported pathogen, which was consistent with other studies conducted showing this microorganism to be the most common cause of UTI. The prevalence of this bacterium ranges from 10% to 73.7% in different populations (13-16). Congruent with the results of other studies (12), *Staphylococcus* was the most frequent Gram-positive bacteria.

Additionally, in this study, the highest rate of resistance in both sexes, regardless of the bacterial strains, was reported to be against amoxicillin (59.2%) followed by ampicillin (53.6%), which were consistent with the results of Setu et al. (17) and Abedi Samakoosh et al. studies (18). Consistent with the results of Mortazavi-Tabatabaei et al. (19) and Hossain et al. (20) studies, the lowest rate of resistance was seen regarding imipenem (11.6%) and amikacin (17.6%). It should be noted that the majority of the studied subjects (96.4%) had a history of recent antibiotic use. As a previous use of antibiotics can affect the prevalence and patterns of antibiotic resistance among patients with UTI (21), the findings of this study should be interpreted considering the fact that there was a positive history of antibiotic use in most subjects.

Global studies indicate that the causes and resistance patterns of urinary infections have changed (22). Therefore, identifying the bacterial agents that cause UTIs and using appropriate and effective antibiotics to eliminate them is one of the practical applications of dealing with these infections and preventing their sequelae. Moreover, due to the constant alteration of antibiotics, the high rates of microbial resistance to common drugs incur exorbitant treatment costs (23, 24). The increasing diversity of resistance to antibiotics can be justified by variations in the regional use of antibiotics. Inappropriate and excessive use of antibiotics leads to resistance; therefore, reducing the prescription of specific antibiotics can lead to a reduction in microbial

resistance (25, 26). The high rate of resistance of bacteria to antibiotics in the present study and other studies conducted in Iran can be attributable to the indiscriminate prescription of antibiotics and their self-administration without a prescription. Additionally, other risk factors, such as recurrent UTIs and urinary tract abnormalities, affect the development of antibiotic resistance. In the treatment and management of UTIs, empirical antibiotics are given prior to the antibiogram results, which, beneficial as it may be for rapid relief, may also increase resistance long term. In this study, the least frequent resistance rate was seen regarding imipenem and amikacin; thus, they can be useful as empirical therapy in UTIs.

5.1. Limitations

One limitation of the present study was the use of data from a single center and a lack of country-wide generalization of resistance to accurately analyze their rates and patterns. However, in this study, different potential contributing demographic factors were analyzed to assist in the understanding of microbial resistance mechanisms. Another limitation was the small sample size, and the study is based on a census basis. Therefore, it is recommended to conduct similar studies with a random sampling of a larger population pool so that the results can be more generalizable.

5.2. Conclusions

In this study, consistent with the literature, a high rate of resistance was observed against the commonly used antibiotics. It is crucial to prescribe antibiotics methodically to prevent bacterial resistance to antimicrobial agents and reserve those with relatively infrequent resistances, such as imipenem and amikacin, for confirmed severe infections. Additionally, considering

Table 2. Prevalence of Antibiotic Resistance Among the Study Population

Antibiotic and Resistance	Prevalence, No. (%)
Amikacin	
Yes	44 (17.6)
No	206 (82.4)
Ampicillin	
Yes	134 (53.6)
No	116 (46.4)
Amoxicillin	
Yes	148 (59.2)
No	102 (40.8)
Ciprofloxacin	
Yes	74 (29.6)
No	176 (70.4)
Cefotaxime	
Yes	93 (37.2)
No	157 (62.8)
Ceftazidime	
Yes	98 (39.2)
No	152 (60.8)
Gentamicin	
Yes	78 (31.2)
No	172 (68.8)
Ceftriaxone	
Yes	97 (38.8)
No	153 (61.2)
Nalidixic acid	
Yes	109 (43.6)
No	141 (56.4)
Kanamycin	
Yes	83 (33.2)
No	167 (66.8)
Imipenem	
Yes	29 (11.6)
No	221 (88.4)

Table 3. The Statistical Relationship Between Gender and Antibiotic Resistance

Antibiotic and Gender	Prevalence of Resistance	P-Value
Amikacin		0.133
Male	11	
Female	33	
Ampicillin		0.866
Male	46	
Female	88	
Amoxicillin		0.686
Male	53	
Female	96	
Ciprofloxacin		0.217
Male	30	
Female	44	
Cefotaxime		0.861
Male	33	
Female	60	
Ceftazidime		0.606
Male	36	
Female	62	
Gentamicin		0.595
Male	29	
Female	49	
Ceftriaxone		0.735
Male	35	
Female	62	
Nalidixic acid		0.175
Male	43	
Female	66	
Kanamycin		0.595
Male	27	
Female	56	
Imipenem		0.97
Male	10	
Female	19	

Table 4. The Statistical Relationship Between Age and Antibiotic Resistance

Antibiotic and Age (y)	Prevalence of Resistance	P-Value
Amikacin		0.053
< 50	22	
> 50	22	
Ampicillin		0.098
< 50	62	
> 50	72	
Amoxicillin		0.056
< 50	64	
> 50	84	
Ciprofloxacin		0.066
< 50	33	
> 50	41	
Cefotaxime		0.132
< 50	39	
> 50	54	
Ceftazidime		0.07
< 50	42	
> 50	56	
Gentamicin		0.585
< 50	30	
> 50	48	
Ceftriaxone		0.056
< 50	42	
> 50	55	
Nalidixic acid		0.64
< 50	41	
> 50	68	
Kanamycin		0.383
< 50	33	
> 50	50	
Imipenem		0.061
< 50	15	
> 50	14	

Table 5. The Statistical Relationship Between Underlying Disease and Antibiotic Resistance

Antibiotic and Underlying Disease	Prevalence of Resistance	P-Value
Amikacin		0.967
Yes	8	
No	36	
Ampicillin		0.128
Yes	20	
No	114	
Amoxicillin		0.082
Yes	22	
No	126	
Ciprofloxacin		0.099
Yes	9	
No	65	
Cefotaxime		0.076
Yes	10	
No	83	
Ceftazidime		0.094
Yes	12	
No	86	
Gentamicin		0.125
Yes	10	
No	68	
Ceftriaxone		0.197
Yes	14	
No	83	
Nalidixic acid		0.499
Yes	18	
No	91	
Kanamycin		0.659
Yes	14	
No	69	
Imipenem		0.735
Yes	6	
No	23	

the importance of understanding antibiotic resistance patterns, epidemiological data from antibiograms are necessary for the treatment and management of UTIs.

Footnotes

Authors' Contribution: BYY conceptualized, designed, and supervised the study, GM reviewed and revised the manuscript, RNS contributed to the drafting, MH contributed to data collection, and AKR contributed to data collection and drafting. All authors read and approved the final manuscript.

Conflict of Interests: The authors declare no conflict of interest.

Data Reproducibility: The dataset presented in the study is available upon request from the corresponding author during submission or after publication. The data are not publicly available due to ethical considerations.

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References

1. Jalil MB, Al Atbee MYN. The prevalence of multiple drug resistance Escherichia coli and Klebsiella pneumoniae isolated from patients with urinary tract infections. *J Clin Lab Anal*. 2022;**36**(9). e24619. [PubMed ID: 35870190]. [PubMed Central ID: PMC9459318]. https://doi.org/10.1002/jcla.24619.

2. Tan CW, Chlebicki MP. Urinary tract infections in adults. *Singapore Med J*. 2016;**57**(9):485–90. [PubMed ID: 27662890]. [PubMed Central ID: PMC5027397]. https://doi.org/10.11622/smedj.2016153.

3. Tehrani FJ, Nikpour S. Effect of health on knowledge, self-efficacy and health behaviours of women with urinary tract infection. *Int J Urol Nurs*. 2014;**8**(1):3–14. https://doi.org/10.1111/ijun.12026.

4. Cordoba G, Holm A, Hansen F, Hammerum AM, Bjerrum L. Prevalence of antimicrobial resistant Escherichia coli from patients with suspected urinary tract infection in primary care, Denmark. *BMC Infect Dis*. 2017;**17**(1):670. [PubMed ID: 29017466]. [PubMed Central ID: PMC5635483]. https://doi.org/10.1186/s12879-017-2785-y.

5. Milovanovic T, Dumic I, Velickovic J, Lalosevic MS, Nikolic V, Palibrk I. Epidemiology and risk factors for multi-drug resistant hospital-acquired urinary tract infection in patients with liver cirrhosis: single center experience in Serbia. *BMC Infect Dis*. 2019;**19**(1):141. [PubMed ID: 30755176]. [PubMed Central ID: PMC6373165]. https://doi.org/10.1186/s12879-019-3761-5.

6. Bader MS, Loeb M, Brooks AA. An update on the management of urinary tract infections in the era of antimicrobial resistance. *Postgrad Med*. 2017;**129**(2):242–58. [PubMed ID: 27712137]. https://doi.org/10.1080/00325481.2017.1246055.

7. Beahm NP, Nicolle LE, Bursey A, Smyth DJ, Tsuyuki RT. The assessment and management of urinary tract infections in adults: Guidelines for pharmacists. *Can Pharm J (Ott)*. 2017;**150**(5):298–305. [PubMed ID: 28894499]. [PubMed Central ID: PMC5582677]. https://doi.org/10.1177/1715163517723036.

8. Geerlings SE. Clinical Presentations and Epidemiology of Urinary Tract Infections. *Urinary Tract Infections: Molecular Pathogenesis and Clinical Management*. Wiley; 2016. p. 27–40.

9. Long B, Koyfman A. The Emergency Department Diagnosis and Management of Urinary Tract Infection. *Emerg Med Clin North Am*. 2018;**36**(4):685–710. [PubMed ID: 30296999]. https://doi.org/10.1016/j.emc.2018.06.003.

10. Walker E, Lyman A, Gupta K, Mahoney MV, Snyder GM, Hirsch EB. Clinical Management of an Increasing Threat: Outpatient Urinary Tract Infections Due to Multidrug-Resistant Uropathogens. *Clin Infect Dis*. 2016;**63**(7):960–5. [PubMed ID: 27313263]. https://doi.org/10.1093/cid/ciw396.

11. Mahony M, McMullan B, Brown J, Kennedy SE. Multidrug-resistant organisms in urinary tract infections in children. *Pediatr Nephrol*. 2020;**35**(9):1563–73. [PubMed ID: 31418063]. https://doi.org/10.1007/s00467-019-04316-5.

12. Mihankhah A, Khoshbakht R, Raeisi M, Raeisi V. Prevalence and antibiotic resistance pattern of bacteria isolated from urinary tract infections in Northern Iran. *J Res Med Sci*. 2017;**22**:108. [PubMed ID: 29026424]. [PubMed Central ID: PMC5629843]. https://doi.org/10.4103/jrms.JRMS_889_16.

13. Odoki M, Almustapha Aliero A, Tibyangye J, Nyabayo Maniga J, Wampande E, Drago Kato C, et al. Prevalence of Bacterial Urinary Tract Infections and Associated Factors among Patients Attending Hospitals in Bushenyi District, Uganda. *Int J Microbiol*. 2019;**2019**:4246780. [PubMed ID: 30906323]. [PubMed Central ID: PMC6397969]. https://doi.org/10.1155/2019/4246780.

14. Odongo I, Ssemambo R, Kungu JM. Prevalence of Escherichia Coli and Its Antimicrobial Susceptibility Profiles among Patients with UTI at Mulago Hospital, Kampala, Uganda. *Interdiscip Perspect Infect Dis*. 2020;**2020**:8042540. [PubMed ID: 32076437]. [PubMed Central ID: PMC7016451]. https://doi.org/10.1155/2020/8042540.

15. Seifu WD, Gebissa AD. Prevalence and antibiotic susceptibility of Uropathogens from cases of urinary tract infections (UTI) in Shashemene referral hospital, Ethiopia. *BMC Infect Dis*. 2018;**18**(1):30. [PubMed ID: 29320984]. [PubMed Central ID: PMC5763535]. https://doi.org/10.1186/s12879-017-2911-x.

16. Jarsiah P, Alizadeh A, Mehdizadeh E, Ataee R, Khanalipour N. [Evaluation of antibiotic resistance model of Escherichia coli in urine culture samples at Kian hospital lab in Tehran, 2011-2012]. *J Mazandaran Univ Med Sci*. 2014;**24**(111):78–83. Persian.

17. Setu SK, Sattar ANI, Saleh AA, Roy CK, Ahmed M, Muhammadullah S. Study of Bacterial pathogens in Urinary Tract Infection and their antibiotic resistance profile in a tertiary care hospital of Bangladesh. *Bangladesh J Med Microbiol*. 2017;**10**(1):22–6. https://doi.org/10.3329/bjmm.v10i1.31449.

18. Abedi Samakoosh M, Aghaei N, Babamahmodi F, Dawodi AR. [Frequency and pattern of urinary pathogens and their antibiotic resistance in patients with urinary tract infection]. *J Mazandaran Univ Med Sci*. 2015;**25**(131):155–8.

19. Mortazavi-Tabatabaei SAR, Ghaderkhani J, Nazari A, Sayehmiri K, Sayehmiri F, Pakzad I. Pattern of Antibacterial Resistance in Urinary Tract Infections: A Systematic Review and Meta-analysis. *Int J Prev Med*. 2019;**10**:169. [PubMed ID: 32133087]. [PubMed Central ID: PMC6826787]. https://doi.org/10.4103/ijpvm.IJPVM_419_17.

20. Hossain A, Hossain SA, Fatema AN, Wahab A, Alam MM, Islam MN, et al. Age and gender-specific antibiotic resistance patterns among Bangladeshi patients with urinary tract infection caused by Escherichia coli. *Heliyon*. 2020;**6**(6). e04161. [PubMed ID: 32548331]. [PubMed Central ID: PMC7286969]. https://doi.org/10.1016/j.heliyon.2020.e04161.

21. Bryce A, Hay AD, Lane IF, Thornton HV, Wootton M, Costelloe C. Global prevalence of antibiotic resistance in paediatric urinary tract infections caused by Escherichia coli and association with routine use of antibiotics in primary care: systematic review and meta-analysis. *BMJ*. 2016;**352**. i939. [PubMed ID: 26980184]. [PubMed Central ID: PMC4793155]. https://doi.org/10.1136/bmj.i939.

22. Linhares I, Raposo T, Rodrigues A, Almeida A. Frequency and antimicrobial resistance patterns of bacteria implicated in community urinary tract infections: a ten-year surveillance study (2000-2009). *BMC Infect Dis*. 2013;**13**:19. [PubMed ID: 23327474]. [PubMed Central ID: PMC3556060]. https://doi.org/10.1186/1471-2334-13-19.

23. Rahman MM, Alam Tumpa MA, Zehravi M, Sarker MT, Yamin M, Islam MR, et al. An Overview of Antimicrobial Stewardship Optimization: The Use of Antibiotics in Humans and Animals to Prevent Resistance. *Antibiotics (Basel)*. 2022;**11**(5). [PubMed ID: 35625311]. [PubMed Central ID: PMC9137991]. https://doi.org/10.3390/antibiotics11050667.

24. Rocha V, Estrela M, Neto V, Roque F, Figueiras A, Herdeiro MT. Educational Interventions to Reduce Prescription and Dispensing of Antibiotics in Primary Care: A Systematic Review of Economic Impact. *Antibiotics (Basel)*. 2022;**11**(9). [PubMed ID: 36139965]. [PubMed Central ID: PMC9495011]. https://doi.org/10.3390/antibiotics11091186.

25. Kirchhelle C, Atkinson P, Broom A, Chuengsatiansup K, Ferreira JP, Fortane N, et al. Setting the standard: multidisciplinary hallmarks for structural, equitable and tracked antibiotic policy. *BMJ Glob Health*. 2020;**5**(9). [PubMed ID: 32967980]. [PubMed Central ID: PMC7513567]. https://doi.org/10.1136/bmjgh-2020-003091.

26. Puvaca N, de Llanos Frutos R. Antimicrobial Resistance in Escherichia coli Strains Isolated from Humans and Pet Animals. *Antibiotics (Basel)*. 2021;**10**(1). [PubMed ID: 33450827]. [PubMed Central ID: PMC7828219]. https://doi.org/10.3390/antibiotics10010069.