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Antibiotic Susceptibility Patterns of Bacterial pathogens in Urinary Tract Infection

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Abstract: Urinary tract infections (UTIs) are common bacterial infections, primarily caused by Escherichia coli. Increasing antimicrobial resistance (AMR) complicates treatment, particularly with E. coli and other uropathogens like Klebsiella pneumoniae. The prevalence of multidrug-resistant strains poses significant challenges in clinical management. This study aims to assess the antibiotic susceptibility patterns of uropathogens and evaluate the demographic, clinical, and risk factor profiles of UTI patients at Private Clinic Chamber, Sylhet Region. This cross-sectional observation study was conducted at Private Clinic Chamber in Sylhet Region from May 2023 to April 2024. The study included 356 adult UTI patients, diagnosed by urine culture. Demographic data were collected via structured interviews, while bacterial pathogens were tested for antibiotic susceptibility. Data were analysed using SPSS, employing descriptive and inferential statistical methods. Ethical approval was obtained, and written informed consent was taken from all participants. Among 356 adult UTI patients, females predominated (66.3%), with most aged over 40. Escherichia coli was the most common pathogen (59%), showing high sensitivity to meropenem (95%) and nitrofurantoin (85%), but notable resistance to ciprofloxacin and TMP/SMX. Multidrug resistance was highest in Pseudomonas aeruginosa (60%). Carbapenems had the best empirical treatment response (95%), while TMP/SMX showed the least effectiveness (35%). UTIs remain a global concern, with rising antimicrobial resistance complicating treatment and necessitating alternative therapies for multidrug-resistant and ESBL-producing strains.

Keywords: Urinary Tract Infections (Utis), Escherichia Coli, Antibiotic Resistance, Antibiotic Susceptibility, Klebsiella Pneumonia.

Original Research Article

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Article at a glance:

Study Purpose: *To assess antibiotic resistance patterns in UTI pathogens and identify clinical and demographic risk factors.*
Key findings: *E. coli showed high resistance to ciprofloxacin and trimethoprim-sulfamethoxazole but was susceptible to meropenem. Pseudomonas aeruginosa had high multidrug resistance. Diabetes and catheter use were major risk factors.*
Newer findings: *The study highlights increased resistance to common antibiotics and underscores the importance of carbapenems for treatment, emphasizing the role of diabetes and catheterization in UTI risk.*
Abbreviations: *UTI - Urinary Tract Infection, E. coli - Escherichia coli, AMR - Antimicrobial Resistance, MDR - Multidrug Resistance.*

INTRODUCTION

Urinary tract infections (UTIs) are among the most prevalent bacterial infections worldwide, affecting both the lower and upper urinary tracts. These infections are predominantly caused by Escherichia coli (E. coli), responsible for approximately 80-90% of all UTIs.[1,2] Other important uropathogens include Klebsiella

pneumoniae, Proteus mirabilis, Pseudomonas aeruginosa, and Enterococcus spp., which contribute to both community-acquired and hospital-acquired infections.[3,4] UTIs are more common in women, with approximately 50-60% of women experiencing at least one UTI during their lifetime.[5] The clinical manifestations of UTIs range from mild symptoms such as dysuria and frequent urination to more severe conditions, including pyelonephritis and sepsis, which can lead to significant morbidity if left untreated[6]. A growing concern in the treatment of UTIs is the increasing prevalence of antimicrobial resistance (AMR) in uropathogens. Resistance to commonly used antibiotics such as fluoroquinolones, trimethoprim-sulfamethoxazole, and beta-lactam antibiotics has become widespread.[7] E. coli, in particular, has exhibited alarming resistance patterns, particularly to fluoroquinolones and third -generation cephalosporins, making empirical therapy more difficult.[8] The emergence of multidrug-resistant (MDR) and extended-spectrum beta-lactamase (ESBL)-producing strains of E. coli has complicated the management of UTIs, necessitating the use of alternative treatment options, which are often more costly and may have a broader side-effect profile.[9,10] Several factors contribute to the development of antibiotic resistance in uropathogens, including the overuse and misuse of antibiotics, inadequate infection control practices in hospitals, and the horizontal gene transfer of resistance determinants between pathogens.[11,12] Hospitalized patients, especially those with indwelling urinary catheters, are at increased risk for infections caused by resistant organisms such as Klebsiella pneumoniae and Pseudomonas aeruginosa.[13] These resistant pathogens are not only associated with more severe forms of UTIs, but also contribute to prolonged hospital stays, increased healthcare costs, and higher rates of mortality.[14]

MATERIALS AND METHODS

This is a cross-sectional type of observational study conducted on the patients visiting at a Private Clinic chamber in Sylhet region from May 2023 to April 2024. The study population consists of 356 patients diagnosed with urinary tract infections (UTIs) during the study period. Data were collected through a combination of clinical examinations, laboratory investigations, and patient interviews. The participants were identified based on their clinical presentation of UTI symptoms, followed by diagnostic confirmation through urine culture and sensitivity tests. Demographic details such as age, gender, educational level, and medical history were gathered through structured interviews and patient records. Additionally, bacterial pathogens isolated from urine samples were tested for antibiotic susceptibility to determine resistance patterns. Empirical treatment responses were monitored for each patient based on the prescribed antibiotic therapy, and follow-up assessments were conducted to evaluate the effectiveness of the treatment. The study included all adult patients (18 years and older) diagnosed with urinary tract infections, as confirmed by urine culture, attending in the Private Clinic Chamber, Sylhet, during the study period. Patients with clear clinical manifestations of UTI, such as dysuria, frequency, and urgency, were included in the study. Patients who were diagnosed with other urinary system disorders (e.g. bladder cancer, renal failure, or stones), had previously undergone long-term antibiotic therapy within the last month, or were pregnant were excluded from the study. Additionally, individuals with incomplete clinical data or who refused to participate in the study were also excluded. The collected data were analysed using SPSS version 25. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize the demographic characteristics, bacterial pathogens, and antibiotic susceptibility patterns. A p-value of less than 0.05 was considered statistically significant. Written informed consent was obtained from all participants, ensuring that they were fully aware of the study's objectives, procedures, and their right to confidentiality and voluntary participation. Participants were assured that their personal information and medical records would remain anonymous and that they could withdraw from the study at any point without affecting their medical care.

RESULTS

Table 1 shows the study population consisted of 356 patients, with the majority (66.3%) being female and 33.7% male. Age distribution showed that most participants were between 21-40 years (33.7%), followed by 41-60 years (25.3%) and 61+ years (34.0%), while only 7.0% were in the 18-20

age group. Regarding education, 33.7% had secondary education, 24.1% had higher education, and 16.9% had no formal education. Smoking status revealed that 50.6% were non-smokers, 25.3% were former smokers, and 24.1% were current smokers.

Table 2 presents the BMI classification of the study population. The majority of participants (39.3%) fall within the normal weight range, followed by 25.3% who are classified as overweight. A significant proportion (19.7%) is underweight (BMI <18.5), while 15.7% of the participants are obese (BMI ≥30).

Table 3 presents the distribution of risk factors associated with urinary tract infections (UTIs) among the study population of 356 patients. The most common risk factor identified was diabetes mellitus, affecting 30.9% of patients, followed by catheterization in 22.5%, and a previous history of UTI in 19.1%. Immunosuppressive therapy was present in 7.6% of the patients. Notably, 14.3% of the cases had no identifiable risk factors. Importantly, 10 patients (2.8%) were excluded from the primary risk analysis due to pregnancy, in line with the study's inclusion criteria that aimed to focus on adult, non-pregnant individuals. This correction ensures a more ethically accurate representation of the adult UTI population.

Figure 1 shows the distribution of bacterial pathogens isolated from urinary tract infection (UTI) cases in the study population. The most common pathogen identified is *Escherichia coli*, which accounts for 59% of the infections. This is followed by *Klebsiella pneumoniae* at 18.3%, and *Proteus mirabilis* at 8.4%. Other pathogens include *Pseudomonas aeruginosa* (5.6%), *Enterococcus spp.* (5.1%), and *Staphylococcus aureus* (3.6%).

Table 4 displays the antibiotic susceptibility pattern of *Escherichia coli*, the most common pathogen in urinary tract infections (UTIs). *Escherichia coli* is highly susceptible to nitrofurantoin (85%) and meropenem (95%). However, the bacteria show higher resistance to ciprofloxacin (40%), amoxicillin/clavulanic acid (40%), and trimethoprim/sulfamethoxazole (60%).

Table 5 outlines the antibiotic susceptibility pattern of Klebsiella pneumoniae, a significant pathogen in urinary tract infections (UTIs). The bacterium demonstrates high susceptibility to meropenem (90%), suggesting its effectiveness as a treatment option. Nitrofurantoin also shows a considerable susceptibility rate of 60%. However, Klebsiella pneumoniae exhibits high resistance to ciprofloxacin (50%), amoxicillin/clavulanic acid (45%), and trimethoprim/sulfamethoxazole (60%), indicating limited efficacy of these antibiotics.

Table 6 presents the resistance patterns of major urinary tract infection (UTI) pathogens in terms of multidrug resistance (MDR), extensively drug resistance (XDR), and pandrug resistance (PDR). Among the pathogens, Pseudomonas aeruginosa has the highest percentage of MDR (60%) and XDR (20%), followed by Klebsiella pneumoniae with 50% MDR and 15% XDR. Escherichia coli shows 40% MDR and 10% XDR, while Staphylococcus aureus has 35% MDR and 10% XDR. Other pathogens, such as Proteus mirabilis, Enterococcus spp., and Pseudomonas aeruginosa, exhibit lower rates of PDR (0-5%).

Figure 2 presents the antibiotic susceptibility of *Pseudomonas aeruginosa* (n=20), a key pathogen in urinary tract infections (UTIs). The bacterium shows high susceptibility to meropenem (95%) and amikacin (80%), with very low resistance to these antibiotics (2% and 10%, respectively). Piperacillin/tazobactam has a moderate susceptibility of 70%, while ciprofloxacin and ceftazidime exhibit lower susceptibility, with 50% and 55%, respectively.

Table 7 presents the antibiotic resistance patterns in *Enterococcus spp.* This organism shows high susceptibility to vancomycin (95%) and linezolid (98%). The bacterium exhibits moderate susceptibility to nitrofurantoin (85%) and amoxicillin (75%), with resistance rates of 10% and 15%, respectively.

Figure 3 presents the response to empirical treatments in urinary tract infection (UTI) cases. Among the treatments, carbapenems demonstrate the highest efficacy with a 95% response rate, followed by nitrofurantoin, which showed a response in 85% of cases. Ciprofloxacin and

amoxicillin/clavulanic acid have moderate success rates, with 50% and 45% response rates, respectively, while trimethoprim/sulfamethoxazole showed the lowest effectiveness, with only 35% of patients responding to it.

Table 1: Demographical data presentation of the study population (n=356)

Demographical Data	Frequency (n=356)	Percentage (%)
Age Group (Years)		
18-20	25	7.0
21-40	120	33.7
41-60	90	25.3
61+	121	34.0
Gender		
Male	120	33.7
Female	236	66.3
Educational Level		
No Formal Education	60	16.9
Secondary Education	120	33.7
Higher Education	86	24.1
Smoking Status		
Non-Smoker	180	50.6
Former Smoker	90	25.3
Current Smoker	86	24.1

Table 2: BMI classification of patients (n=356)

BMI Category	Frequency	Percentage
Underweight (<18.5)	70	19.7
Normal weight (18.5-24.9)	140	39.3
Overweight (25-29.9)	90	25.3
Obese (≥30)	56	15.7

Table 3: Risk factors associated with UTI cases (n=356)

Risk Factor	Frequency (n=356)	Percentage (%)
Diabetes Mellitus	110	30.9%
Catheterization	80	22.5%
Immunosuppressive Therapy	27	7.6%
History of UTI	68	19.1%
No Identifiable Risk Factor	51	14.3%

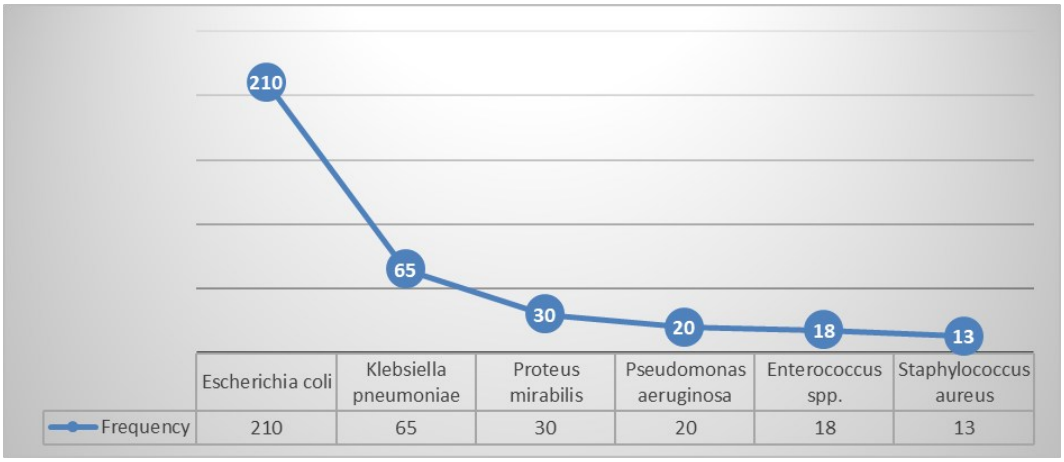

Figure 1: Distribution of bacterial pathogens in UTI cases (n=356)

Table 4: Antibiotic susceptibility pattern of Escherichia coli (n=210)

Antibiotic	Susceptible (%)	Intermediate (%)	Resistant (%)
Nitrofurantoin	85	5	10
Ciprofloxacin	50	10	40
Amoxicillin/Clavulanic acid	45	15	40
Trimethoprim/Sulfamethoxazole	30	10	60
Meropenem	95	3	2

Table 5: Antibiotic susceptibility pattern of Klebsiella pneumoniae (n=65)

Antibiotic	Susceptible (%)	Intermediate (%)	Resistant (%)
Nitrofurantoin	60	15	25
Ciprofloxacin	40	10	50
Amoxicillin/Clav.	35	20	45
Trimethoprim/Sulfamethoxazole	25	15	60
Meropenem	90	5	5

Table 6: Resistance pattern of major UTI pathogens

Pathogen	MDR (%)	XDR (%)	PDR (%)
Escherichia coli	40	10	2
Klebsiella pneumoniae	50	15	5
Proteus mirabilis	30	5	0
Pseudomonas aeruginosa	60	20	5
Enterococcus spp.	25	5	0
Staphylococcus aureus	35	10	3

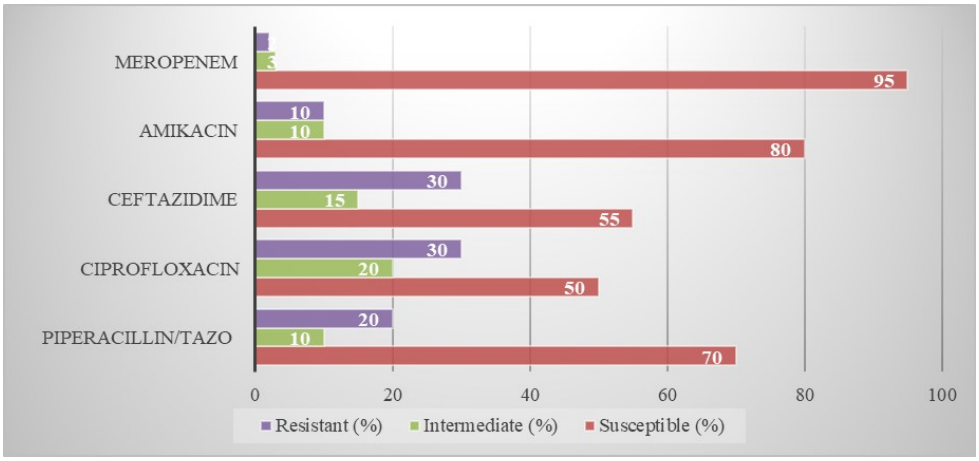

Figure 2: Antibiotic susceptibility of Pseudomonas aeruginosa (n=20)

Table 7: Antibiotic resistance in Enterococcus spp. (n=18)

Antibiotic	Susceptible (%)	Intermediate (%)	Resistant (%)
Vancomycin	95	3	2
Linezolid	98	2	0
Nitrofurantoin	85	5	10
Amoxicillin	75	10	15

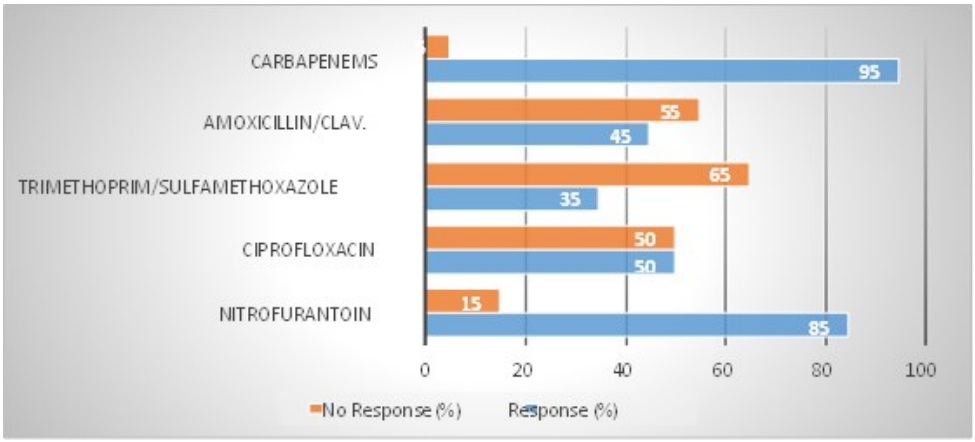

Figure 3: Empirical treatment response in UTI cases (n=356)

DISCUSSION

The demographic distribution of the study population in this research reveals that the majority of participants (33.7%) fall within the 21-40 age group, with a higher proportion of females (66.3%) than males (33.7%). This finding is consistent with other studies which have reported similar age and gender distributions in UTI patients, with females being more frequently affected due to anatomical and physiological differences, such as shorter urethras that predispose them to urinary tract infections.[15] Additionally, the prevalence of urinary tract infections across different age groups aligns with the findings reported the highest incidence among middle-aged adults, especially women.[16] In terms of educational background, most participants in the study had secondary education (33.7%), which may reflect general socio- economic trends in Bangladesh, where a significant proportion of the population has limited access to higher education. This demographic distribution is consistent with findings were observed similar educational trends among UTI patients in Bangladesh, emphasizing the need for public health interventions targeting lower education levels to reduce the incidence of infections.[17] Regarding smoking status, 50.6% of the study participants were non-smokers, which suggests a potential protective factor in this cohort,

as smoking has been linked with an increased risk of UTIs due to its immunosuppressive effects. This finding contrasts with a study shows a higher incidence of UTIs among smokers, indicating that smoking may influence infection rates through changes in immune response and the microbiome.[18] The study also found that diabetes mellitus (28.1%) and catheterization (21.1%) were among the most common risk factors for urinary tract infections, which concurs with other studies that have identified these factors as major contributors to UTI development.[19] Specifically, diabetes is well-known for its impact on immune function and glucose control, which can increase susceptibility to infections.[20] Similarly, catheterization is a well-established risk factor for hospital-acquired UTIs, with studies highlighting the critical role of urinary catheters in introducing pathogens into the urinary system.[21] Regarding the bacterial pathogens isolated, Escherichia coli was the most common pathogen identified in our study, accounting for 59% of infections. This finding is in line with several studies across the globe, as E. coli remains the predominant pathogen in urinary tract infections worldwide.[22] Other pathogens such as Klebsiella pneumoniae (18.3%) and Proteus mirabilis (8.4%) were also identified, which aligns with findings where observed a similar distribution of UTI pathogens in Indian hospitals.[23] The antibiotic susceptibility patterns in this study show that *Escherichia coli* was highly susceptible to nitrofurantoin (85%) and meropenem (95%), consistent with findings from recent studies that have reported high susceptibility of E. coli to these antibiotics, especially in hospital settings.[24] In contrast, there was significant resistance to ciprofloxacin (40%) and trimethoprim/sulfamethoxazole (60%), which is in line with increasing global resistance trends to these commonly used antibiotics for UTIs.[25] Similarly, Klebsiella pneumoniae exhibited moderate resistance to ciprofloxacin (50%) and trimethoprim/sulfamethoxazole (60%), reflecting concerns regarding multidrug resistance (MDR) in Gram-negative bacteria.[26] The study's findings regarding multidrug resistance (MDR), extensively drug resistance (XDR), and pandrug resistance (PDR) are noteworthy. Pseudomonas aeruginosa had the highest rates of MDR (60%) and XDR (20%), which is consistent with global trends of increasing antimicrobial resistance, particularly in hospital-acquired infections.[27] This is a significant concern as XDR Pseudomonas aeruginosa infections are associated with poor clinical outcomes and limited treatment options. Furthermore, the response to empirical treatments was consistent with the resistance patterns observed in this study. Carbapenems demonstrated the highest efficacy with a 95% response rate, reflecting their continued importance as first-line treatment for resistant Gram-negative infections. This finding mirrors the results of a, which reported a similarly high efficacy of carbapenems in treating hospital-acquired UTIs caused by resistant pathogens.[28] However, the lower effectiveness of ciprofloxacin (50%) and trimethoprim/sulfamethoxazole (35%) suggests that these antibiotics may no longer be reliable for empirical treatment in settings with high antimicrobial resistance.

Limitations

The limitation of the study is that it focuses solely on the antibiotic susceptibility patterns of uropathogens without assessing clinical outcomes or treatment efficacy. The molecular mechanisms of resistance, such as ESBL or carbapenemase production, were not analyzed, limiting a deeper understanding of resistance trends.

CONCLUSION

In conclusion, urinary tract infections (UTIs) remain a significant global health concern, with Escherichia coli being the predominant causative agent. The increasing prevalence of antimicrobial resistance, particularly in fluoroquinolones and third-generation cephalosporins, has complicated treatment strategies, leading to challenges in empirical therapy. The emergence of multidrug-resistant (MDR) and extended-spectrum beta-lactamase (ESBL)-producing strains has further exacerbated the situation, necessitating the exploration of alternative therapeutic options.

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