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ORIGINAL ARTICLE

# Prevalence of antibiotic resistance in patients with urinary tract infections

**Fatima Khurshid,[1*] Hina Aziz,[2] Mohammad Zain,[3] Faraz Arshad,[4] Misbah Mughal,[5] Tayyaba Ghazanfar[6]**

[1] Medical Doctor, Department of Medicine, Mohi-ud-Din Teaching Hospital, Mirpur AJK, Pakistan

[2] Medical Graduate, Department of Medicine, Fatima Jinnah Medical University, Lahore, Pakistan

[3] District Medical Officer, Department of Health Card Office, State Life, Islamabad, Pakistan

[4] House Officer, Department of Medicine, Shaikh Zayed Hospital, Lahore, Pakistan

[5] Lecturer, Department of Biosciences, Islamic International University, Islamabad, Pakistan

[6] Executive Territorial Business Head-Supply Chain, Health Services, Islamabad, Pakistan

**Author`s Contribution**

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**Correspondence**

*Fatima Khurshid*
*Fatimakhurshid61@yahoo.com*

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## ABSTRACT

**Introduction:** Antibiotic resistance is a significant threat to the effective treatment of urinary tract infections (UTIs). The frequency of antibiotic-resistant UTIs is becoming increasingly concerning due to the possible consequences for patient health and healthcare expenses.

**Methodology:** A retrospective research at DHQ Hospital Mirpur AJK examined 225 patients with febrile UTIs from Dec 2023 to Feb 2024. Urine samples were collected and antibiotic testing were performed in accordance with Clinical and Laboratory Standards Institute standards.

**Results:** The study revealed alarming antibiotic resistance rates in urine isolates. Klebsiella spp. showed high resistance to Ceftriaxone (54%), Colistin (57%), and Cefuroxime (86%). Staphylococcus aureus exhibited significant resistance to Erythromycin (64%) and Doxycycline (81%). Escherichia coli displayed resistance to Ceftriaxone (23%) and Amoxicillin (25%). Notably, all species were susceptible to Vancomycin, with no observed resistance.

**Conclusion:** This study demonstrates significant antibiotic resistance among bacterial species that cause urinary tract infections (UTIs), with Klebsiella pneumoniae showing the highest resistance rates. Effective antibiotic stewardship are urgently required to address this issue and enhance UTI care.

**Keywords:** *Antibiotic resistance, Urinary tract infection, Antimicrobials, Klebsiella pneumoniae, Antibiotic Stewardship.*

## Introduction

The discovery of antibiotics is among the biggest discoveries made by humanity in the 20th century. The antibacterial revolution revolutionized modern biomedicine and continues to define, shape, and expand its possibilities as well as limitations. Unfortunately, any medicinal agent's potential for resistance to develop restricts its efficacy.[1] Antimicrobial drugs that have been used to combat infections date back to ancient civilizations when natural extracts with therapeutic powers were used. Even before the name "antibiotics" was created, plant and mold extracts showed antibacterial activity.[2] American microbiologist Selman Waksman and his team's pioneering work resulted in the creation of the name "antibiotics." They successfully identified chemical compounds from bacteria that might prevent the development of other germs.[3]

However, Alexander Fleming's inadvertent discovery of penicillin in 1928 marked the beginning of modern antibiotic therapy. This discovery bridged the gap between ancient knowledge, like the Egyptians' use of moldy bread to cure ailments, and the age of antibiotics.[4] The post-World War

II period, known as the "golden era" of antibiotic development, saw the discovery of various antibiotic classes that are still in use today.[3] Antimicrobial resistance is posing an increasingly serious threat to global healthcare. This is resulting in increased patient care costs, longer hospital stays, and higher mortality rates. Almost all common infections observed in clinical practice have demonstrated significant resistance to traditional antibiotic therapy. Many organisms are multidrug-resistant.[5]

Urinary tract infections (UTIs) are one of the most prevalent infectious disorders affecting people, and the second leading cause of antibiotic prescriptions, trailing only respiratory tract infections.[6] Urinary tract infections (UTIs) are common infectious diseases that affect around 150 million people each year. They can harm the urethra, bladder, or kidneys, causing serious morbidity and significant medical costs. Recurrent UTIs cost over $5 billion in the United States alone each year.[7] UTIs can occasionally cause serious complications such as pyelonephritis, sepsis, and kidney abscesses.

UTI can lead to serious mortality and morbidity, especially in immunocompromised individuals and those who are older. If drug-resistant bacteria are present, any urinary infection in otherwise healthy people can have disastrous results. Women have a higher risk of UTIs than men. Male urinary infections, on the other hand, are typically problematic and require further treatment.[8] Each year, approximately 20% of women aged 20 to 56 years suffer from a urinary tract infection (UTI), and 40-50% will have at least one UTI in their lifetime. One out of every four patients who were affected had a recurrence, with 27% having one within 6 to 12 months. [9]

Uropathogenic Escherichia coli (UPEC) is the primary cause of both mild and complex urinary tract infections (UTIs). Klebsiella pneumoniae, Staphylococcus saprophyticus, Enterococcus faecalis, Group B Streptococcus (GBS), Proteus mirabilis, Pseudomonas aeruginosa, Staphylococcus aureus, and Candida spp. are other prevalent bacteria in mild UTIs. The most prevalent causes of complex UTIs include Enterococcus spp., Klebsiella pneumoniae, Candida spp., Staphylococcus aureus, Proteus mirabilis, Pseudomonas aeruginosa, and Group B Streptococcus (GBS).[10] Bacterial AMR is expected to directly cause 1.27 million deaths worldwide in 2019 and contribute to 4.95 million deaths.[9]

According to the analysis, AMR killed more people in 2019 than HIV or malaria combined, making it the leading cause of death globally. In 2021, the World Health Organization (WHO) identified AMR as one of the top 10 global public health threats to humanity.[9] A study found that data from the Global Burden of Disease Study 2019 were used to investigate the incidence, mortality, and Disability-Adjusted Life Years (DALYs) of UTIs in 204 countries and territories between 1990 and 2019. In 2019, there were estimated to be 404.61 million UTI infections worldwide, resulting in 236,790 deaths and 520,200 DALYs.[11]

The rationale for this study is the growing concern about antibiotic resistance in urinary tract infections (UTIs). UTIs are common infections that, if not addressed, can lead to major health consequences. Antibiotic-resistant bacteria have arisen and are spreading, making effective UTI treatment challenging. Understanding the prevalence of antibiotic resistance in different bacterial species in UTIs is crucial for developing personalized treatment plans and improving patient outcomes. This study aims to contribute to current knowledge by studying UTI patients' resistance patterns and demographic characteristics, consequently providing important insights for therapeutic decision-making and antibiotic resistance treatment in UTI.

## Methodology

A retrospective research was carried out at DHQ Hospital Mirpur AJK to look at patients suffering from urinary tract infections. Between Dec 2023 and Feb 2024, the research planned to assess samples taken from both inpatients and outpatients with febrile UTIs. Permission was granted through ERB under Ref # 16/Academic Block/Trauma Center/ Surgery 2023. The study included 225 febrile UTI patients. A febrile UTI was defined as a temperature of 38°C or higher, at least 5 white blood cells visible under a high-power microscope, and at least 105 colony-forming units (CFU)/mL in urine culture. Urine samples were collected using techniques appropriate for the patient's age. For toilet-trained children, the midstream technique was employed to guarantee adequate hygiene prior to collecting the urine specimen.

Urine samples were collected in a sterile bag from children who had not been taught to use the restroom. The samples were labeled with unique patient IDs and stored correctly for future testing. The Clinical and Laboratory Standards Institute guidelines were followed while identifying microorganisms and testing for antibiotic resistance. To determine bacterial growth, urine samples were plated on sheep blood agar and MacConkey agar plates. Urine samples with more than 105 CFU/mL were found to have a urinary tract infection. The interpretation criteria for determining antibiotic resistance were determined according to the breakpoints established by the European Committee on Antimicrobial Susceptibility Testing (EUCAST).[12] Bacterial identification was performed on isolates from positive urine cultures to determine which uropathogens were present. The discovered isolates were also tested for antibiotic susceptibility.

This involved subjecting the isolates to a variety of medicines to determine their response and resistance patterns. The data was collected and then imported into IBM SPSS Statistics (version 23) for further analysis. Descriptive statistics were generated using SPSS, and the results were presented as tables and figures. To establish antimicrobial resistance trends, the number of resistant isolates was divided by the total number of isolates tested. The susceptibility of these uropathogens to different antibiotics was expressed as a percentage. We reviewed the data for quality and completeness during the collection process, as well as at the end and after entering the data into SPSS for statistical analysis. The hospital's Ethical Committee examined and approved the research protocol, ensuring that the study was carried out ethically. The committee thoroughly assessed the method to safeguard the participants' rights and safety. The study followed the committee's ethical rules and recommendations.

## Results

A retrospective study was conducted at DHQ Hospital Mirpur AJK to investigate the prevalence of antibiotic resistance in patients with urinary tract infections (UTIs). The study included 225 febrile UTI patients with a diverse demographic profile. In terms of age distribution, the study found that 25% of UTI patients were under the age of 18, indicating a high occurrence of pediatric cases. The majority of instances (38%) were reported by those aged 18 to 40, with 22% in the 41-60 age range and 15% over 60. These findings highlight people's susceptibility to UTIs across age groups, as well as the importance of personalized treatment regimens.

In terms of gender, the survey discovered that 26% of UTI patients were male and 74% were female. This gender disparity emphasizes females' higher susceptibility to UTIs, which can be attributed to anatomical and hormonal differences. The study also included residency, which found that 30% of UTI infections occurred in rural areas and 70% in urban settings. The difference in UTI prevalence between rural and urban areas could be related to changes in healthcare availability, hygiene behaviors, or environmental factors.

**Table 1: Sociodemographic and Clinical Characteristics of the Patients**

| Characteristics | Frequency | Percentages |
|---|---|---|
| **Age** | | |
| < 18 years | 57 | 25% |
| 18-40 years | 86 | 38% |
| 41-60 years | 48 | 22% |
| > 60years | 34 | 15% |
| **Sex** | | |
| Male | 59 | 26% |
| Female | 166 | 74% |
| **Residence** | | |
| Rural | 68 | 30% |
| Urban | 157 | 70% |
| **Clinical Feature** | | |
| Fever | 178 | 79% |
| Dysuria | 201 | 89.3% |
| Urgency | 167 | 74.2% |
| Abdominal Pain | 144 | 64% |

The study further evaluated the clinical aspects of UTIs in individuals. Fever was the most common symptom, showing up in 79% of cases. Dysuria (painful urination) was reported by 89.3% of the patients, demonstrating that it is common in UTIs. 74.2% of cases reported urgency, which is defined as a strong desire to urinate. Sixty-four percent of the patients reported abdominal pain, indicating that the infection had spread to the kidneys or bladder. These thorough findings shed light on the distinct characteristics and demographics of UTI patients, potentially informing targeted prevention, diagnosis, and treatment strategies.

Understanding the prevalence of antibiotic resistance in these populations is crucial for developing effective therapeutics and addressing the growing problem of antimicrobial resistance in UTIs (Table 1). Out of 225, a total of 141 cases of bacterial infections were identified in the study. Klebsiella pneumoniae was the most common of the bacteria detected, accounting for 32 cases (22.6%). Enterococcus faecalis was next with 14 (10%) instances, followed by Proteus mirabilis with 10 (7%). Escherichia coli was found in 37 cases (26.2%), Pseudomonas aeruginosa in 13 cases (9.2%), Staphylococcus aureus in 24 cases (17%), and Serratia marcescens in 11 (8%) cases. These findings provide significant information about the spread of bacterial illnesses in the research population (Figure 1).

The study's findings elucidate the levels of antibiotic resistance in several bacterial species isolated from urine samples. Notably, Klebsiella spp. exhibited the highest resistance to Ceftriaxone (54%), underscoring the challenges in treating infections caused by this bacterial species. Escherichia coli showed a lower but still significant resistance rate of 23%, whereas Serratia and Proteus spp. showed resistance rates of 12% and 7%, respectively. Pseudomonas aeruginosa had the lowest resistance rate (4%). Moving on to Ciprofloxacin, Klebsiella spp. exhibited a 34% resistance rate, Staphylococcus aureus 25%, and Escherichia coli 14%. Enterococcus spp. and Serratia spp. showed lower resistance rates of 9% and 7%, respectively, while Proteus spp. and Pseudomonas aeruginosa had even lower rates of 5% and 6%.

Klebsiella spp. showed 50% resistance to Cefalaxin, while Staphylococcus aureus showed 25% resistance. Enterococcus spp. showed a 9% resistance rate, demonstrating the wide range of resistance among bacterial species. Klebsiella spp. were 57% resistant to Colistin, whilst Staphylococcus aureus was only 43% resistant. Klebsiella spp. showed an 86% resistance rate to Cefuroxime, while Escherichia coli had a lower but still substantial resistance rate of 14%. Klebsiella spp. had a 45% ampicillin resistance rate, while Enterococcus spp. had 17%. E. coli showed a 25% resistance rate, while Proteus and Serratia spp. showed 5% and 5% resistance rates, respectively. The incidence of Amoxicillin resistance in Klebsiella spp. was 53%.

Proteus species showed a 3% resistance rate, whereas E. Coli showed a 32% resistance rate among other species. Pseudomonas aeruginosa and Serratia spp. had resistance rates of 5% and 7%, respectively. Compared to Enterococcus spp., which had a resistance rate of 36% to erythromycin, Staphylococcus aureus had a high resistance rate of 64%. Moving on to cefoxitin, 29% of Klebsiella spp. showed resistance, whilst 24% of Escherichia coli showed a minor increase in resistance. With a resistance rate of 47%, Staphylococcus aureus was the highest of the three species. While Escherichia coli only showed a 24% resistance rate to Gentamycin, Klebsiella spp. showed a significant 66% resistance rate.

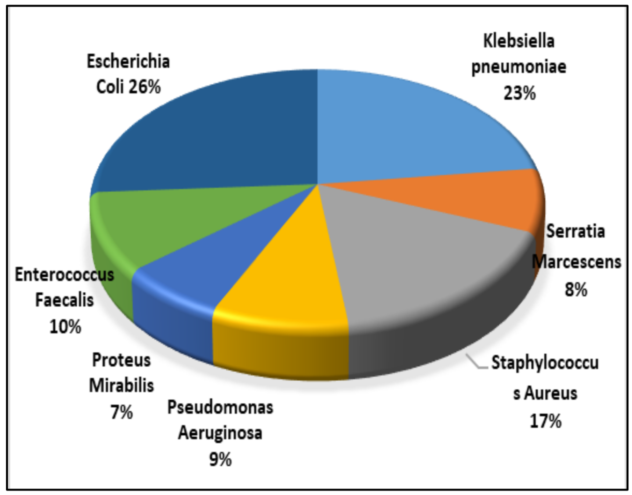


**Figure 1: Distribution of significant uropathogenic microorganisms among patients with urinary tract infection.**

A 10% resistance rate was found in Pseudomonas aeruginosa. Levofloxacin resistance was observed in 36% of Klebsiella spp. and 25% in Staphylococcus aureus. Lower resistance rates of 16% and 11% were observed in Escherichia coli and Enterococcus spp. The lowest resistance rate, 5%, was seen in Proteus species. According to the data, 53% and 51% of Klebsiella spp. were resistant to imipenem and meropenem. A study found that 28% of Escherichia coli were resistant to Meropenem and 19% to Imipenem. Meropenem (13%) and imipenem (5%), to which Proteus spp. exhibited decreased resistance rates. Resistance rates for Imipenem were 10%, and those for Meropenem were 15% and 6% for

Pseudomonas aeruginosa and Serratia spp. The percentage of Klebsiella spp. that were resistant to cefepime and linezolid was 59% and 60%, respectively. Staphylococcus aureus strains that were resistant to linezolid accounted for 40% of the total. With a resistance rate of 2%, Proteus species had the lowest rate of Cefepime. In contrast to Pseudomonas aeruginosa, Escherichia coli shown a 22% resistance rate to Cefepime. Cefepime resistance in Serratia spp. was 10%. The results also showed that some bacterial species were resistant to fosfomycin and nalidexic acid. 56% of Klebsiella spp., 33% of Escherichia coli, and 11% of Pseudomonas aeruginosa showed resistance to nalidexic acid. 50% of Staphylococcus aureus and Enterococcus spp. were resistant to fosfomycin. Moreover, Novobiocin proved to be 100% resistant to Staphylococcus aureus. The majority of bacteria, specifically Klebsiella spp., were resistant to Rifampicin (50%) more than Escherichia coli (30%) and Enterococcus spp. (20%). Proteus species displayed 8% resistance to sulfamethoxazole, Escherichia coli showed 18%, Staphylococcus aureus displayed 26%, and Serratia species displayed 3% resistance.

Klebsiella species demonstrated 45% resistance to sulfamethoxazole. It's interesting to note that none of the bacterial species under investigation—Klebsiella spp., Enterococcus spp., Proteus spp., Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus, and Serratia spp.—exhibited resistance to vancomycin. Staphylococcus aureus showed a higher proportion of resistance to Doxycycline (81%), compared to 19% for Enterococcus spp. It was discovered that 44% of Staphylococcus aureus and 56% of Klebsiella spp. were resistant to tigecycline. Penicillin G resistance in Enterococcus spp. was 25%, but Staphylococcus aureus showed 75% resistance. Lastly, Staphylococcus aureus exhibited 76% resistance to clindamycin, compared to 24% resistance in Escherichia coli. The data analysis reveals Amikacin resistance rates in various bacterial species. Klebsiella spp. revealed a 42% resistance rate, whilst Proteus spp. showed an 8% resistance rate. Escherichia coli exhibited 21% resistance, Pseudomonas aeruginosa 8%, and Staphylococcus aureus 21%. The data demonstrate that none of the bacterial species identified were resistant to Polymycin B. Polymycin B was found to be effective against Klebsiella spp., Enterococcus spp., Proteus spp., Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus, and Serratia spp.

The resistance rates to nitrofurantoin were 37% for Klebsiella spp., 4% for Proteus spp., 38% for Escherichia coli, and 21% for Staphylococcus aureus. In terms of Tetracycline resistance, Klebsiella spp. exhibited a 36% rate, Enterococcus spp. showed a 5% rate, Proteus spp. showed a 5% rate, Escherichia coli showed a 17% rate, and Staphylococcus aureus showed a 36% rate. Finally, in the instance of Tazobactam, Klebsiella spp. showed the highest resistance rate (73%), indicating a significant challenge in treating these infections. Proteus spp. showed a resistance rate of 9%, whereas Escherichia coli showed a resistance rate of 14%. Pseudomonas aeruginosa has a relatively low resistance rate of 4%.

The study reveals significant clinical implications regarding antibiotic resistance. High resistance rates in Klebsiella spp., particularly to Ceftriaxone, pose a challenge in treating infections caused by this bacterial species. This suggests the need for alternative antibiotics and targeted treatment strategies to combat infections caused by multidrug-resistant Klebsiella spp. In clinical practice, this may involve adjusting treatment protocols and implementing surveillance and infection control measures. The resistance rates in Escherichia coli, a common cause of urinary tract infections, suggest the need for judicious use of antibiotics. Intermediate resistance rates suggest that antibiotic treatment options for Escherichia coli infections may be effective but require careful consideration.

This highlights the importance of antimicrobial stewardship programs and appropriate prescribing practices to avoid further selection of resistant strains. Lower resistance rates in Serratia and Proteus spp. may provide more treatment options for infections caused by these bacteria. The study also highlights the importance of understanding local resistance patterns to tailor empirical therapy and ensure optimal treatment outcomes. Lastly, the absence of resistance to certain antibiotics, such as vancomycin, among the studied bacterial species is promising. These antibiotics can serve as important treatment options for infections caused by these organisms and provide valuable alternatives when other antibiotics are ineffective due to resistance.

The findings of this study demonstrate the varying levels of antibiotic resistance among different bacterial species. Certain pathogens, such as Klebsiella spp. and Staphylococcus aureus, are demonstrably resistant to a variety of medications, emphasizing the need for alternative treatment options and good antimicrobial stewardship programs. These findings emphasize the need to monitor antibiotic resistance trends to make sound treatment decisions and combat emergence of resistant bacterial strains. Additional research and surveillance are needed to develop effective approaches for minimizing and managing antibiotic resistance (Table 2).

**Table 2: Antibiotic resistance pattern of different organisms isolated from the urine specimen of the patients**

| Antibiotic | *Klebsiella spp.* | *Enterococcus spp.* | *Proteus spp.* | *Escherichia coli* | *Pseudomonas aeruginosa* | *Staphylococcus aureus* | *Serratia spp.* |
|---|---|---|---|---|---|---|---|
| **Ciprofloxacin** | 29 (34%) | 8 (9%) | 4 (5%) | 12 (14%) | 5 (6%) | 22 (25%) | 6 (7%) |
| **Ceftriaxone** | 31 (54%) | NA | 4 (7%) | 13 (23%) | 2 (3%) | NA | 7 (12%) |
| **Cefalaxin** | 16 (50%) | 3 (9%) | 2 (6%) | 3 (9%) | NA | 8 (25%) | NA |
| **Colistin** | 4 (57%) | NA | NA | NA | NA | 3 (43%) | NA |
| **Cefuroxime** | 12 (86%) | NA | NA | 2 (14%) | NA | NA | NA |
| **Ampicilin** | 27 (45%) | 10 (17%) | 3 (5%) | 15 (25%) | 2 (3%) | NA | 3 (5%) |
| **Amoxicillin** | 31 (52.5%) | NA | 2 (3%) | 19 (32%) | 3 (5%) | NA | 4 (7%) |
| **Erythromycin** | NA | 4 (36%) | NA | NA | NA | 7 (64%) | NA |
| **Cefoxitin** | 11 (29%) | NA | NA | 9 (24%) | NA | 18 (47%) | NA |
| **Gentamycin** | 19 (65.5%) | NA | NA | 7 (24%) | 3 (10.5%) | NA | NA |
| **Levofloxacin** | 29 (36%) | 9 (11%) | 4 (5%) | 13 (16%) | 1 (1%) | 20 (25%) | 5 (6%) |
| ***Meropenem*** | 17 (53%) | NA | 4 (13%) | 9 (28%) | 2 (6%) | NA | NA |
| **Imipenem** | 21 (51%) | NA | 2 (5%) | 8 (19%) | 4 (10%) | NA | 6 (15%) |
| **Linezolid** | 6 (60%) | NA | NA | NA | NA | 4 (40%) | NA |
| **Cefepime** | 24 (58%) | NA | 1 (2%) | 9 (22%) | 3 (7%) | NA | 4 (10%) |
| **Nalidexic Acid** | 5 (56%) | NA | NA | 3 (33%) | 1 (11%) | NA | NA |
| **Fosfomycin** | NA | 2 (50%) | NA | NA | NA | 2 (50%) | NA |
| **Rifampicin** | NA | 2 (20%) | NA | 3 (30%) | NA | 5 (50%) | NA |
| **Sulfamethoxazole** | 28 (45%) | NA | 5 (8%) | 11 (18%) | NA | 16 (26%) | 2 (3%) |
| **Tetracycline** | 20 (36%) | 3 (5%) | 3 (5%) | 9 (17%) | NA | 20 (36%) | NA |
| **Vancomycin** | NA | NA | NA | NA | NA | NA | NA |
| **Doxycycline** | NA | 5 (19%) | NA | NA | NA | 21 (81%) | NA |
| **Tigecycline** | 5 (56%) | NA | NA | NA | NA | 4 (44%) | NA |
| **Penicillin G** | NA | 4 (25%) | NA | NA | NA | 12 (75%) | NA |
| **Amikacin** | 10 (42%) | NA | 2 (8%) | 5 (21%) | 2 (8%) | 5 (21%) | NA |
| **Polymycin B** | NA | NA | NA | NA | NA | NA | NA |
| **Clindamycin** | NA | NA | NA | 4 (24%) | NA | 13 (46%) | NA |
| **Nitrofurantoin** | 9 (37%) | NA | 1 (4%) | 9 (38%) | NA | 5 (21%) | NA |
| **Novobiocin** | NA | NA | NA | NA | NA | 3 (100%) | NA |
| **Tazobactum** | 16 (73%) | NA | 2 (9%) | 3 (14%) | 1 (4%) | NA | NA |

## Discussion

Drug-resistant infections develop when organisms adapt in ways that render antimicrobial therapies ineffective. As a result, infections survive and spread. When infections are treatable with antimicrobials, people can be treated, and future transmission in the community is readily managed. This has saved hundreds of millions of lives since the widespread usage of these "miracle drugs" over 70 years ago. Antimicrobial resistance (AMR) is reducing treatment efficacy in both developing and industrialized nations. If this trend continues, the world will confront a situation in which numerous infectious diseases have "no cure and no vaccine".[12,13]

Hospital-acquired urinary tract infections (UTIs) are a major concern in healthcare settings because they are linked to drug resistance. Urinary tract infections (UTIs) account for 20-40% of all infections encountered in hospitals worldwide. Patients in the hospital with urinary system abnormalities (such as those in the urology unit) are more likely to get UTIs during their stay. It is responsible for up to 60-70% of all hospital infections.[14] Antibiotics are required for effective treatment of UTIs. Broad-spectrum antibiotics are commonly used to begin treatment. However, antibiotic abuse and widespread availability without adequate management have resulted in the worldwide establishment of antibiotic resistance among common bacteria associated with UTIs.[15] This study's findings provide a thorough assessment of antibiotic resistance trends in different bacterial species isolated from urine samples. The high levels of resistance to numerous antibiotics found in Klebsiella spp. and Staphylococcus aureus serve as a stark reminder of the difficulties in treating infections caused by these bacteria. These findings not only support but also reflect previous study findings, which have shown a steady increase in resistance among these specific bacterial species throughout time.[16, 17]

Klebsiella spp. were extremely resistant to several antibiotics, including Ceftriaxone, Ciprofloxacin, and Cefalaxin. This resistance trend is consistent with previous research, which has consistently reported higher resistance levels in Klebsiella spp. This disturbing development underscores the difficulties and problems that healthcare providers have while treating infections caused by this particular bacterial species.[18,19] Staphylococcus aureus also demonstrated significant drug resistance, including Ciprofloxacin, Cefalaxin, and Erythromycin. These findings are consistent with previous research that has demonstrated greater rates of resistance in Staphylococcus aureus, indicating a challenging terrain for treating infections caused by this bacterium. Escherichia coli showed varying resistance rates to various antibiotics, with some having very low resistance levels and others, such as Cefuroxime and Amoxicillin, having substantially higher resistance.

These findings are consistent with earlier research exposing the varied resistance rates observed in Escherichia coli, emphasizing the challenges of managing antibiotic resistance in this bacterial species.[20, 21] Compare the resistance rates of Proteus spp. to those of Klebsiella spp. and Staphylococcus aureus, and we noticed that the overall resistance is lower. However, despite lower overall resistance rates, Proteus spp. still shown considerable resistance to certain antibiotics such as Amikacin. This holistic perspective sheds light on the patterns in antibiotic resistance among many bacterial species.[22, 23] The overall reduced resistance rates observed in Pseudomonas aeruginosa are consistent with findings from earlier investigations. Despite this overall trend, certain medications, such as Ciprofloxacin, nevertheless showed significant resistance rates, emphasizing the significance of understanding Pseudomonas aeruginosa's resistance profiles to properly advise treatment options.[24, 25] Serratia spp. and Enterococcus spp. have varying resistance rates to various antibiotics, showing the complex and diverse landscape of antibiotic resistance patterns among these bacteria.

This variability underscores the significance of tailored and targeted treatment strategies that account for the various resistance profiles of Serratia spp. and Enterococcus spp. to improve therapeutic outcomes.[25, 26] The lack of resistance to Vancomycin and Polymycin B is remarkable, as these antibiotics are routinely used as last-resort treatments for multidrug-resistant infections. However, resistance to specific antibiotics has been found in some cases, emphasizing the significance of ongoing observation. According to this study, Vancomycin may still be an effective treatment for certain bacteria-related disorders. However, the presence of Vancomycin-resistant bacteria in other studies emphasizes the importance of continued monitoring.

It should be emphasized that the data presented in this study are based on specific bacterial species isolated from urine specimens and may not include the entire range of resistance patterns. Additionally, resistance rates may vary geographically and over time, underscoring the importance of constant monitoring and surveillance. Overall, this study found frightening levels of resistance to commonly used antibiotics in several bacterial species.

Healthcare settings are a major source of antibiotic-resistant bacteria, with factors like multidrug-resistant organisms, invasive procedures, and exposure to antibiotics contributing to resistance. To prevent the spread of antibiotic-resistant UTIs, robust infection control measures, such as hand hygiene protocols and surveillance, are crucial. Antimicrobial stewardship programs promote the appropriate use of antibiotics, optimize treatment guidelines, and improve patient outcomes. Infection control measures include standard precautions, isolation strategies, and active surveillance. Public awareness about antibiotic use, its dangers, and the importance of completing prescribed treatment courses is also crucial.

Research into novel treatment approaches and antimicrobial agents is vital for addressing antibiotic-resistant UTIs. Factors such as antibiotic misuse, patient demographics, and healthcare settings influence antibiotic resistance patterns. A multifaceted approach, including antimicrobial stewardship programs, infection control measures, public awareness campaigns, and ongoing research and development efforts, can mitigate the impact of antibiotic resistance and preserve effective treatment options.

## Conclusion

In coclusion, this study illustrates the diverse levels of resistance shown by different bacterial species to several antibiotics commonly used to treat urinary tract infections. Klebsiella spp. consistently showed the highest resistance rates across multiple drugs, emphasizing the crucial need for effective strategies in managing infections caused by these multidrug-resistant organisms. The findings further emphasize the importance of judicious antibiotic selection and ongoing surveillance in the treatment of infections caused by Escherichia coli and Staphylococcus aureus, which have significant resistance rates.

These findings highlight the need for antimicrobial stewardship programs, infection control measures, and continuous research in combating the global problem of antibiotic resistance. A multimodal strategy can help improve patient outcomes, keep existing therapies effective, and lead the development of new antibiotic-resistant bacterial infection treatments.

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