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A LONGITUDINAL ASSESSMENT OF ANTIMICROBIAL RESISTANCE TRENDS IN UTI ISOLATES: GUIDING RATIONAL ANTIBIOTIC USE IN A TERTIARY CARE SETTING

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ABSTRACT:
To study the sensitivity of an Antibiotic to towards the bacteria according to the Antibiogram for urinary tract infections in a tertiary care hospital. In a tertiary care centre, a retrospective analysis including 200 patients (n=200) was carried out during an 18-month period. Patients who were pregnant or nursing, postpartum, elderly male and female patients, outpatients, inpatients, including those in the intensive care unit, and paediatric patients were also excluded. Antibiogram of the hospital was collected and the treatment strategy was planned accordingly.
Out of 200 patients, 57.5% were males and 42.5% were females. In the total number of gram-negative bacteria, Klebsiella pneumonia, accounted for 24% followed by E. coli with 20% and Pseudomonas aeruginosa (10%). In gram positive bacteria, both Staphylococcus aureus and Enterococcus sps were occupied with 8% (n=16) each. Amongst all the antibiotics, for UTIs meropenem 70 (35%) was reported to get prescribed to the maximum followed by cefoperazone 50 (25%), and its combination with sulbactum 20 (10%). The values were found to be statistically significant (*p=0.0439; F=3.865; df=10). From the results, it can be concluded that, Cefaperazone generally demonstrated good susceptibility to both Gram-positive and Gram-negative bacteria. For Gram-positive bacteria, vancomycin and linezolid might be used as backup medications; for Gram-negative bacteria, carbapenems and cefaperazone work well. Antibiotic resistance can be decreased by using an antibiogram to determine the optimal antibiotic therapy.

KEYWORDS: Antibiogram, susceptibility, urinary tract infection, treatment

INTRODUCTION
Urinary tract infections (UTIs) are the most common infections in the general population. They are also the most prevalent hospital-acquired infections and the second leading cause of hospital visits [1]. UTIs affect individuals across all age groups and genders. Each year, UTIs account for approximately one million emergency room visits and seven million outpatient consultations. The increased incidence of UTIs results in higher healthcare costs, prolonged hospital stays, and reduced quality of life for affected individuals, thereby imposing a substantial healthcare burden [2].
Healthcare professionals and policymakers are increasingly developing strategies and implementing preventive measures to address urinary tract infections (UTIs), recognizing the severity of this issue [3]. Multiple etiological factors contribute to UTIs, including sexual activity, pregnancy, kidney stones, enlarged prostate, urinary catheters, weakened immune system, and insufficient fluid intake. Furthermore, specific risk factors differ between men and women [4]. For example, women are more susceptible to UTIs due to a shorter urethra, absence of bactericidal prostatic secretions, higher bacterial load in the urothelial mucosa, urinary tract blockages, sexual activity, and pregnancy [5]. In contrast, UTIs are more prevalent in older men, individuals with enlarged prostates, and those with neurogenic bladder dysfunction [6].
Escherichia coli is the most prevalent bacterium responsible for urinary tract infections (UTIs), followed by Klebsiella pneumoniae, Staphylococcus species, Proteus species, Pseudomonas aeruginosa, Enterococcus species, and Enterobacter species [3]. Annually, UTIs account for approximately 150 million cases worldwide, leading to healthcare expenditures exceeding $6 billion. Antimicrobial drug resistance (AMR) develops rapidly, particularly when antimicrobial medications are widely accessible and affordable, and is often difficult to detect. Therefore, continuous monitoring of antimicrobial usage is essential. Factors such as patient age group, prevalent infections, regional antibiotic resistance trends, and clinical condition influence the initial selection of antibiotic therapy [7].
The term "bacterial susceptibility" refers to the likelihood that a bacterium will be inhibited or eradicated by an antimicrobial agent. Laboratory tests, known as antibiotic susceptibility testing (AST), categorize bacterial responses to antibiotics as "susceptible," "intermediate," or "resistant." Susceptibility, also referred to as sensitivity, indicates that the antibiotic is likely to inhibit or kill the bacterial pathogen, making it an effective treatment option. A "resistant" result signifies that the antibiotic is unlikely to be effective, as the bacteria can continue to grow despite exposure. An "intermediate" result suggests that the antibiotic may be effective at higher doses or with increased frequency, and this category serves as a buffer to account for minor variations in testing. Additionally, the effectiveness of an antibiotic may

vary depending on the site of infection within the body. Resistance occurs when bacteria adapt and become unresponsive to the medication, increasing the risk of treatment failure [8].

A hospital antibiogram is a periodic report that summarizes bacterial susceptibility to various antibiotics using cumulative data from the hospital's microbiology laboratory. This report supports the development of antimicrobial stewardship initiatives, facilitates monitoring of local resistance trends, and aids in the selection of appropriate empirical antibiotic therapies. The antibiogram presents the proportion of each bacterial organism susceptible to different antibiotics and compiles the results of antimicrobial susceptibility testing for local isolates. By aggregating data from individual susceptibility tests, the antibiogram serves as a statistical tool to inform clinical decisions regarding the most effective antibiotics for specific infections within a given healthcare setting.
The region-wide report of culture and sensitivity data is provided by the hospital antibiogram. It indicates evolution of an organism's susceptibility pattern. Consequently, it will assist clinicians in selecting the right antibiotic, reducing the overuse of antibiotics and the emergence of resistance. Thus, the purpose of this study is to identify the antibiotic susceptibility pattern and bacteriological profile of UTI bacterial isolates in a tertiary medical facility.

METHODOLOGY

Study methodology

Inclusion criteria In-patients who got admitted including ICU, Pregnant and lactating women, geriatric male and female patients, postpartum ladies and out-patients.
Exclusion criteria: Paediatric patients

Study procedure: A data collection form was designed to collect the required information. The patient demographics, past medical history, comorbid conditions, laboratory parameters, and prescribed treatment were collected. In patients of ICU the initial mid-stream urine sample was obtained by transurethral bladder catheterization or supra-pubic aspiration while taking aseptic measures. For a maximum of 12 to 24 hours, samples that could not be inspected immediately were stored in a refrigerator at 40C. A second urine culture was carried out in contaminated cases. From non-ICU patients and out-patients urine samples were collected and analysed.

Analysis design

A total count of 200 patients (n=200) participated in an 18-month retrospective analysis conducted at a tertiary care facility between January 2024 and May 2025.

Ethics

The Research project was approved by IEC, CMR College of pharmacy with CMRCP/IEC/2024-25/12.

Statistics

The statistical analysis was carried out using SPSS version 23.0 and the mean and standard deviation. The chi-squared test was used to analyse baseline data, causes, and treatment plans (qualitative variables), and the variables were evaluated.

RESULTS

A total of 200 patients were examined for the presence of UTIs. It was discovered that there were 115 (57.5%) males and 85 (42.5%) females. Figure 1 showed that of the 200 patients, 140 (70%) were older than 55 years. Of these, 90 (78.2%) were men and 50 (58.8%) were women.Total – 200; Females – 85 (42.5 %); Males – 115 (57.5%)

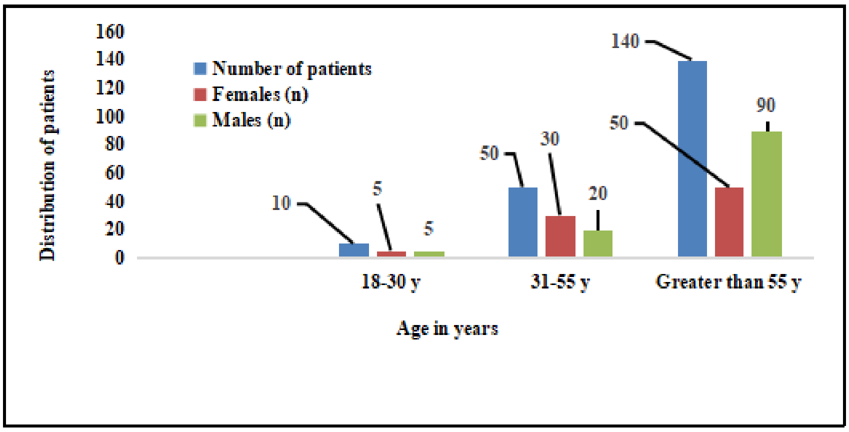
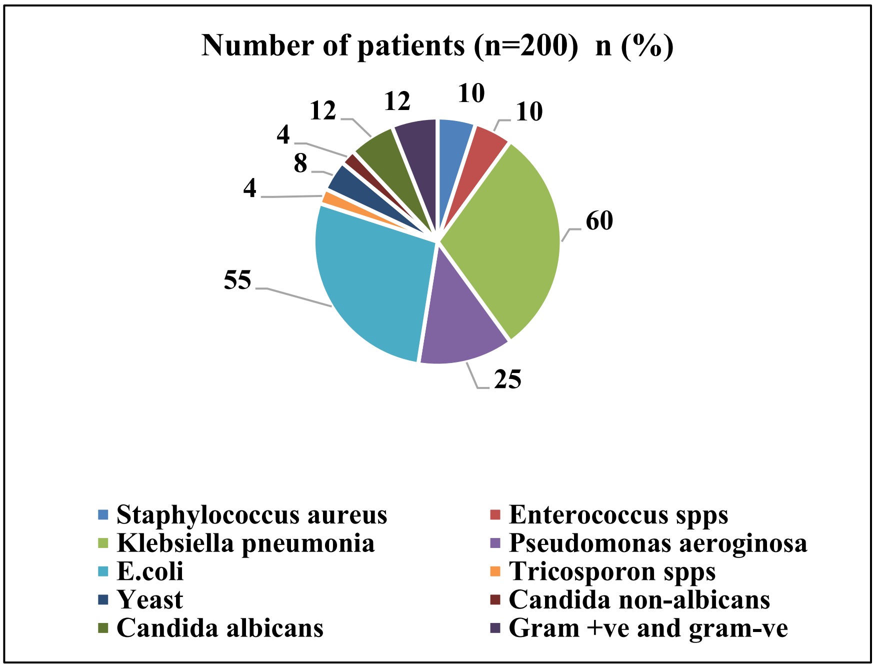


Fig. 1. showed the distribution of patients with UTIs

Gram positive and gram-negative microorganism records were examined in the current investigation. Of the total number of patients, 70% (n=140) had gram-negative organisms, followed by gram-positive bacteria (n=20) and fungus (14%). As shown in the Figure 2, the p value (0.999) was determined to be statistically non-significant. Mean = 50; SD = 16.5; df=3; Chi Square – 6.762; nsp=0.999; ns=non-significant



In Table 1, showed the distribution of Gram-positive and Gram-negative bacteria among UTI patients. Gram negative bacteria were reported with 54% (n=108) followed by gram positive bacteria 16 % (n=32). Amongst the Gram-negative bacteria, 24 % had Klebsiella pneumonia, followed by Pseudomonas aeroginosa (10%) and E. coli (20%) respectively in their urine samples. In the negative bacteria, Staphylococcus aureus and Enterococcus spp showed 8 % each (n=16) which showed that there was no significant difference (nsp=0.999).

Table 1: represented the distribution of Gram positive and negative bacteria amongst the UTI patients

Gram negative bacteria	n	%
Klebsiella pneumonia	48	24
Pseudomonas aeroginosa	20	10
E. coli	40	20
	108	54
Gram positive bacteria		
Staphylococcus aureus	16	8
Enterococcus spp	16	8
	32	16
Mean = 28; SD = 13.3; df=4; Chi Square – 1.062; nsp=0.999; ns=non-significant		

Table 2 & 3 illustrated the Antibiogram of gram-negative and positive organisms based on hospital setting. Healthcare facilities and public health authorities can track changes in local bacterial epidemiology and evolving resistance patterns over time by producing antibiograms once a year or more frequently. This information helps measure a facility's resistance rates against regional statistics and guides public health interventions. To assist physicians, choose treatments for urinary tract infections (UTIs), an antibiogram shows which bacteria are Sensitive (good), Intermediate (borderline/use with caution), or Resistant (ineffective) to antibiotics. Common culprits like E. coli are frequently sensitive to Nitrofurantoin and Imipenem but resistant to older medications like Ampicillin, highlighting rising resistance to broad-spectrum options like fluoroquinolones.

Table 2: Antibiogram of Gram-negative organisms based on Hospital setting

RESISTANCE	SENSITIVE	INTERMEDIATE
Klebsiella pneumonia		
Gentamicin	Carbapenams	Imipenem
Amikacin		Tigecycline
Ceftazidime		Colistin
Ciprofloxacin		
Nitrofurantoin		
Cotrimaxozole		
Piperacillin+Tazobactum		
Cefeperazone+Sulbactum		

Cefepime		
Pseudomonas aeruginosa		
	Cefoperazone	
	Amikacin	
	Ceftazidime	
	Ciprofloxacin	
	Oflaxacin	
	Tobromycin	
	Netilimycin	
	Piperacillin+tazobactum	
	Cefeperazone+sulbactum	
	Meropenem	
	Cefipime	
	Imipenem	
Escherichia coli		
Ceftazidime	Gentamicin	
Ceftriaxone	Amikacin	
Ciprofloxacin	Meropenem	
Co-Trimaxazole	Imipenem	
Cefotaxime		
Piperacillin+Tazobactum		
Cefepime		
Efoperazone+Tazobactum		

Table 3: Antibiogram of Gram-positive organisms based on Hospital setting

RESISTANCE	SENSITIVE	INTERMEDIATE
Staphylococcus aureus		
	Amoxicillin+Clavulanic acid	
	Cefoperazone	
	Clindamycin	
	Cefuroxime	
	Cefepime	
	Amoxicillin	
	Ceftizoxime	
	Ciprofloxicin	
Enterococcus species		
Amoxicillin + Clavulanic acid	Vancomycin	
	Cefoperazone	
	Linelozid	
	Nitrofurantoin	
	Amoxicillin	
	Ciprofloxicin	

In the treatment plan, there is every chance to choose a right antibiotic. Figure 3 illustrated that amongst all the antibiotics, for UTIs meropenem 70 (35%) was reported to get prescribed to the maximum followed by cefoperazone 50 (25%), and its combination with sulbactum 20 (10%). The values were found to be statistically significant (*$p=0.0439$; $F=3.865$; $df=10$). Mean = 18.18; SD=22.28; F-Test - *$p=0.0439$; $F=3.865$; $df=10$

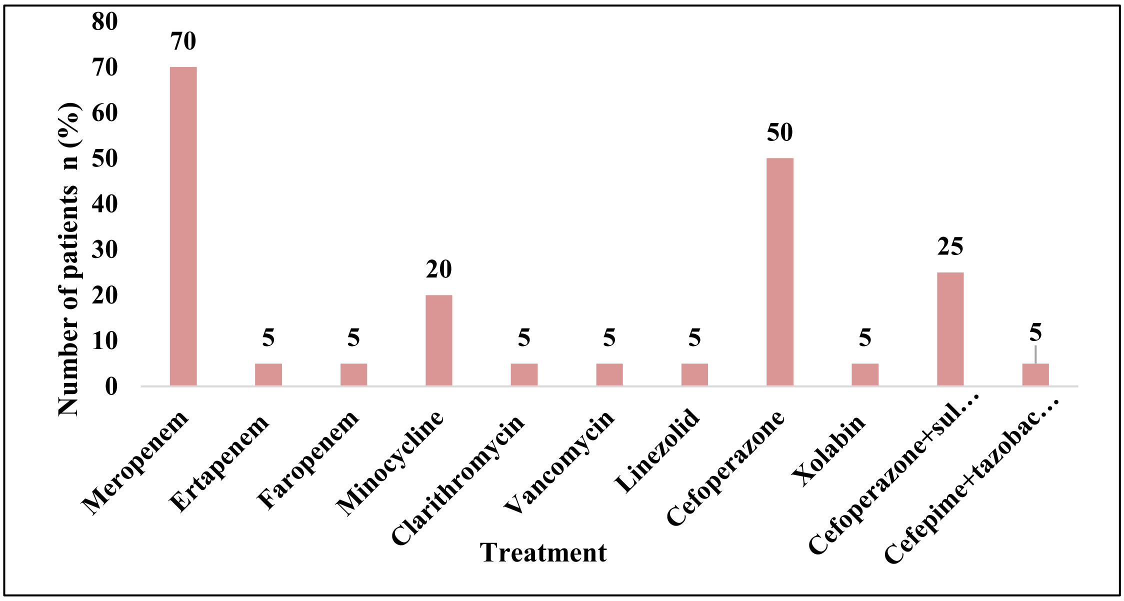


Fig. 3: UTI treatment for patients (n=200)

In the current study, particular antibiotic was selected for particular species of bacteria depending upon the urine culture test. Amongst all the antibiotics, a total of 78 (39%) patients was suggested with meropenem for the bacteria - Klebsiella pneumonia and E. coli respectively. The two bacteria Pseudomonas aeruginosa and Staphylococcus aureus were sensitive for cefaperazone in 72 (36%) patients. Other drugs like vancomycin, linezolid, ertapenem and faropenem were sensitive for Staphylococcus aureus, Klebsiella pneumonia and Enterococcus spps. The values were proven to be significant statistically (**p=0.0339), in Figure 4.

Table 4: Bacterial distribution in the urine isolates

Bacteria	Drugs used	n = 200 (%)
Klebsiella pneumonia	Carbapenems - Meropenem	38 (19)
	Ertapenem	5 (2.5)
	Faropenem	5 (2.5)
Pseudomonas aeroginosa	Cefaperazone	50 (25)
E. coli	Meropenem	40 (20)
Staphylococcus aureus	Cefaperazone	16 (8)
Enterococcus spps	Vancomycin	5 (2.5)
	Linezolid	5 (2.5)
	Cefaperazone	6 (3)
	Mean = 18.89; SD=18.34; **p=0.0339; df=9	

With regard to the sensitivity of organisms towards antibiotics, meropenem and cefaperazone occupied for about 51.76% and 42.35%, followed by 2.94% each for vancomycin, linezolid, ertapenem and faropenam respectively.

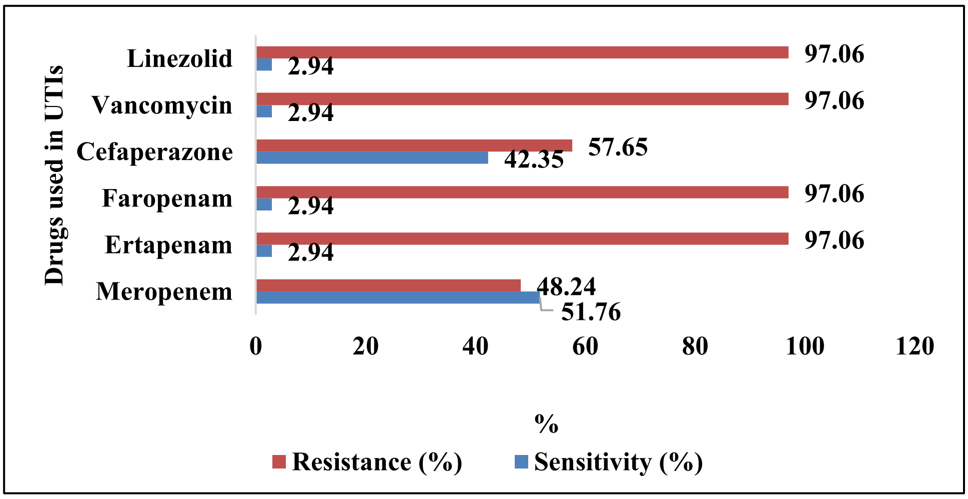


Fig. 4: Sensitivity and resistance of organisms in UTI patients

DISCUSSION

UTIs can cause major problems such as kidney infections (pyelonephritis), irreversible kidney damage, sepsis (a potentially fatal blood infection), and pregnancy problems (preterm birth) if left untreated. Recurrent UTIs may require other approaches, such as oestrogen therapy for postmenopausal women [11]. Because there are few treatment options available, uropathogens have become more resistant to various antimicrobials globally, offering a significant challenge to clinicians. Uropathogens are microbes, primarily bacteria like E. coli, that cause urinary tract infections (UTIs) by colonizing the urinary system, often using virulence factors to attach to bladder cells and form biofilms, leading to symptoms like painful urination and frequency [12]. Gram-positive Enterococcus faecalis and Staphylococcus aureus, as well as Gram-negative rods like Klebsiella pneumoniae, Pseudomonas aeruginosa, and Proteus mirabilis, are common culprits; E. coli is the most common, particularly in community-acquired infections. These pathogens can cause both uncomplicated (normal urinary tract) and complicated (with catheters, stones, or abnormalities) UTIs, with complicated infections often involving biofilms and antibiotic resistance. Managing UTIs entails using a methodical approach to diagnose the infection and administering the proper empirical treatment by selecting the right antibiotic [13]. Therefore, early diagnosis, the detection of antibiotic sensitivity patterns, and the proper treatment of UTIs are essential in order to spare patients unnecessary financial burden and prevent the development of long-term issues. Antibiotics are the mainstay of treatment, but self-care measures like drinking water and avoiding irritants also assist.

Urinary tract bacterial infections are a common cause of community-based medical treatment [14]. It is anticipated that the causes, methods, and patterns of antibiotic resistance of uropathogens would continue to evolve over time and vary geographically [15]. Treating UTIs requires identifying the bacteria and figuring out the susceptibility to antibiotics is imperative. Determining the type of organism causing the infection and selecting an appropriate antibiotic for that particular organism are frequently crucial to the successful treatment of bacterial UTIs [16].

In the present study, males were with high percentage (57.5%) than females (42.5%), with a greater number of patients who crossed 55 years of age. However, one of the most prevalent bacterial illnesses, UTIs are far more common in women than in men according to the previous studies [17]. A positive urine analysis or culture combined with a number of symptoms can be used to diagnose a UTI. The present study observed that gram negative bacteria was occupied with 7/10th of the total number of patients (n=200). According to the latest updates, the majority of Gram-negative bacteria discovered typically in the digestive system, were found to be more prevalent in urinary tract infections which proved consistency with the present research study [18]. The prevalence of Gram-positive bacteria, such as Enterococcus and Streptococcus, and Gram-negative bacteria, such as Escherichia coli and K. pneumoniae, was nearly identical to the percentage of urinary tract infection pathogens seen in other investigations.

The Antibiogram's purpose is to help choose the most effective antibiotic to treat a specific UTI, especially in cases where local resistance patterns are common [19]. An antibiogram is a profile that shows the susceptibility of a specific local UTI-causing bacterium to various antibiotics. Common uropathogens like E. coli and Klebsiella often show good susceptibility to some older antibiotics, such imipenem or nitrofurantoin, but significant resistance to others, like ampicillin. Location-specific and regularly updated antibiograms are crucial for guiding empirical treatment and tackling the escalating issue of antibiotic resistance [20]. In the present study, the hospital antibiogram showed a periodic summary of antimicrobial susceptibilities of local bacterial isolates submitted to the hospital's clinical microbiology laboratory. Antibiograms are often used by clinicians to assess local susceptibility rates, as an aid in selecting empiric antibiotic therapy, and in monitoring resistance trends over time within an institution. Antibiograms can also use to compare susceptibility rates across institutions and track resistance trends [21].

In the present study, carbapenems – Meropenem was found to be more sensitive for Klebsiella and E. coli and has been prescribed to the patients. The results were consistent with the previous study results. The success rates were higher in case of resistant bacteria as well [22]. Also, Pseudomonas aeruginosa (n=50) and Staphylococcus aureus (n=16) were treated with Cefaperazone in the present study. According to the previous study, cefaperazone showed good activity and proved to be safe against both the bacteria in UTIs [22]. Vancomycin is a crucial antibiotic for Enterococcus infections; however, resistance is a significant issue that results in Vancomycin-Resistant Enterococci (VRE), particularly E. faecium, which requires alternate therapies such linezolid, but E. faecalis is typically sensitive. The present also revealed the treatment of same infections with vancomycin, and the results seems to be promised [23]. Similarly, because it inhibits the formation of bacterial proteins, linezolid is an essential antibiotic for treating severe infections caused by resistant Gram-positive bacteria, particularly Vancomycin-Resistant Enterococcus (VRE) like E. faecium and E. faecalis. The present study explores the same linezolid for the treatment of Enterococcus spps [24].

In urinary tract infections (UTIs), sensitivity and resistance describe the effectiveness of antibiotics against specific pathogenic bacteria. Common pathogens such as Escherichia coli are increasingly resistant to older antibiotics, including ampicillin and ciprofloxacin, but often remain susceptible to newer agents such as nitrofurantoin, fosfomycin, and carbapenems [25]. The present study highlighted that the sensitivity for meropenem was 51.76% followed by cefaperazone (42.35%) whereas for the other drugs such as vancomycin and linezolid the sensitivity was reported to be below 3%. Urine culture and antibiotic sensitivity testing (antibiogram), are essential for guiding appropriate therapy, especially given the increasing prevalence of multidrug-resistant strains.

CONCLUSION

Physicians may find this study's data on the antibiotic resistance trend of urine isolates useful in starting empirical treatment and developing hospital antibiotic policies. The most common urine isolate was Klebsiella, which was followed by, E. coli, Pseudomonas, and other species. Overall, cefaperazone showed good susceptibility to both Gram-positive and Gram-negative bacteria. Vancomycin and linezolid should be used as backup drugs for Gram-positive bacteria; carbapenems and cefaperazone are excellent for Gram-negative bacteria. Using an antibiogram to choose the best antibiotic therapy will reduce antibiotic resistance. The development of multi-drug-resistant bacteria will become a serious threat to the health care system, and the standard empirical treatment options will no longer be effective. Therefore, more advanced research studies are needed to formulate cautionary guidelines to prevent the development of antibiotic resistance.

Conflict Of Interest: The authors have no conflicts of interest regarding this study.

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