Content available at: https://www.ipinnovative.com/open-access-journals

Indian Journal of Microbiology Research

Journal homepage: https://www.ijmronline.org/

Original Research Article

Exploring bacterial profiles and antibiotic susceptibility patterns in urinary tract infection cases at Idlib university hospital, Syria

Fouad Al-Daoud[1], **Gohar Hussain Mushtaq**[2]*

[1]*Dept. of Laboratory Diagnosis, Faculty of Medicine, Idlib University, Idlib, Syria*
[2]*Dept. of Biochemistry, Center for Scientific Research, Faculty of Medicine, Idlib University, Idlib, Syria*

ARTICLE INFO

Article history:
Received 02-05-2024
Accepted 21-05-2024
Available online 16-07-2024

Keywords:
Urinary tract infection
Antibiotic susceptibility
Uropathogens
E. coli
Antimicrobial resistance

ABSTRACT

Background: The main objective of this study was to identify, analyze, and evaluate the bacteriological profile and antimicrobial susceptibility patterns of symptomatic urinary tract infections (UTIs) among patients at Idlib University Hospital in Northwest Syria. By isolating and characterizing the uropathogens, the study aimed to gain insights into their current antimicrobial susceptibilities. This information is crucial in order to combat the increasing antibiotic resistance and provide effective treatment options for UTIs, which are prevalent both in the community and hospital settings.

Materials and Methods: This observational research took place at Idlib University Hospital in Northwest Syria spanning from June 2022 to December 2023. Our study involved 320 patients exhibiting symptoms of UTI (68.4% females and 31.6% males). Urine samples were cultured to identify the microorganisms responsible for UTI. Biochemical tests were employed to identify the isolated bacteria, while the antimicrobial susceptibility was determined through disk diffusion susceptibility testing.

Results: Our study found *Escherichia coli* to be the leading cause of UTIs, accounting for 58.4% of cases, followed by *Proteus* spp. Gram-negative bacteria comprised 85% of isolated strains. The 13–65 age group showed the highest UTI susceptibility (41.3%). High resistance was observed to ampicillin/sulbactam, cefotaxime, ceftriaxone, and co-trimoxazole. Conversely, minimal resistance was noted against Meropenem, Imipenem, Gentamicin, and Levofloxacin.

Conclusion: This research highlights the prevalence of antibiotic-resistant infections within the hospital under study. Hence, there is an imperative to enhance the efficiency of comprehensive infection control initiatives to effectively handle and regulate hospital-acquired infections caused by highly resistant microorganisms.

1. Introduction

Urinary tract infections (UTIs) are a prevalent and significant health concern worldwide, necessitating prompt antibiotic treatment to avert potential complications, including pyelonephritis.[1] Among extraintestinal bacterial infections, UTIs stand out as one of the most common ailments encountered in medical practice, affecting individuals of all age groups, from newborns to the elderly.[2] Globally, more than 150 million people are diagnosed with UTIs annually,[1,3] constituting 8% and 2% of total reported infections in the United States[4] and France,[5] respectively. Similarly, UTIs account for approximately 10% of all infections in Saudi Arabia, ranking as the second most common reason for emergency department admissions.[6] The annual cost of treating UTIs in a single Saudi Arabian hospital is estimated to exceed $800,000.[7]

* *Corresponding author*.
E-mail address: dr.goher_mushtaq@idlib-university.com (G. H. Mushtaq).

https://doi.org/10.18231/j.ijmr.2024.013

The primary route of infection, responsible for the majority of UTIs, involves the retrograde ascent of bacteria from the fecal flora through the urethra into the bladder and kidneys, particularly in females due to their shorter and wider urethra and the transfer of microflora.[8] The unique anatomical features of the female urethra and vagina make it susceptible to trauma during sexual intercourse and exposure to pathogens during pregnancy and childbirth.[9,10] Approximately 60% of women will experience at least one symptomatic UTI in their lifetime, with higher rates among sexually active females.[11] In contrast, men are less susceptible to community-associated UTIs and their complications, largely due to anatomical differences.[11] UTI can affect either the lower or both upper and lower parts of the urinary tract. The term "cystitis" specifically refers to an infection impacting the bladder, characterized by symptoms like painful urination, frequent urges to urinate, and at times, tenderness in the lower abdomen. Although most UTIs are non-life-threatening and do not result in irreversible harm, kidney involvement poses a risk of tissue damage and an increased likelihood of bacteremia.[12]

Bacterial infections are the leading cause of UTIs, contributing to over 80% of cases, with *Escherichia coli* (*E. coli*) responsible for approximately 75% of these infections.[11,13] Other causative agents include *Klebsiella pneumoniae*, *Staphylococcus saprophyticus*, *Enterococcus faecalis*, and *Proteus mirabilis*.[11] Notably, antibiotic susceptibility profiles of these pathogens may vary geographically, potentially influenced by the use of different antibiotic classes recommended in various regions for UTI treatment.[14–17] Local surveillance for antimicrobial resistance (AMR) is crucial to ensure the rational and context-specific use of antibiotics for UTI treatment. This underscores the importance of prescribing prophylactic antibiotics based on recent surveillance studies, which can aid in eradicating the likely causative bacteria, reducing complications, and shortening treatment durations.[6]

Understanding the prevalence and antibiotic resistance patterns of bacteria causing UTIs is crucial for healthcare providers to tailor effective treatments. However, the frequency and resistance profiles of these bacteria can vary between communities, regionally, locally, and over time, thus highlighting the need for local data to make optimal treatment decisions. Monitoring and managing antibiotic resistance rates of pathogenic bacteria is essential due to the significant public health implications and impacts associated with antibiotic resistance. Recognizing the essential role of local data in guiding treatment decisions and understanding the lack of comprehensive information on UTI prevalence in the Idlib region, our study seeks to address this gap by investigating the distribution of bacteria causing UTIs and their antibiotic susceptibility patterns. The goal of this study is also to highlight the need for ongoing local antibiotic surveillance programs to evaluate microbial resistance patterns and tailor antibiotic therapies accordingly.

2. Materials and Methods

Single bacterial species (pure cultures) identified from positive urine cultures collected between June 2022 and December 2023 were included in this study. Positive urine cultures were defined as those containing $\geq 10^5$ colony-forming units (CFU) of one specific bacterial species per milliliter of urine. Mid-stream urine samples were collected by adult patients themselves using designated sterile urine collection containers. For patients with more than one urine culture, only the first reported episode was included in this study because no guidelines were available to differentiate between multiple cultures. Cultures with polymicrobial growth (more than one species), low colony counts ($<10^5$ CFU/mL), and samples belonging to patients taking antibiotics were excluded from this investigation. Patients who tested positive in their cultures were categorized as individuals with UTIs, and they were further grouped based on age and gender.

2.1. Bacterial identification and antibiotic sensitivity testing

Urine samples were cultured on digested soy agar plates and MacConkey agar using a 10 μl calibrator, and the plates were then incubated for 24-48 hours at 37°C. Subsequently, the isolated bacteria were stained with Gram stain and classified as Gram-positive cocci (GPC) or Gram-negative rods (GNR), followed by complete identification and antibiotic susceptibility testing using the Kirby-Bauer disk diffusion method.[18] The data obtained was analyzed and interpreted in accordance with the Clinical Laboratory Standards Institute (CLSI) guidelines.[19] The sensitivity of isolates associated with UTI was evaluated against a combination of antibiotics available in the local market including Amikacin (30μg), Amoxicillin/clavulanic acid (30μg), Ampicillin/sulbactam (10μg/10μg), Cefadroxil (30μg), Cefixime(5μg), Cefotaxime(30μg), Cefuroxime (30μg), Ceftriaxone (30μg), Ciprofloxacin (10μg), Doxycycline (30μg), Gentamicin (10μg), Imipenem (10μg), Levofloxacin (15μg), Meropenem (10μg), Nitrofurantoin (100μg), Norfloxacin (10μg), Ofloxacin (10μg), Tobramycin (10μg), Piperacillin/Tazobactam (100μg/10μg), Co-Trimoxazole (25μg) and Vancomycin (30μg).

2.2. Statistical analysis

Data were entered and analyzed using SPSS version 25 (IBM Corporation, New York, USA) software. Discreet variables were represented as frequencies and percentages. The findings were displayed through tabular formats.

3. Results

A summary of the different microorganisms isolated during the study period is shown in Table 1. It is clear that *E. coli* was the predominant uropathogen 187 (58.4%) causing UTI, followed by *Proteus* spp. 47 (14.7%), *Staphylococcus* spp. 42 (13.1%), *Klebsiella* spp.16 (5.0%) and *Enterobacter* spp. 12 (3.8%).

Table 1: Frequency and percentage of bacterial agents isolated from urine specimens in the study population

Percent	Frequency	Bacterium
58.4	187	*Escherichia coli*
14.7	47	*Proteus* spp.
13.1	42	*Staphylococcus* spp.
5.0	16	*Klebsiella* spp.
5.0	16	*Pseudomonas* spp.
3.8	12	*Enterobacter* spp.
100.0	320	Total

Of the 320 patients included in the study, the majority of the bacteria were isolated from females (68.4%), while the remaining (31.6%) were from males. The most prevalent organism found in the females and males was *E. coli* (42.8% and 15.6% respectively). In females, *Proteus* spp. was the second most prevalent organism at 10.6%, followed by *Staphylococcus* spp. (8.4%), Klebsiella spp. (3.8%), *Enterobacter* spp. (1.9%), and *Pseudomonas* spp. (0.9%). Among males, the second most prevalent organism was *Staphylococcus* spp. (4.7%) followed by *Proteus* spp. (4.1%), *Pseudomonas* spp. (4.1%), *Enterobacter* spp. (1.9%) and *Klebsiella* spp. (1.3%) (Table 2).

Table 2: Distribution percentage of bacterial agents isolated from urine specimens among gender in the study population

Bacterium	Gender		Total (%)
	Female (%)	Male (%)	
Escherichia coli	42.8	15.6	58.4
Proteus spp.	10.6	4.1	14.7
Staphylococcus spp.	8.4	4.7	13.1
Klebsiella spp.	3.8	1.3	5.0
Enterobacter spp.	1.9	1.9	3.8
Pseudomonas spp.	0.9	4.1	5.0
Total (%)	68.4	31.6	100.0

The most susceptible age group for UTI was 13–65 years (41.3%), followed by 0–13 years (35.3%), and >65 years (23.4%). The highest number of *E. coli* was found in the age group of 13–65 (23.4%), followed by 0–13 years (19.1%), and > 65 years (15.9%). The second most prevalent organism among the age group of 13–65 years was *Staphylococcus* spp. (7.5%), followed by *Proteus* spp. (6.6%), *Klebsiella* spp. (1.9%), *Pseudomonas* spp. (0.9%), and *Enterobacter* spp. (0.9%). For 0–13 years, the second most prevalent organism was *Proteus* spp. (5.6%), followed by Staphylococcus spp. (3.8%), *Pseudomonas* spp. (2.8%), *Enterobacter* spp. (2.2%) and *Klebsiella* spp. (1.9%). Likewise, for patients aged > 65 years, the second most prevalent organism was *Proteus* spp. (2.5%), followed by *Staphylococcus* spp. (1.9%), *Klebsiella* spp. (1.3%), *Pseudomonas* spp. (1.3%), and *Enterobacter* spp. (0.6%) (Table 3)

Table 3: Distribution percentage of bacterial agents isolated from urine specimens among the age groups of the study population

Bacterium	Age (%)			Total (%)
	0-13	13-65	>65	
Escherichia coli	19.1	23.4	15.9	58.4
Proteus spp.	5.6	6.6	2.5	14.7
Staphylococcus spp.	3.8	7.5	1.9	13.1
Klebsiella spp.	1.9	1.9	1.3	5.0
Pseudomonas spp.	2.8	0.9	1.3	5.0
Enterobacter spp.	2.2	0.9	0.6	3.8
Total (%)	35.3	41.3	23.4	100.0

Of the patients included in the study, the inpatients were (48.3%), whereas the outpatients were (51.7%). The most prevalent bacterial agent found in the inpatients group was *E. coli* (35%) followed by *Proteus* spp. (4.9%) and *Pseudomonas* spp. (4.2%). For outpatient group, the most prevalent bacterial agent was *E. coli* (30.1%) followed by *Staphylococcus* spp. (9.8%) and *Proteus* spp. (6.3%) (Table 4).

Table 4: Distribution percentage of bacterial agents isolated from urine specimens among the admission groups of the study population

Bacterium	Admission (%)		Total (%)
	Inpatients	Outpatients	
Escherichia coli	35	30.1	65.1
Proteus spp.	4.9	6.3	11.2
Staphylococcus spp.	2.1	9.8	11.9
Pseudomonas spp.	4.2	2.8	7.0
Klebsiella spp.	0.7	2.1	2.8
Enterobacter spp.	1.4	0.7	2.1
Total (%)	48.3	51.7	100

Table 5 presents antimicrobial susceptibility profiling of the isolated UTI pathogens. Based on Table 5, Cefotaxime was found to be the most resistant drug in 87.5% cases of *E. coli* followed by Cefadroxil (77.5%), Co-trimoxazole (75.9%) and Ampicillin/sulbactam (73.8%). However, Meropenem emerged as the most sensitive drug in 89% isolates of *E. coli*, followed by Imipenem (85.2%) and Amikacin (81.2%). All 47 isolates (100%) of *Proteus* spp. were found to be resistant to Cefotaxime followed by Co-Trimoxazole (85.3%), Cefadroxil (81.8%),

Cefuroxime (76.5%). However, (86.7%) of isolates were sensitive to Meropenem followed by Amikacin (85%), Piperacillin/Tazobactam (77.8%), Gentamicin (74.2%) and Ofloxacin (70.2%). The resistance and sensitivity range of tested antimicrobial agents against *Proteus* spp. was 5%-100% and 0%-86.7% respectively (Table 5).

All 42 isolates (100%) of *Staphylococcus* spp. were resistant to Cefotaxime and Tobramycin followed by Cefixime (85.3%), Cefadroxil (89.5%), Cefuroxime (87.5%), Ceftriaxone (81.8%), Ampicillin/sulbactam and Co-Trimoxazole (75%). However, (77.8%) of isolates were sensitive to Piperacillin/Tazobactam followed by Amikacin (73.3%), Imipenem (73.3.8%), Nitrofurantoin (66.7%) and Meropenem (63.6%). The resistance and sensitivity range of tested antimicrobial agents against *Staphylococcus* spp. was 20%-100% and 0%-77.8% respectively (Table 5).

All 16 isolates (100%) of *Klebsiella* spp. were resistant to Ampicillin/sulbactam, Cefotaxime and Piperacillin/Tazobactam followed by Co-Trimoxazole (91.7%), Cefixime (88.9%), Nitrofurantoin (87.5%), Ceftriaxone (78.6%), Ceftriaxone (81.8%) and Cefuroxime (75%). However, 61.5% of isolates were sensitive to Imipenem and Norfloxacin followed by Gentamicin (58.3.%). The resistance and sensitivity range of tested antimicrobial agents against *Klebsiella* spp. was 0%-100% and 0%-61.5% respectively (Table 5).

All 16 isolates (100%) of *Pseudomonas* spp. were 100% resistant to Amoxicillin/clavulanic acid, Ampicillin/sulbactam, Cefadroxil, and Cefotaxime followed by highly resistant to Nitrofurantoin (91.7%), Ceftriaxone (90.9%), Cefixime (88.9%), Co-Trimoxazole (88.9%), Doxycycline (80%) and Piperacillin/Tazobactam (75%). However, 80% of isolates were sensitive to both of Cefuroxime and Imipenem followed by both of Meropenem and Ofloxacin (75%). The resistance and sensitivity range of tested antimicrobial agents against *Pseudomonas* spp. was 0%-100% and 0%-80% respectively (Table 5).

All 12 isolates (100%) of *Enterobacter* spp. were resistant to Amoxicillin/clavulanic acid, Ampicillin/sulbactam, and Cefadroxil followed by Cefixime, Cefotaxime, Cefuroxime and Ceftriaxone. However, 91.7% of the isolates were sensitive to Amikacin followed by Imipenem (72.7%). The resistance and sensitivity range of tested antimicrobial agents against *Enterobacter* spp. was 0%-100% and 0%-91.7%, respectively (Table 5).

4. Discussion

Bacterial UTIs frequently prompt medical attention within the community. Successfully treating individuals with these infections depends on identifying the specific organisms responsible and choosing an appropriate antibiotic that targets those organisms effectively. Healthcare providers need to be aware of how often bacteria provoke UTIs and the way they resist antibiotics. This knowledge helps tailor treatments effectively. However, these bacteria's prevalence and resistance vary among different communities, so local data is crucial for optimal treatment choices. There is an urgent need to take an action to combat the spread of antimicrobial resistance[20] as the prevalence of antibiotic resistance among causes of UTIs continues to increase.[21–23] Accordingly, multiple steps have been recommended, each with an important role in combating antimicrobial resistance, with antibiotic surveillance programs being one of the top 10 resistance control strategies.[24] For instance, antibiotic surveillance programs have been recommended to combat antimicrobial resistance, with such programs being recognized as one of the top 10 strategies for resistance control. Several Saudi cities, including Mecca, Jeddah, and Riyadh, have routinely conducted antibiotic surveillance programs for microorganisms associated with UTIs.[25–27]

Amidst the conflicting research data on antibiotic susceptibility in UTIs,[28] clinicians are compelled to evaluate local bacterial cultures for guiding targeted antibiotic therapies. This approach becomes crucial to mitigate the escalating threat of antibiotic resistance in communities and underscores the significance of local insights in making informed decisions about antibiotic treatment. This study's goal was to identify how often different agents cause UTIs and assess their current resistance to antibiotics among the outpatients visiting Idlib University hospital in Syria.

The results of our study have shown that *E. coli* stands out as the primary causative factor behind the UTIs, contributing to as much as 58.4% of occurrences. Within our investigation, the prevailing UTIs were primarily attributed to Gram-negative bacteria, constituting around 85% of all isolated strains (Tables 1 and 2). Consistent with existing literature, our study accentuates predominant role played by *E. coli* in UTIs across genders.[29–32]

In our research, we found that *E. coli* and *Proteus* species were the predominant organisms identified. While *E. coli* is widely recognized as the primary cause of UTIs in medical literature, our study revealed a different second most common pathogen (*Proteus* spp.) compared to previous researches. For instance, two studies from Turkey reported *Klebsiella* species as the second most prevalent organism, consistent with our findings.[33,34] Kidwai et al. observed *S. aureus* and *Klebsiella* species as the second most common bacteria after *E. coli* among Pakistani patients in low socioeconomic strata.[35] According to a retrospective study conducted by Ağca and Toklu, the second most frequently detected bacteria in urine samples after *E. coli* were *Pseudomonas aeruginosa* (6%), *Enterococcus* species (5%), *Klebsiella* species (5%), and *Staphylococcus aureus* (4%).[36] These variations elucidate the importance of considering local epidemiological factors and patient demographics when assessing UTI etiology and designing

Table 5: Antimicrobial susceptibility profiling of isolated UTI pathogens

	Isolated UTI pathogens																	
	***Escherichia coli* (N=187)**			***Proteus* spp. (N=47)**			***Staphylococcus* spp. (N=42)**			***Klebsiella* spp. (N=16)**			***Pseudomonas* spp. (N=16)**			***Enterobacter* spp. (N=12)**		
Antimicrobial agents	R (%)	I (%)	S (%)	R (%)	I (%)	S (%)	R (%)	I (%)	(%)	R (%)	I (%)	S (%)	R (%)	I (%)	S (%)	R (%)	I (%)	S (%)
Amikacin	11.8	7.1	81.2	5	10	85	20	6.7	73.3	26.7	26.7	46.7	43.8	0	56.3	0	8.3	91.7
Amoxicillin / clavulanic acid	40.5	27.3	32.2	36.4	24.2	39.4	41.2	5.9	52.9	64.3	28.6	7.1	100	0	0	66.7	8.3	25
Ampicillin / sulbactam	73.8	11.9	14.3	66.7	0	33.3	75	12.5	12.5	100	0	0	100	0	0	NT	NT	NT
Cefadroxil	77.5	16.7	5.9	81.8	12.1	6.1	50	14.3	35.7	55.6	44.4	0	100	0	0	100	0	0
Cefixime	56.1	7.9	36	63.3	13.3	23.3	89.5	5.3	5.3	88.9	0	11.1	88.9	0	11.1	100	0	0
Cefotaxime	87.5	3.1	9.4	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0
Cefuroxime	58.1	9.7	32.3	76.5	5.9	17.6	87.5	0	12.5	75	0	25	20	0	80	83.3	16.7	0
Ceftriaxone	70.4	7	22.5	64.9	10.8	24.3	81.8	0	18.2	78.6	14.3	7.1	90.9	0	9.1	81.8	0	18.2
Ciprofloxacin	43.5	10.1	46.4	33.3	10	56.7	26.7	26.7	46.7	61.5	7.7	30.8	38.5	7.7	53.8	25	0	75
Doxycycline	49.2	13.1	37.7	44.8	6.9	48.3	40	20	40	42.9	57.1	0	80	0	20	55.6	11.1	33.3
Gentamicin	25.9	1.8	72.3	22.6	3.2	74.2	61.5	15.4	23.1	33.3	8.3	58.3	40.7	8.3	50	44.4	0	55.6
Imipenem	6.6	8.2	85.2	18.9	10.8	70.3	26.7	0	73.3	30.8	7.7	61.5	10	10	80	27.3	0	72.7
Levofloxacin	39.1	11.3	49.6	26.7	3.3	70	27.8	22.2	50	33.3	22.2	44.4	33.3	0	66.7	20	0	80
Meropenem	11	0	89	6.7	6.7	86.7	36.4	0	63.6	16.7	0	38.3	25	0	75	40	0	60
Nitrofurantoin	27.5	8.8	63.7	46.5	11.6	41.9	22.2	11.1	66.7	87.5	0	12.5	91.7	0	8.3	60	10	30
Norfloxacin	43.6	3.6	52.7	26.8	4.9	68.3	43.8	18.8	37.5	38.5	0	61.5	41.7	0	58.3	44.4	0	55.6
Ofloxacin	47.3	6.3	46.4	29.2	0	70.8	50	16.7	33.3	41.7	8.3	50	25	0	75	50	0	50
Tobramycin	23.4	9.4	67.2	23.1	23.1	53.8	100	0	0	42.9	28.6	28.6	40	0	60	42.9	14.3	42.9
Piperacillin/ Tazobactam	34.1	2.4	63.4	22.2	0	77.8	22.2	0	77.8	100	0	0	75	0	25	50	0	50
Co-Trimoxazole	75.9	3.5	20.6	85.3	0	14.7	75	6.3	18.8	91.7	0	8.3	88.9	11.1	0	75	0	25
Vancomycin	NT	NT	NT	NT	NT	NT	50	0	50	NT	NT	NT	NT	NT	NT	NT	NT	NT

NT = Not Tested

treatment strategies.

With respect to the distribution percentage of bacterial agents in different age groups (Table 3), the age group of 13–65 years appears to be the most susceptible to UTIs, with the highest incidence (41.3%), followed by the 0–13 years group (35.3%), and those aged >65 years (23.4%). Possible reasons for being the age group of 13–65 years to be the most susceptible to UTIs could be attributed to heightened sexual activity, increased frequency of pregnancies, and the utilization of specific contraceptives such as diaphragms or spermicides, which could be associated with UTIs in this age group.[37] *E. coli* remains the primary cause of UTIs across all age groups, while the distribution of other organisms varies, highlighting potential age-related differences in susceptibility and bacterial profiles associated with UTIs.

In our current study, the overall percentage revealed a more balanced distribution of uropathogens between inpatients and outpatients. Unlike the higher prevalence of uropathogens among inpatients reported in previous studies,[38,39] we observed a similar occurrence rate among inpatients and outpatients in our study. This discrepancy suggests potential variations in the patient population as well as healthcare practices in conflict areas such as Idlib. However, overall the gram-negative isolates were more common among the inpatients as compared to the outpatients which could be explained in terms of hospitalization, underlying health conditions, prolonged antibiotic usage, and compromised immune systems of the inpatients.[40]

The issue of antimicrobial resistance poses a significant challenge in effectively treating infections instigated by various bacterial pathogens and has exhibited a rising trend across time. The comprehensive analysis of antimicrobial susceptibility pattern of isolated UTI pathogens (Table 5) sheds light onto the resistance patterns of various bacterial isolates. *E. coli* demonstrated heightened resistance to Cefotaxime (87.5%), while exhibiting considerable sensitivity to Meropenem (89%). Moreover, *E. coli* exhibited elevated resistance to ampicillin/sulbactam (73.8%) but showed considerable sensitivity to piperacillin/tazobactam. Resistance to ampicillin in many *E. coli* strains is mediated by plasmid-mediated TEM-1 β-lactamase.[41] Hence, the efficacy of ampicillin-sulbactam in treating *E. coli* infections heavily relies on the inhibitory action of sulbactam. However, sulbactam's potency as a TEM-1 inhibitor is relatively limited,[41] and *E. coli* resistance can arise through various mechanisms. Therefore, as seen in our data, Piperacillin-tazobactam may offer protection against the emergence of *E. coli* strains resistant to ampicillin-sulbactam, likely due to relatively high susceptibility of *E. coli* to piperacillin-tazobactam.[41,42] Piperacillin is less favored as a substrate for TEM-1 compared to ampicillin, and tazobactam demonstrates stronger inhibition of TEM-1 β-lactamase than sulbactam. Consequently, piperacillin-tazobactam exhibits superior activity against *E. coli* strains producing TEM-1.[41,43,44]

Proteus spp. showcased complete resistance to Cefotaxime but exhibited significant sensitivity to Meropenem (86.7%). *Staphylococcus* spp., on the other hand, displayed universal resistance to Cefotaxime and Tobramycin, with Piperacillin/Tazobactam emerging as the most effective agent (77.8%). *Klebsiella* spp. and *Pseudomonas* spp. both exhibited widespread resistance to multiple agents, emphasizing the challenges in selecting effective treatments. Carbapenems seem to serve as the final line of defense against *Klebsiella* spp. and *Pseudomonas* spp. as it has been reported in the literature.[45,46] Likewise, *Enterobacter* spp. revealed high resistance to several agents, with notable sensitivity to Amikacin (91.7%). The uropathogens isolated showed elevated resistance levels to ampicillin/sulbactam, cefotaxime, ceftriaxone, and co-trimoxazole. The notable resistance seen with these antibiotics could stem from the community's tendency toward self-medication and indiscriminate use of drugs to treat various bacterial infections.[39] In contrast, minimal resistance was found across nearly all pathogens analyzed against antibiotics like Meropenem, Imipenem, Gentamicin, and Levofloxacin. The limited resistance noted for these medications may be attributed to their comparatively higher cost. Consequently, these antibiotics might serve as viable alternatives for empirically treating UTIs in our community. These findings accentuate the variability in antimicrobial susceptibility across different pathogens, emphasizing the importance of targeted and informed antibiotic therapy, thereby suggesting that a tailored approach is crucial for effective treatment based on the specific susceptibility patterns observed in each pathogen.

5. Conclusion

In summary, the identification of bacterial strains in UTIs displaying elevated resistance to frequently prescribed antimicrobials pose a significant challenge for clinicians, limiting available treatment options and emphasizing the need for a reevaluation of empirical treatment approaches. Given the evolving nature of drug resistance among pathogens, enhancing the efficacy of comprehensive infection control initiatives is imperative to mitigate and manage nosocomial infections stemming from highly resistant organisms. The findings from this current study shed light on the intricate landscape of antimicrobial resistance among diverse bacterial strains, necessitating a nuanced approach to treatment selection in the area of Northwest Syria. The observed patterns serve as a valuable resource for clinicians, aiding in the optimization of antibiotic therapies based on the prevalent bacterial species and their respective resistance profiles. Future

research should delve into the molecular mechanisms driving resistance, facilitating the development of targeted interventions for improved treatment outcomes.

6. Conflicts of Interest

The authors declare that there is no conflict of interest.

7. Ethical Approval

This study was approved by the Ethics Committee of the University of Idlib. Patient privacy and data confidentiality were maintained in accordance with the Declaration of Helsinki.

8. Source of Funding

None.

9. Author Contributions

Writing original draft, Fouad Al-Daoud; Conceptualization, Fouad Al-Daoud and Gohar Mushtaq; Data Curation, Fouad Al-Daoud; Methodology, Fouad Al-Daoud and Gohar Mushtaq; Review & editing, Gohar Mushtaq.

10. Data Availability Statement

Raw data were generated at Idlib University Hospital. Derived data supporting the findings of this study are available from the corresponding author GM on request.

References

1. Flores-Mireles AL, Walker JN, Caparon M, Hultgren SJ. Urinary tract infections: epidemiology, mechanisms of infection and treatment options. *Nat Rev Microbiol*. 2015;13(5):269–84.
2. Kunin CM. Urinary Tract Infections in Females. *Clin Infect Dis*. 1994;18(1):1–12.
3. Gebremariam G, Legese H, Woldu Y, Araya T, Hagos K, Gebreyesuswasihun A. Bacteriological profile, risk factors and antimicrobial susceptibility patterns of symptomatic urinary tract infection among students of Mekelle University, northern Ethiopia. *BMC Infect Dis*. 2019;19(1):950.
4. Caterino JM, Ting SA, Sisbarro SG, Espinola JA, Camargo CA. Age, Nursing Home Residence, and Presentation of Urinary Tract Infection in U.S. Emergency Departments. *Acad Emerg Med*. 2001;19(10):1173–80.
5. François M, Hanslik T, Dervaux B, Strat YL, Souty Y, Vaux C, et al. The economic burden of urinary tract infections in women visiting general practices in France: a cross-sectional survey. *BMC Health Serv Res*. 2009;16(1):365.
6. Salam MQ, Al-Jeraisy MI, Salam M. Prevalence and predictors of antibiotic prescription errors in an emergency department, Central Saudi Arabia. *Drug Healthc Patient Saf*. 2015;7:103–11.
7. Alanazi MQ. An evaluation of community-acquired urinary tract infection and appropriateness of treatment in an emergency department in Saudi Arabia. *Ther Clin Risk Manag*. 2018;14:2363–73.
8. Jones RN, Inabo HI. Antimicrobial susceptibility of some urinary tract clinical isolates to commonly used antibiotics. *Afr J Biotechnol*. 2006;5:487–9.
9. Sweih NA, Jamal W, Rotimi VO. Spectrum and antibiotic resistance of uropathogens isolated from hospital and community patients with urinary tract infections in two large hospitals in Kuwait. *Med Princ Pract*. 2005;14(6):401–7.
10. Kolawale AS, Kolawale OM, Kandaki-Olukemi YT, Babatunde SK, Durowade KA. Prevalence of urinary tract infections (UTI) among patients attending Dalhatu Araf Specialist Hospital, Lafia, Nasarawa State, Nigeria. *Int J Med Med Sci*. 2009;1(5):163–7.
11. Sobel JD, Kaye D. Urinary Tract Infections. In: Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases. Elsevier; 2015. p. 886–913.
12. Hvidberg H, Struve C, Krogfelt KA, Christensen N, Rasmussen SN, Frimodt-Møller N. Development of a Long-Term Ascending Urinary Tract Infection Mouse Model for Antibiotic Treatment Studies. *Antimicrob Agents Chemother*. 2000;44(1):156–63.
13. Kang CI, Kim J, Park DW, Kim BN, Ha US, Lee SJ, et al. Clinical Practice Guidelines for the Antibiotic Treatment of Community-Acquired Urinary Tract Infections. *Infect Chemother*. 2018;50(1):67–100.
14. Onanuga A, Awhowho G. Antimicrobial resistance of Staphylococcus aureus strains from patients with urinary tract infections in Yenagoa, Nigeria. *J Pharm Bioallied Sci*. 2012;4(3):226–30.
15. Alsohaim SIA, Bawadikji AA, Elkalmi R, Mahmud M, Hassali MA. Relationship between antimicrobial prescribing and antimicrobial resistance among UTI patients at Buraidah Central Hospital, Saudi Arabia. *J Pharm Bioallied Sci*. 2019;11(2):162–9.
16. Alzahrani M, Ali M, Anwar S. Bacteria Causing Urinary Tract Infections and Its Antibiotic Susceptibility Pattern at Tertiary Hospital in Al-Baha Region, Saudi Arabia: A Retrospective Study. *J Pharm Bioallied Sci*. 2020;12(4):449–56.
17. Abejew AA, Denboba AA, Mekonnen AG. Prevalence and antibiotic resistance pattern of urinary tract bacterial infections in Dessie area. *BMC Res Notes*. 2014;7(1):687.
18. Cappuccino J, Welsh C. Microbiology: A Laboratory Manual. 12th ed. New Jersey: Pearsons; 2019.
19. Performance Standards for Antimicrobial Susceptibility Testing. CLSI Supplement M100, 31st Edition. USA: Clinical and Laboratory Standards Institutue (CLSI); 2021. Available from: https://www.treata.academy/wp-content/uploads/2021/03/CLSI-31-2021.pdf.
20. Parsonage B, Hagglund PK, Keogh L, Wheelhouse N, Brown RE, Dancer SJ. Control of Antimicrobial Resistance Requires an Ethical Approach. *Front Microbiol*. 2017;8:2124.
21. Huang ES, Stafford RS. National Patterns in the Treatment of Urinary Tract Infections in Women by Ambulatory Care Physicians. *Arch Intern Med*. 2002;162(1):41–7.
22. Zhanel GG, Karlowsky JA, Harding GK, Carrie A, Mazzulli T, Low DE. A Canadian national surveillance study of urinary tract isolates from outpatients: comparison of the activities of trimethoprim-sulfamethoxazole, ampicillin, mecillinam, nitrofurantoin, and ciprofloxacin. The Canadian Urinary Isolate Study Group. *Antimicrob Agents Chemother*. 2000;44(4):1089–92.
23. Gupta K, Scholes D, Stamm WE. Increasing Prevalence of Antimicrobial Resistance Among Uropathogens Causing Acute Uncomplicated Cystitis in Women. *JAMA*. 1999;281(8):736–8.
24. Zowawi HM. Antimicrobial resistance in Saudi Arabia. *Saudi Med J*. 2016;37(9):935–40.
25. Faidah HS, Ashshi AM, El-Ella GAA, Al-Ghamdi AK, Mohamed AM. Urinary Tract Infections among Pregnant Women in Makkah, Saudi Arabia. *Biomed Pharmacol J*. 2013;30(1):1–7.
26. Eltahawy AT, Khalaf RMF. Urinary Tract Infection at a University Hospital in Saudi Arabia: Incidence, Microbiology, and Antimicrobial Susceptibility. *Ann Saudi Med*. 1988;8(4):261–6.
27. Alanazi MQ, Alqahtani FY, Aleanizy FS. An evaluation of E. coli in urinary tract infection in emergency department at KAMC in Riyadh, Saudi Arabia: retrospective study. *Ann Clin Microbiol Antimicrob*. 2009;17(1):3.
28. Rizvi ZA, Jamal AM, Malik AH, Zaidi SMJ, Rahim NUA, Arshad D. Exploring Antimicrobial Resistance in Agents Causing Urinary Tract Infections at a Tertiary Care Hospital in a Developing Country. *Cureus*. 2020;12(8):e9735.

29. Tessema B, Kassu A, Mulu A, Yismaw G. Pridominant isolates of urinary tract pathogens and their antimicrobial susceptiblity patterns in Gondar University Teaching Hospital, nothwest Ethiopia. *Ethiop Med J*. 2007;45(1):61–7.
30. Raka L, Mulliqi-Osmani G, Berisha L, Begolli L, Omeragiq S, Parsons L, et al. Etiology and susceptibility of urinary tract isolates in Kosova. *Int J Antimicrob Agents*. 2004;23:2–5.
31. Farajnia S, Alikhani MY, Ghotaslou R, Naghili B, Nakhlband A. Causative agents and antimicrobial susceptibilities of urinary tract infections in the northwest of Iran. *Int J Infect Dis*. 2009;13(2):140–4.
32. Dromigny JA, Nabeth P, Claude J. Distribution and susceptibility of bacterial urinary tract infections in Dakar, Senegal. *Int J Antimicrob Agents*. 2002;20(5):339–47.
33. Uslu M, Bağcıoğlu M, Tekdoğan Ü, Kocaaslan R, Çeçen K. Epidemology and Antibiotic Resistance of Urinary Tract Infection in the Kars Region. *Kafkas J Med Sci*. 2019;9(2):90–6.
34. Ünsal H, Kaman A, Tanır G. Relationship between urinalysis findings and responsible pathogens in children with urinary tract infections. *J Pediatr Urol*. 2019;15(6):606–7.
35. Kidwai SS, Nageen A, Ghaznavi S, Basheer F, Ara J. Antibiotic susceptibility in commonly isolated pathogens from urinary tract infection in a cohort of subjects from low socioeconomic strata. *Pak J Med Sci*. 2017;33(2):254–9.
36. Agca H, Toklu GD. Bacteria Isolated from Urine Samples and Their Antimicrobial Susceptibilities. *J Clin Anal Med*. 2013;4:30–3.
37. Najar M, Saldanha C, Banday K. Approach to urinary tract infections. *Indian J Nephrol*. 2009;19(4):129.
38. Kengne M, Dounia AT, Nwobegahay JM. Bacteriological profile and antimicrobial susceptibility patterns of urine culture isolates from patients in Ndjamena, Chad. *Pan Afr Med J*. 2017;28:258.
39. Girma A, Aemiro A. The Bacterial Profile and Antimicrobial Susceptibility Patterns of Urinary Tract Infection Patients at Pawe General Hospital, Northwest Ethiopia. *Scientifica (Cairo)*. 2022;2022:3085950.
40. Seifu WD, Gebissa AD. Prevalence and antibiotic susceptibility of Uropathogens from cases of urinary tract infections (UTI) in Shashemene referral hospital. *BMC Infect Dis*. 2018;18(1):30.
41. Livermore DM. beta-Lactamases in laboratory and clinical resistance. *Clin Microbiol Rev*. 1995;8(4):557–84.
42. Jones RN, Pfaller MA, Doern GV, Erwin ME, Hollis RJ. Antimicrobial Activity and Spectrum Investigation of Eight Broad-Spectrum β-Lactam Drugs: A 1997 Surveillance Trial in 102 Medical Centers in the United States. *Diagn Microbiol Infect Dis*. 1998;30(3):215–28.
43. Reguera JA, Baquero F, Pérez-Díaz JC, Martínez JL. Factors determining resistance to β-lactam combined with β-lactamase inhibitors in Escherichia coli. *J Antimicrob Chemother*. 1991;27(5):569–75.
44. Vanjak D, Muller-Serieys C, Picard B, Bergogne-Berezin E, Lambert-Zechovsky N. Activity of beta-lactamase inhibitor combinations on Escherichia coli isolates exhibiting various patterns of resistance to beta-lactam agents. *Eur J Clin Microbiol Infect Dis*. 1995;14(11):972–8.
45. Ding Y, Wang H, Pu S, Huang S, Niu S. Resistance Trends of Klebsiella pneumoniae Causing Urinary Tract Infections in Chongqing. *Infect Drug Resist*. 2011;14:475–81.
46. Shah DA, Wasim S, Abdullah FE. Antibiotic resistance pattern of Pseudomonas aeruginosa isolated from urine samples of Urinary Tract Infections patients in Karachi, Pakistan. *Pak J Med Sci*. 2015;31(2):341–5.

Author biography

Fouad Al-Daoud, Associate Professor and Director https://orcid.org/0000-0001-7306-7407

Gohar Hussain Mushtaq, Professor https://orcid.org/0000-0003-4880-4035

Cite this article: Al-Daoud F, Mushtaq GH. Exploring bacterial profiles and antibiotic susceptibility patterns in urinary tract infection cases at Idlib university hospital, Syria. *Indian J Microbiol Res* 2024;11(2):63-70.