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Unraveling the Resistance: A Study on Urinary Tract Infections and Antibiotic Susceptibility in a specialized hospital in Dhaka

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Abstract:

Background: Urinary tract infections (UTIs) are among the most common infections worldwide, affecting individuals of all ages and both sexes. The increasing prevalence of UTIs, coupled with rising antibiotic resistance, underscores the need to evaluate UTI pathogens and their antibiotic susceptibility. ***Objectives:*** This study was conducted at Rushmono Specialized Hospital to assess the microbiological profile and resistance patterns of UTI pathogens in hospitalized patients. ***Methodology:*** A total of 147 UTI patients (55 males and 92 females) were included in the study. Urine samples were analyzed for microbial growth, and pathogens were identified using standard microbiological techniques, including Gram staining and biochemical testing. Antibiotic susceptibility testing was performed using the disk diffusion method to determine resistance and sensitivity patterns against commonly prescribed antibiotics. ***Result:*** Of the 147 patients, 59 (40.14%) had positive microbial growth, while 88 (59.86%) had negative cultures. Among the 55 male patients, 17 (23.61%) had positive cultures, whereas 42 of the 92 female patients (56.00%) showed bacterial growth, reflecting the higher prevalence of UTIs in females. Gram-positive organisms accounted for 9.52% of the isolates, while Gram-negative organisms made up 31.97%. The most common Gram-positive pathogens were Staphylococcus aureus (4.76%) and Enterococci (4.08%), whereas Escherichia coli (19.73%) and Enterobacter (10.20%) were the predominant Gram-negative organisms. Antibiotic susceptibility testing revealed high resistance in Gram-positive organisms to Penicillin G (17.01%) and Erythromycin (25.85%), while Vancomycin, Linezolid, and Imipenem remained effective. Among Gram-negative isolates, E. coli exhibited significant resistance to Ceftazidime (78.13%), Nalidixic acid (66.67%), and Amoxiclav (64.29%), but showed high sensitivity to Ciprofloxacin (73.91%) and Meropenem (93.55%). ***Conclusion:*** This study highlights the increasing antibiotic resistance among UTI pathogens, both Gram-positive and Gram-negative. High resistance rates to common antibiotics emphasize the need for continuous local surveillance of resistance patterns.

Keywords: UTI, Antibiotic susceptibility, Multidrug-resistant strain, Antibiotic.

Introduction:

Globally, Urinary Tract Infections (UTIs) represent a major public health burden, affecting individuals across all demographics. In healthcare environments, UTIs are a leading cause of morbidity and increased costs. Urinary tract infec-

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tions (UTIs) are one of the most prevalent infectious diseases worldwide, significantly affecting individuals of all ages and sexes.[1] UTIs are particularly common in healthcare settings, contributing to both morbidity and healthcare costs.[2] The urinary tract is susceptible to infections due to its direct contact with the external environment, and factors such as poor hygiene, sexual activity, catheter use, and underlying medical conditions (such as diabetes and immune suppression) increase the risk of infection.[1]According to global health reports, UTIs are the second most common type of infection in primary care settings and one of the most frequent reasons for hospitalization, particularly among older adults and individuals with chronic conditions. The most common pathogens responsible for UTIs are bacteria, with Escherichia coli (E. coli) being the leading culprit in 70-90% of cases.[1] Antibiotic resistance is a major public health concern & overuse and misuse of antibiotics & inadequate infection control practices in healthcare settings are considered as the major cause.[3,4] This resistance not only diminishes the effectiveness of commonly used antibiotics but also limits the available treatment options, thereby necessitating regular surveillance of bacterial resistance patterns in specific populations.[5] As UTIs are among the most frequent reasons for antibiotic prescriptions in hospital settings, understanding the local patterns of microbial resistance is crucial for guiding empirical therapy and improving patient outcomes.[6] In light of this, our study aimed to investigate the microbiological profile and antibiotic resistance patterns of UTI pathogens in patients admitted to Rushmono Specialized Hospital. This hospital, a key healthcare facility in the region, provides a wide range of medical services and treats a substantial number of UTI cases annually. The purpose of the study was to determine the prevalence of bacterial pathogens in UTI samples, identify the antibiotic susceptibility profiles of these pathogens, and assess trends in resistance that could guide treatment strategies in this healthcare setting. By analyzing a comprehensive sample of patients, including both male and female individuals, we sought to provide valuable insights into the current state of UTI management at Rushmono Specialized Hospital and contribute to broader efforts to combat antibiotic resistance in the region. Our study specifically focused on identifying the microorganisms responsible for UTIs, with a particular emphasis on understanding their Gram reaction (Gram-positive or Gram-negative) and determining their resistance or susceptibility to a variety of commonly used antibiotics. In doing so, we aimed to not only characterize the local resistance patterns but also highlight potential therapeutic challenges and the need for tailored antibiotic regimens. Given the rising incidence of multi-drug-resistant organisms, this research holds important implications for hospital infection control measures and antibiotic stewardship programs.[7] The importance of this study lies in its potential to inform clinical decision-making and optimize UTI treatment in the hospital. The identification of resistant pathogens can help clinicians adjust their treatment strategies to ensure better patient outcomes and reduce the emergence and spread of resistant strains. Furthermore, the data generated from this research could serve as a basis for developing more effective infection control practices within the hospital and could contribute to national and global efforts to monitor and combat antibiotic resistance.[8]

Materials and Methods

This retrospective study was conducted at Rushmono Specialized Hospital, focusing on the microbiological profile and antibiotic susceptibility patterns of urinary tract infection (UTI) pathogens. The study analyzed 147 urine samples collected from 147 patients, comprising 59 males and 88 females, who were diagnosed with UTI and admitted to the hospital. The study was conducted over a period from 15/07/2023 to 15/01/2025.

Sample Collection and Processing

Clean-catch midstream urine (MSU) samples of approximately 4-5 ml were collected using sterile disposable containers from UTI patients. The samples were transported to the microbiology laboratory promptly for analysis.9 The presence of microorganisms was determined using semi-quantitative culture methods on three different agar media: MacConkey agar, 5% blood agar, and cystine lactose electrolyte deficient medium (CLED) agar (Oxoid Ltd, Basingstoke, Hampshire, UK). The samples were incubated at 37°C for 24–48 hours in aerobic conditions.[10] Routine urine microscopy was performed to count white blood cells (WBCs) and compare findings with culture results for the diagnosis of UTI.[11] If no growth was observed after 24 hours, the cultures were further incubated for an additional 24 hours before concluding that no growth was present.[12] Organisms were identified using standard microbiological and biochemical tests, such as Gram staining, colony morphology, lactose fermentation, indole, citrate utilization, catalase, coagulase, oxidase, and urease tests, following WHO guidelines.

Inclusion and Exclusion Criteria

Inclusion criteria for the study included patients presenting with UTI symptoms and a requisition for urine culture and sensitivity tests from both indoor and outdoor departments.[3] Exclusion criteria included patients who had incomplete data or who were treated with antibiotics prior to sample collection.[14]

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing was carried out using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar.[15] Antibiotic discs from Oxoid Ltd, Basingstoke, Hampshire, UK, were used, and the testing was performed according to Clinical and Laboratory Standards Institute (CLSI) guidelines. Antibiotics tested for both Gram-positive and Gram-negative isolates included:

- **For Gram-positive organisms:** Ampicillin (Amp), Cephradine (Ceph), Cotrimoxazole (Cot), Ciprofloxacin (Cip), Nitrofurantoin (Nit), Levofloxacin (Lev), Nalidixic acid (NA), Cefotaxime (CTX), Ceftriaxone (CTR), Amoxiclav (AMC), Gentamicin (Gen), Ceftazidime (CAZ), Amikacin (AK), Meropenem (Mero), Vancomycin (Van), Linezolid (Lz), Oxacillin (Ox), Cloxacillin (Clox), Erythromycin (Ery), Doxycycline (Do).[15]
- **For Gram-negative organisms:** Ampicillin (Amp), Cephradine (Ceph), Cotrimoxazole (Cot), Ciprofloxacin (Cip), Nitrofurantoin (Nit), Levofloxacin (Lev), Nalidixic acid (NA), Cefotaxime (CTX), Ceftriaxone (CTR), Amoxiclav (AMC), Gentamicin (Gen), Ceftazidime (CAZ), Amikacin (AK), Meropenem (Mero), Cefixime (CXM), Piperacillin-tazobactam (PIT), Colistin (Col).[15]

The diameter of inhibition zones was measured and interpreted based on CLSI guidelines to determine whether the isolates were resistant or sensitive to each antibiotic.[16]

Antibiotic Susceptibility Patterns

The results of antibiotic susceptibility testing for the Gram-positive and Gram-negative organisms isolated are summarized below:

Gram-Positive Organisms

The antibiotic susceptibility pattern for Gram-positive organisms (Staphylococcus aureus, Coagulase-negative staphylococci (CONS), and Enterococci) is presented in Table 3.

- Staphylococcus aureus (7 isolates) showed significant resistance to Penicillin G (17.01%) and Erythromycin (25.85%). However, it was highly sensitive to Vancomycin, Linezolid, and Imipenem, which demonstrated no resistance.
- Enterococci (6 isolates) also showed resistance to common antibiotics, but were sensitive to Vancomycin and Linezolid.
- Overall, Gram-positive bacteria exhibited high resistance rates to Penicillin G and Erythromycin, while remaining largely sensitive to Vancomycin, Linezolid, and Imipenem.[17]

Gram-Negative Organisms

The antibiotic susceptibility pattern for Gram-negative organisms (Escherichia coli, Enterobacter, Pseudomonas, Klebsiella, and Acinetobacter) is presented in Table 4.

- Escherichia coli (29 isolates) was highly resistant to Ceftazidime (78.13%), Nalidixic acid (66.67%), and Amoxiclav (64.29%). However, it exhibited high sensitivity to Ciprofloxacin (73.91%) and Meropenem (93.55%).
- Enterobacter (15 isolates) showed moderate resistance to multiple antibiotics, with notable resistance to Ceftriaxone and Cefepime.
- Other Gram-negative organisms, such as Klebsiella and Acinetobacter, showed varied resistance profiles with significant resistance to Amoxiclav and Cefepime.[18]

Results:

Distribution of Samples Received

The total number of samples received from UTI patients was 147, split equally between males and females. A breakdown of growth positivity and negativity is as follows:

Table 1: Percentage Distribution of Growth Positive and Growth Negative Cases by Sex

Sex	Growth Positive	Growth Negative	Total	% Positive	% Negative
Male	17	55	147	23.61%	76.39%
Female	42	33		56.00%	44.00%
Total	59	88		40.14%	59.86%

Overall, 59 samples (40.14%) tested positive for microbial growth, while 88 samples (59.86%) were negative. The growth positivity rate was higher among females (56.00%) compared to males (23.61%).

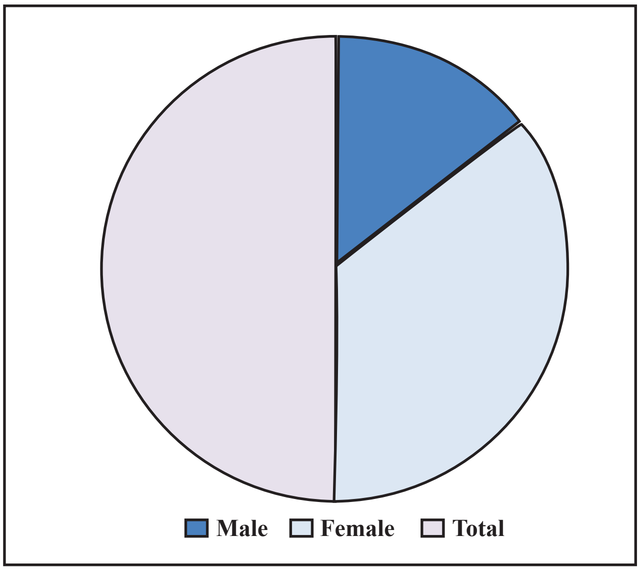

Figure 1 : Distribution of Growth Positive and Growth Negative Cases by Sex

Table 2: Distribution of Bacterial Isolates by Gram Reaction

Gram Reaction	Organism	Count	Percentage
Gram Positive	*S. aureus*	7	4.76%
	CONS	1	0.68%
	Enterococci	6	4.08%
Total gram positive		14	9.52%
Gram negative	*E. coli*	29	19.73%
	Enterobacter	15	10.20%
	Pseudomonas	1	0.68%
	Klebsiella	1	0.68%
	Acinatobacteer	1	0.68%
Total Gram Negative		47	31.97%
Total		147	100.00%

Gram-negative organisms, particularly E. coli, are the leading contributors to UTI infections in this sample population.

Table 3 : Gram-Positive Bacterial Antibiotic Sensitivity and Resistance Pattern

Antibiotic	Sensitive (S)	Resistant (R)	Total %	Sensitive %	Resistant %
Penicillin G	1	25	26	0.68%	17,01%
Vancomycin	9	-	9	6.12%	-
Linezolid	13	-	13	8.84%	-
Erythromycin	3	38	41	2.04%	25.85%
Cefuroxime	4	28	32	2.72%	19.05%
Meropenem	3	-	3	2.04%	-
Imipenem	9	-	9	6.12%	-
Nitroglycerin	12	1	13	8.16%	0.68%
Tetracycline	12	3	15	8.16%	2.04%
Doxycycline	1	3	4	0.68%	2.04%
Amoxiclav	4	1	5	2.72%	O.68%
Ceftriaxone	1	4	5	0.68%	2.72%
Cefepime	2	2	4	1.36%	1.36%
Co-trimoxazole	6	4	10	4.08%	2.72%
Levofloxacin	7	2	9	4.76%	1.36%
Netilmicin	6	-	6	4.08%	-

- **Highly Resistant Antibiotics:** Erythromycin (25.21% resistant), Cefuroxime (18.37% resistant), and Penicillin G (16.99% resistant) showed high resistance rates.
- **Most Effective Antibiotics (100% Sensitivity):** Vancomycin, Linezolid, Meropenem, Imipenem, and Netilmicin showed no resistance.
- **Moderate Effectiveness:** Tetracycline, Co-trimoxazole, Levofloxacin, and Amoxiclav had mixed sensitivity and resistance.
- **Least Effective Antibiotics:** Erythromycin, Cefuroxime, and Penicillin G had the highest resistance percentages

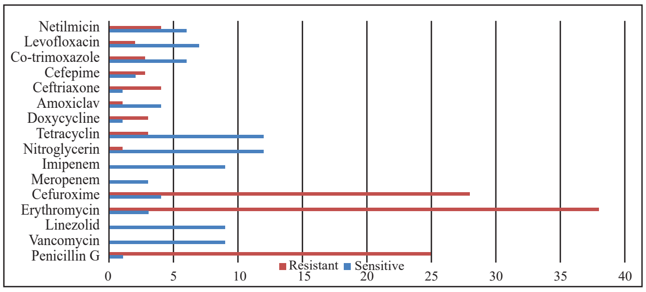

Figure 2 : Gram-Positive Bacterial Antibiotic Sensitivity and Resistance Pattern

- **Highly Effective Antibiotics (≥80% Sensitivity):** Imipenem (100% S), Co-trimoxazole (100% S), Meropenem (93.55% S), and Gentamicin (88.24% S) showed the highest sensitivity rates, indicating their strong efficacy.
- **Moderately Effective Antibiotics (50–79% Sensitivity):** Ciprofloxacin (73.91% S), Nitroglycerin (80% S), Tetracycline (62.50% S), Netilmicin (66.67% S), Levofloxacin (54.55% S), and Doxycycline (53.33% S) displayed moderate effectiveness, suggesting their potential use depending on the clinical scenario.
- **Poorly Effective Antibiotics (<50% Sensitivity):** Ceftazidime (21.88% S), Nalidixic Acid (33.33% S), Collistin (40% S), Amoxiclav (35.71% S), Cefepime (33.33% S), and Ceftriaxone (50% S) exhibited high resistance, indicating limited therapeutic use.
- **Complete Resistance Data Not Available:** Some antibiotics, including Meropenem, Imipenem, and Co-trimoxazole, had no recorded resistant cases, suggesting strong activity but requiring further confirmation.

Overall, carbapenems (Meropenem, Imipenem) and Co-trimoxazole demonstrated the highest effectiveness, while Ceftazidime, Amoxiclav, and Cefepime had significant resistance. The findings emphasize the importance of antibiotic susceptibility testing to guide appropriate treatment decisions.

Table 4:: Antibiotic Sensitivity and Resistance Profiles of Isolated Gram-negative Organisms

Antibiotic	Sensitive (S)	Resistant (R)	Total %	Sensitive %	Resistant %
Ceftazidime	7	25	32	21.88%	78.13%
Ciprofloxacin	34	12	46	73.91%	26.09%
Nalidixic acide	1	2	3	33.33%	66.67%
Collistin	2	3	5	40.00%	60.00%
Gentamicin	15	2	17	88.24%	11.76%
Meropenem	31	-	31	93.55%	-
Imipenem	11	-	11	100.00%	-
Nitroglycerin	8	2	10	80.00%	20.00%
Tetracycline	10	6	16	62.50%	37.50%
Doxycycline	8	7	15	53.33%	46.67%
Amoxiclav	5	9	14	35.71%	64.29%
Ceftriaxone	9	9	18	50.00%	50.00%
Cefepime	2	4	6	33.33%	66.67%
Co-trimoxazole	7	-	7	100.00%	-
Levofloxacin	6	5	11	54.55%	45.45%
Netilmicin	6	3	9	66.67%	33.33%

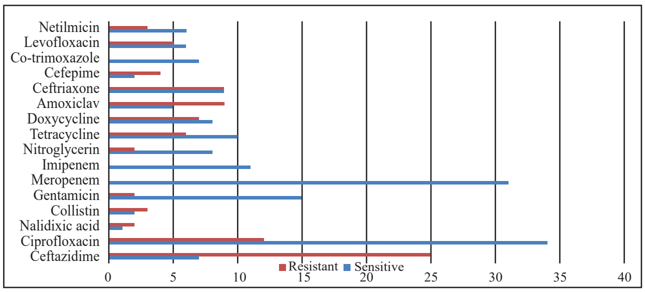

Figure 3 : Antibiotic Sensitivity and Resistance Profiles of Isolated Gram-negative Organisms

5. Gender-Based Analysis

Based on the data in Table 1, the growth positivity rate was significantly higher in females (56.00%) compared to males (23.61%). Among males, 23.61% had growth-positive cultures, while 76.39% were growth-negative. In contrast, females had a 56.00% growth-positive rate and a 44.00% growth-negative rate. The overall growth positivity rate was 40.14%, with 59.86% of the cultures being growth-negative. These findings suggest that females are more prone to urinary tract infections, possibly due to anatomical differences, which may require gender-specific management and prevention strategies.

Discussion

Urinary Tract Infections (UTIs) continue to be one of the most common bacterial infections globally, and their prevalence and resistance patterns have significant public health implications.[19] This study aimed to investigate the microbial etiology of UTIs, the differences in infection rates based on sex, and the patterns of antibiotic resistance. The results showed a higher growth positivity rate in females (56.00%) compared to males (23.61%), that indicate a sex-based disparity in UTI prevalence.[20] Females are generally more prone to UTIs than males due to anatomical differences, such as a shorter urethra, which facilitates easier bacterial entry, particularly fecal bacteria such as Escherichia coli.[21] These anatomical factors, combined with hormonal influences and sexual activity, put females at a higher risk of developing UTIs.[22] This study's findings are consistent with the literature, which has repeatedly shown that females are at greater risk for recurrent infections due to these factors.[23] The male UTI population, though smaller in number, tends to present with more complicated infections. This has been documented in various studies, including Schappert, who noted that UTIs in males are often more severe and are frequently linked to underlying conditions such as prostate issues or urinary tract obstructions.[24] This study found a much lower growth positivity rate among males (23.61%) than females (56.00%), which is reflective of these differences in severity and frequency.[25] Furthermore, males with UTIs often present with more complicated or healthcare-associated infections, which are less frequent but potentially more resistant to antibiotics.[26] The distribution of microbial organisms in this study showed that Gram-negative bacteria, particularly E. coli, were the predominant pathogens, responsible for 19.73% of all UTI cases.[27] This is in agreement with previous studies, such as those by Foxman, which found that E. coli is the leading cause of UTI infections worldwide, accounting for up to 80% of cases.[28] The high prevalence of Gram-negative organisms, including Enterobacter (10.20%) and other less common pathogens such as Klebsiella and Pseudomonas, is also consistent with reports from global surveillance studies.[29] Gram-negative bacteria are known to be more adept at acquiring resistance to antibiotics, which is a growing concern in the management of UTIs. E. coli, in particular, is often resistant to several classes of antibiotics, and the increasing resistance in these organisms complicates the treatment and management of UTIs.[30] In this study, Gram-positive organisms accounted for a smaller proportion of infections, with Staphylococcus aureus and Enterococci being the most commonly isolated species. This is in line with studies by Nicolle,[31] who found that while Gram-positive bacteria are less common in community-acquired UTIs, they are frequently involved in hospital-acquired or complicated UTIs. S. aureus, especially methicillin-resistant S. aureus (MRSA), poses a significant threat due to its resistance to multiple antibiotics.[32] This study's findings of high resistance to common antibiotics such as Penicillin G (96.15%) and Erythromycin (92.68%) highlight the growing concern of multidrug-resistant (MDR) pathogens, which has been a consistent issue in healthcare settings.[33] MRSA, for example, is a significant cause of both community-acquired and healthcare-associated UTIs, and its increasing prevalence complicates treatment strategie.[34] The presence of Enterococci in this study further supports previous findings, as Enterococcus faecalis is often linked to complicated or hospital-acquired UTIs.[31] The antibiotic resistance patterns observed in this study are troubling, as they reflect the broader global trend of rising resistance in UTI pathogens.[35] These antibiotics are first-line treatments for many bacterial infections, and the increasing resistance to them is a direct reflection of overuse and misuse of antibiotics, while some antibiotics, such as Vancomycin, Linezolid, and Meropenem, showed no resistance, the overall picture of resistance is concerning.[36] This study found that Penicillin G, Erythromycin, and Cefuroxime had the highest resistance rates, which is consistent with global concerns about the rise of resistance in both Gram-positive and Gram-negative organisms.[37] Notably, E. coli isolates in this study exhibited high resistance to Ceftazidime (78.13%), which is commonly used to treat Gram-negative infections. The resistance to third-generation Cephalosporins, such as Ceftazidime, points to the increasing prevalence of extended-spectrum beta-lactamase (ESBL)-producing E. coli strains, which are resistant to many beta-lactam antibiotics. This trend has been observed in numerous studies worldwide, and the rise of ESBL-producing bacteria presents a significant challenge in UTI management. However, this study also found that antibiotics such as Gentamicin (88.24%) and Meropenem (93.55%) still had good efficacy against E. coli, although the latter is a last-resort antibiotic that should be used judiciously to avoid the development of carbapenem-resistant organisms.[38] The results of this study are in line with research by Bush & Jacoby, which highlighted the growing problem of antibiotic resistance in E. coli and other Gram-negative bacteria. The high resistance rates observed in this study emphasize the importance of using targeted antibiotics based on culture and sensitivity testing rather than relying on empirical treatment, which could contribute to further resistance development. Ciprofloxacin, for example, showed moderate resistance (26.09%), and its continued use as a first-line treatment may need to be reconsidered given the rising rates of resistance.[39] Additionally, the use of antibiotics like Ceftriaxone and Cefepime, which showed moderate resistance in this study, calls for caution in their application, particularly in the face of rising multidrug resistance.[40] While carbapenems such as Imipenem and Meropenem showed excellent effectiveness, their potential overuse is a concern.[41] Carbapenems are considered last-resort antibiotics for treating resistant infections, but their widespread use could lead to the emergence of carbapenem-resistant organisms.[38] This is a significant challenge, as these bacteria are resistant to nearly all available antibiotics, leaving few treatment options.[36] The need for careful stewardship of these antibiotics is critical to prevent their overuse and preserve their effectiveness in treating resistant infections.[42] The findings of this study underscore the growing issue of antibiotic resistance in UTIs and highlight the need for continued surveillance of antimicrobial resistance patterns.[8] The high rates of resistance observed in both Gram-positive and Gram-negative organisms align with concerns raised in previous studies about the increasing prevalence of multidrug-resistant pathogens.[35] The findings also emphasize the importance of implementing antimicrobial stewardship programs, particularly in healthcare settings, to reduce the misuse of antibiotics and slow the spread of resistance.[7] Furthermore, these results reinforce the need for public health initiatives that promote proper hygiene, hydration, and the responsible use of antibiotics to prevent UTIs and reduce the development of resistance.[8]

Conclusion

This study highlights significant findings regarding the prevalence, microbial etiology, and antibiotic resistance patterns associated with Urinary Tract Infections (UTIs). Presence of multidrug-resistant strains, including ESBL-producing E. coli and methicillin-resistant S. aureus (MRSA), complicating treatment options. The ongoing surveillance of resistance patterns will play a crucial role in shaping effective treatment strategies and safeguarding the effectiveness of existing antibiotics

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