

**Antimicrobial Resistance Trends in a Rural Tertiary Care Teaching Hospital: A Retrospective Observational Study**Thacker JD<sup>1</sup>, Desai HA<sup>2</sup>, Anturlikar SS<sup>3</sup>, Damor RR<sup>4</sup><sup>1</sup>Third Year Resident, Department of Pharmacology, Parul Institute of Medical Sciences and Research, Parul University, Vadodara, Gujarat, India<sup>2</sup>Associate professor, Department of Pharmacology, Parul Institute of Medical Sciences and Research, Parul University, Vadodara, Gujarat, India<sup>3</sup>Tutor, Department of Pharmacology, Parul Institute of Medical Sciences and Research, Parul University, Vadodara, Gujarat, India<sup>4</sup>Assistant Professor, Department of Pharmacology, Parul Institute of Medical Sciences and Research, Parul University, Vadodara, Gujarat, India

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**Abstract:**

**Background:** The global burden of antimicrobial-resistant infections is growing at an alarming rate, being responsible for more than half a million deaths worldwide each year. The resistance crisis has prompted a rise in antimicrobial stewardship (AMS) programme, which aim to reduce inappropriate antibiotic use. India is one of the largest consumers of antibiotics worldwide and antibiotic sales are increasing rapidly. Hence, it was decided to explore the anti-microbial sensitivity and resistance status of *E. coli*, *K. pneumoniae* (KP), and *P. aeruginosa* (PA) from the data base of a rural tertiary care teaching hospital.

**Aim:** To evaluate the anti-microbial susceptibility and resistance pattern at a rural tertiary care teaching hospital of three important microorganisms, namely *E. coli*, *K. pneumoniae* (KP), and *P. aeruginosa* (PA).

**Methodology:** This was an observational retrospective study of 3 months (June 2023 – August 2023) to determine the antimicrobial susceptibility pattern of cultures of various specimens collected during this period. To maintain feasibility, systematic randomization of data collection days was done. The data was collected every alternate day for 3 months.

**Results:** The antimicrobial resistance patterns observed for *E. coli* showed high resistance rates to commonly used antibiotics such as Ampicillin (88.14%), Cefalotin (86.67%), and Nalidixic Acid (90.37%). Notably, Fosfomycin showed a remarkably low resistance rate (2.22%). *K. pneumoniae* exhibited high resistance to Ceftriaxone (92.3%), Cefuroxime (92.3%), and Piperacillin/Tazobactam (92.3%), while Colistin and Tigecycline resistance were relatively low (7.69% and 15.38%, respectively). *P. aeruginosa* presented a varied resistance pattern, with the highest resistance observed for Tigecycline (97.92%), while Colistin resistance remained low (10.42%).

**Conclusion:** The escalating trends of antimicrobial resistance pose a significant global health challenge. An antimicrobial stewardship programme with educational intervention and the sensitization of medical students to rational antimicrobial prescriptions is need of the hour to control the menace of antimicrobial resistance.

**Keywords:** *E. coli*, *K. pneumoniae* (KP), and *P. aeruginosa* (PA), Antimicrobial-resistance, antimicrobial stewardship (AMS) programme.

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**Introduction**

Global burden of antimicrobial-resistant infections is growing at an alarming rate, being responsible for more than half a million deaths worldwide each year [1,2,3]. In the absence of effective control interventions, the annual number of deaths related to resistance may rise to 10 million per year by 2050, according to a UK government commissioned review [3], although others have forecast lower numbers, particularly in parts of the

world where non-antimicrobial measures can be implemented to prevent infectious disease mortality [4]. These projections include both the international burden and local variation in resistance rates. Several reviews have highlighted the impact of international travel, including immigration, on the worldwide spread of resistant bacteria to countries that are effectively controlling their antibiotic use [3,5,6]. Resistance crisis has prompted a rise in

antimicrobial stewardship (AMS) which aim to reduce inappropriate antibiotic use. Although AMS focuses on antibiotic prescribing practice, it is underpinned by an understanding of local antibiotic susceptibility pattern, which in turn depends on the availability of a reliable medical microbiology laboratory resource. In light of the crisis of antimicrobial drug resistance (AMR), the implementation of clinical bacteriology laboratories in low-resource settings improves patient management, delivering both guidance for individual patient infection management and surveillance in support of antibiotic treatment guidelines and policies [6,7].

Antibiotics are essential medicines that combat bacterial infections with the aid of disrupting the methods essential for bacterial cell growth and proliferation. They represent one of mankind's crucial medical inventions, saving millions of lives throughout the years. The first novel antibiotic introduced into the world; Penicillin was discovered by Alexander Fleming in 1928. Penicillin has saved and is still saving millions of lives worldwide playing a major role in treating bacterial diseases and in the creation of today's pharmaceutical industry [8,9].

Antimicrobial Resistance (AMR) occurs when bacteria, viruses, fungi, and parasites change over time and no longer respond to medicines. As a result, infections become harder to treat, increasing the risk of disease spread, severe illness, and death. The main drivers of AMR are the misuse and overuse of antimicrobials in humans, animals, and plants. [10]. AMR is a severe health issue with an extreme impact on the global health sector and economy. Irrational use of anti-microbials has led us to use high-end antibiotics for minor infections in hospitals, and it poses a significant risk for the development of resistance in upcoming generations [11]. India carries one of the largest burdens of drug-resistant pathogens worldwide.

New Delhi Metallo-beta-lactamase 1 (NDM-1), reported in 2008, rapidly spread to other countries and was named after India's capital. India is one of the largest consumers of antibiotics worldwide, and antibiotic sales are increasing rapidly [12]. *E. coli* is a widely studied bacterium due to its prevalence in various environments, including the human gut. *E. coli* strains often exhibit antibiotic resistance, making them relevant for antimicrobial research. *E. coli* is a common cause of urinary tract infections (UTIs) and other infections. Investigating its resistance can inform clinical practices [13]. *K.*

*pneumoniae* causes hospital-acquired infections, especially in immunocompromised patients. It is associated with pneumonia, bloodstream infections, and UTIs. Some *K. pneumoniae* strains are resistant to carbapenem antibiotics, posing a significant challenge in healthcare settings. *K. pneumoniae* contributes to morbidity and mortality, emphasizing the need for effective treatments [14]. *P. aeruginosa* thrives in diverse environments, including hospitals. It causes infections in immunocompromised individuals, such as those with cystic fibrosis. *P. aeruginosa* exhibits intrinsic and acquired resistance to multiple antibiotics. *P. aeruginosa* forms robust biofilms, contributing to chronic infections [15]. Hence, it was decided to explore the anti-microbial sensitivity and resistance status of *E. coli*, *K. pneumoniae*, and *P. aeruginosa* from the data base of a rural tertiary care teaching hospital.

### Material and Method

The current research was an observational retrospective study of 3 months (June 2023 – August 2023) to determine the antimicrobial susceptibility pattern on cultures of various specimens collected during this period. To maintain feasibility, systematic randomization of data collection days was done. The data was collected every alternate day for 3 months. Data on the identified microorganisms and their antimicrobial susceptibility pattern was obtained through a proper channel from the Clinical Microbiology Laboratory of Parul Sevashram Hospital, Limda, Waghodia, Vadodara, a tertiary teaching rural hospital. The data regarding culture and sensitivity (C/S) was isolated from the different specimens, such as pus, blood, tracheal fluid, pleural fluid, bronchoalveolar lavage, sputum, and urine, and analysed from the out-patients (OP) and in-patients (IP) registers.

### Results

Our retrospective observational study conducted at a rural tertiary care teaching hospital over a three-month period (June to August) analysed total of 2,563 samples. Out of these, 1,033 samples were positive for microbial growth, with 373 samples positive for the three organisms of interest: *E. coli*, *K. pneumoniae*, and *P. aeruginosa*. Post-randomization, 196 samples were selected for further analysis, distributed as follows: *E. coli* (135), *K. pneumoniae* (13), and *P. aeruginosa* (48).

The distribution of these organisms across various hospital departments was as follows:

**Table 1:**

Departments	<b>E. coli (135)</b>	<b>KP (13)</b>	<b>PA (48)</b>
OPD	26	1	6
ICU	25	9	18
Medicine ward	29	1	11

Surgery ward	34	1	13
Paediatric ward	14	1	0
Obstetrics and gynaecology ward	7	0	0

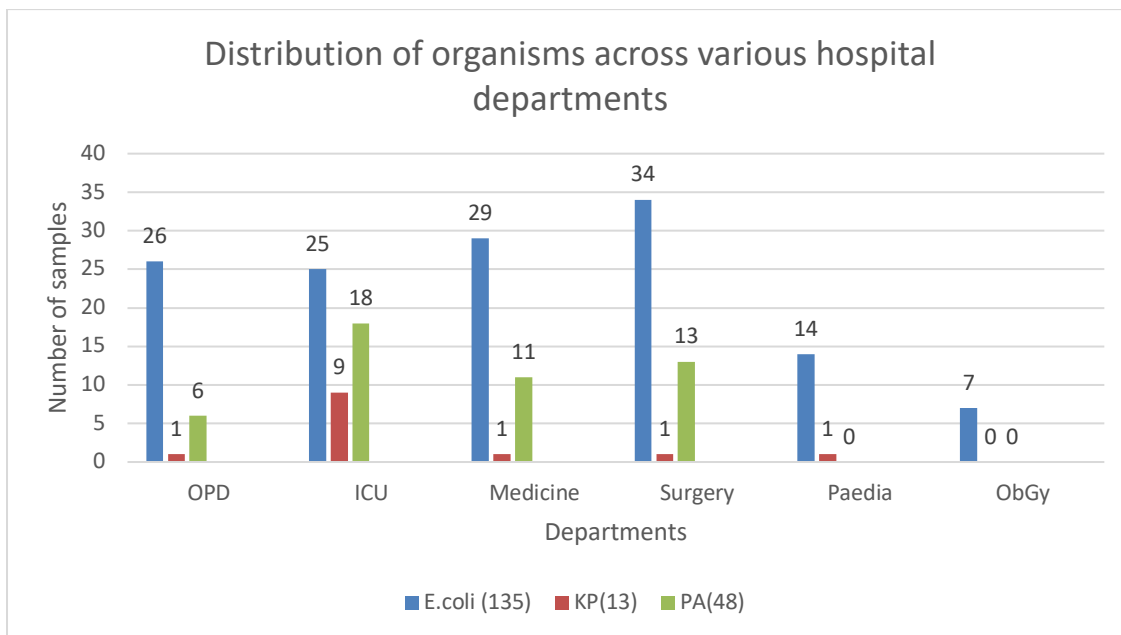


Figure 1: Distribution of organisms across various hospital departments

The specimens from which these organisms were isolated were blood, urine, pus, and other specimens, with urine being the most common source for E. coli. Other specimens include: bronchoalveolar lavage (BAL), endotracheal tube fluid (ET fluid), sputum, and peritoneal fluid as shown in Table 2 and Figure 2.

Table 2:

Specimen	E. coli (135)	KP (13)	PA (48)
Blood	9	3	2
Urine	89	1	15
Pus	27	2	12
Others	10	7	19

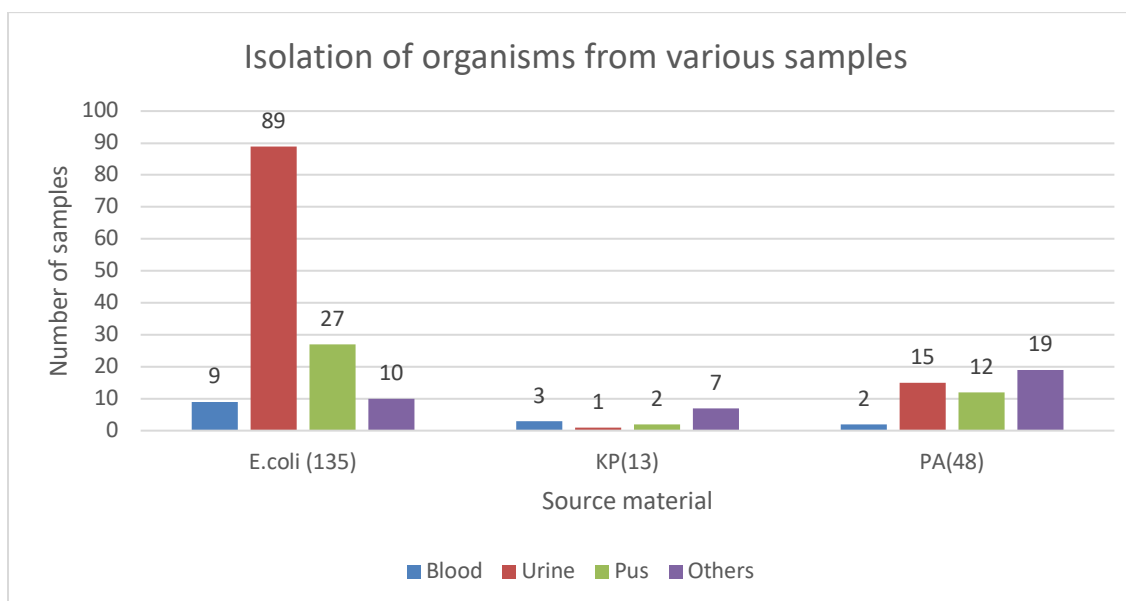
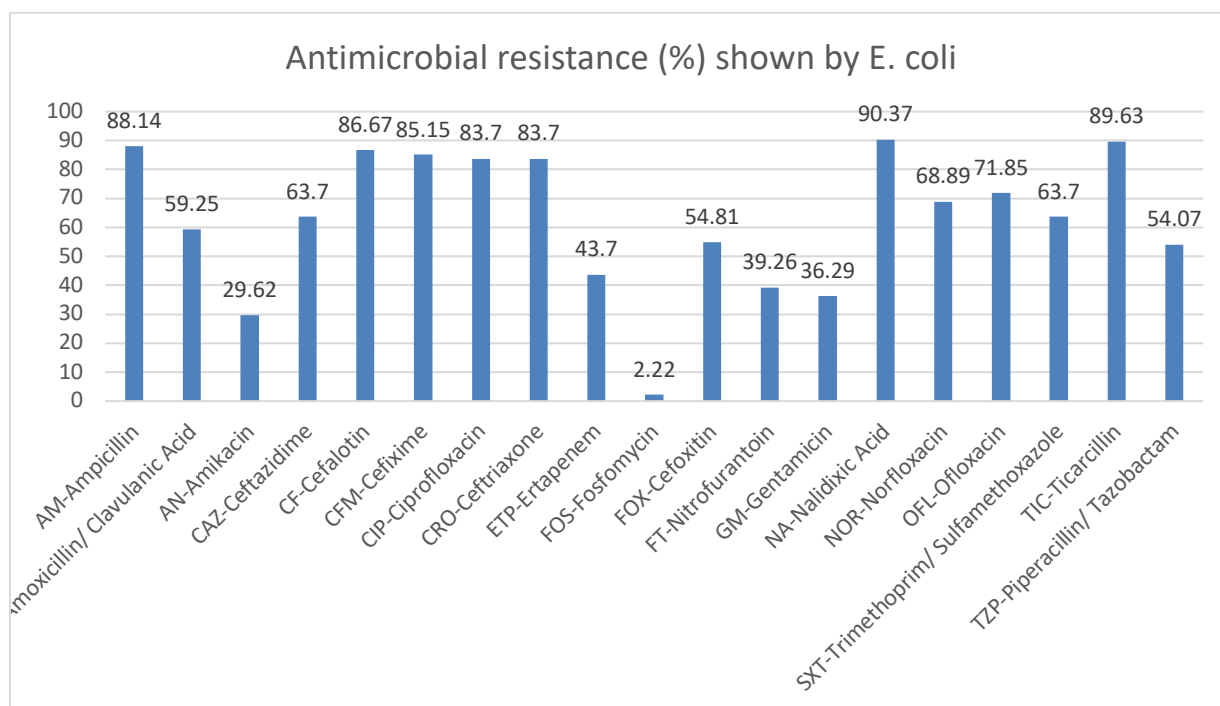


Figure 2: Isolation of organisms from various samples

The antimicrobial resistance pattern observed for *E. coli* showed high resistance rate to commonly used antibiotics such as Ampicillin (88.14%), Cefalotin (86.67%), and Nalidixic Acid (90.37%). However, Fosfomycin showed a remarkably low resistance rate (2.22%) as shown in Table 3 and Figure 3.

**Table 3:**

Antimicrobial agent	Antimicrobial resistance (%) shown by <i>E. coli</i>
AM-Ampicillin	88.14
AMC-Amoxicillin/ Clavulanic Acid	59.25
AN-Amikacin	29.62
CAZ-Ceftazidime	63.7
CF-Cefalotin	86.67
CFM-Cefixime	85.15
CIP-Ciprofloxacin	83.7
CRO-Ceftriaxone	83.7
ETP-Ertapenem	43.7
FOS-Fosfomycin	2.22
FOX-Cefoxitin	54.81
FT-Nitrofurantoin	39.26
GM-Gentamicin	36.29
NA-Nalidixic Acid	90.37
NOR-Norfloxacin	68.89
OFL-Ofloxacin	71.85
SXT-Trimethoprim/ Sulfamethoxazole	63.7
TIC-Ticarcillin	89.63
TZP-Piperacillin/ Tazobactam	54.07

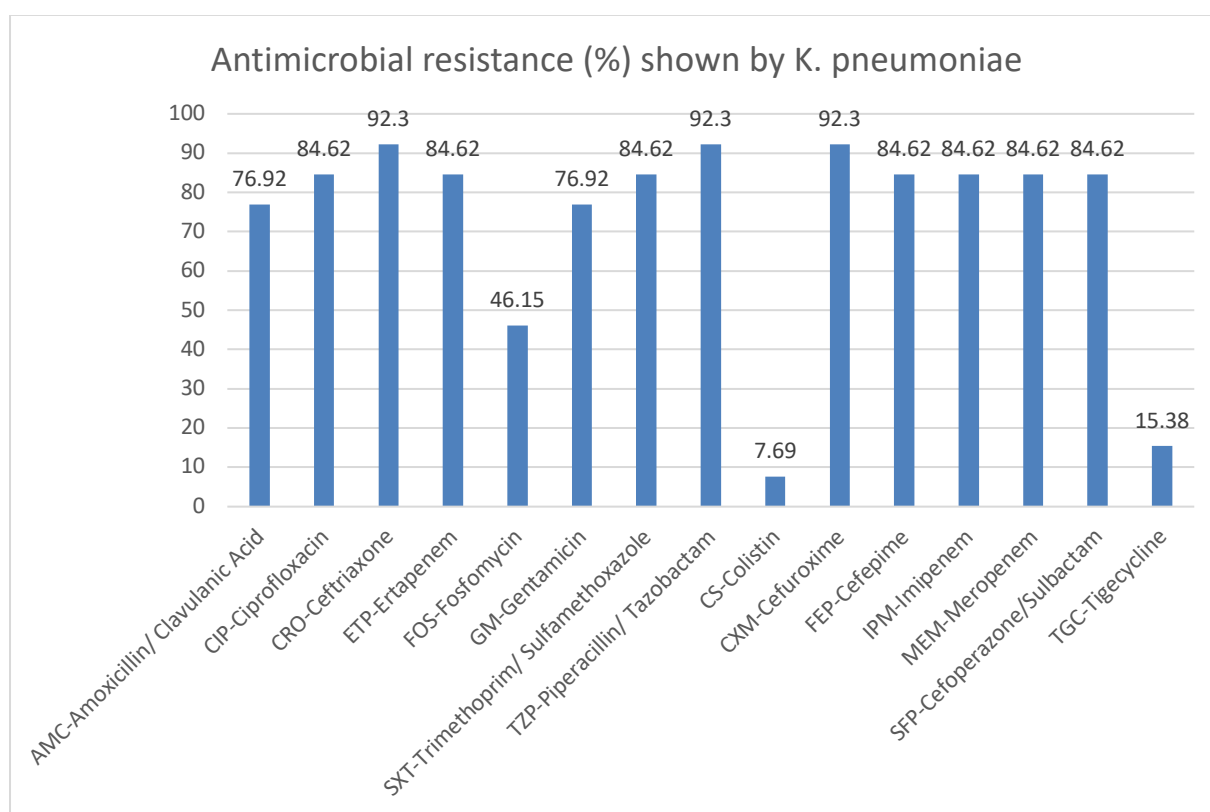


**Figure 3: Antimicrobial resistance (%) shown by *E. coli***

*K. pneumoniae* exhibited high resistance to Ceftriaxone (92.3%), Cefuroxime (92.3%), and Piperacillin/Tazobactam (92.3%), while Colistin and Tigecycline resistance was relatively low (7.69% and 15.38%, respectively) as shown in Table 4 and Figure 4.

**Table 4:**

Antimicrobial agent	Antimicrobial resistance (%) shown by <i>K. pneumoniae</i>
AMC-Amoxicillin/ Clavulanic Acid	76.92
CIP-Ciprofloxacin	84.62
CRO-Ceftriaxone	92.3
ETP-Ertapenem	84.62
FOS-Fosfomycin	46.15
GM-Gentamicin	76.92
SXT-Trimethoprim/ Sulfamethoxazole	84.62
TZP-Piperacillin/ Tazobactam	92.3
CS-Colistin	7.69
CXM-Cefuroxime	92.3
FEP-Cefepime	84.62
IPM-Imipenem	84.62
MEM-Meropenem	84.62
SFP-Cefoperazone/Sulbactam	84.62
TGC-Tigecycline	15.38

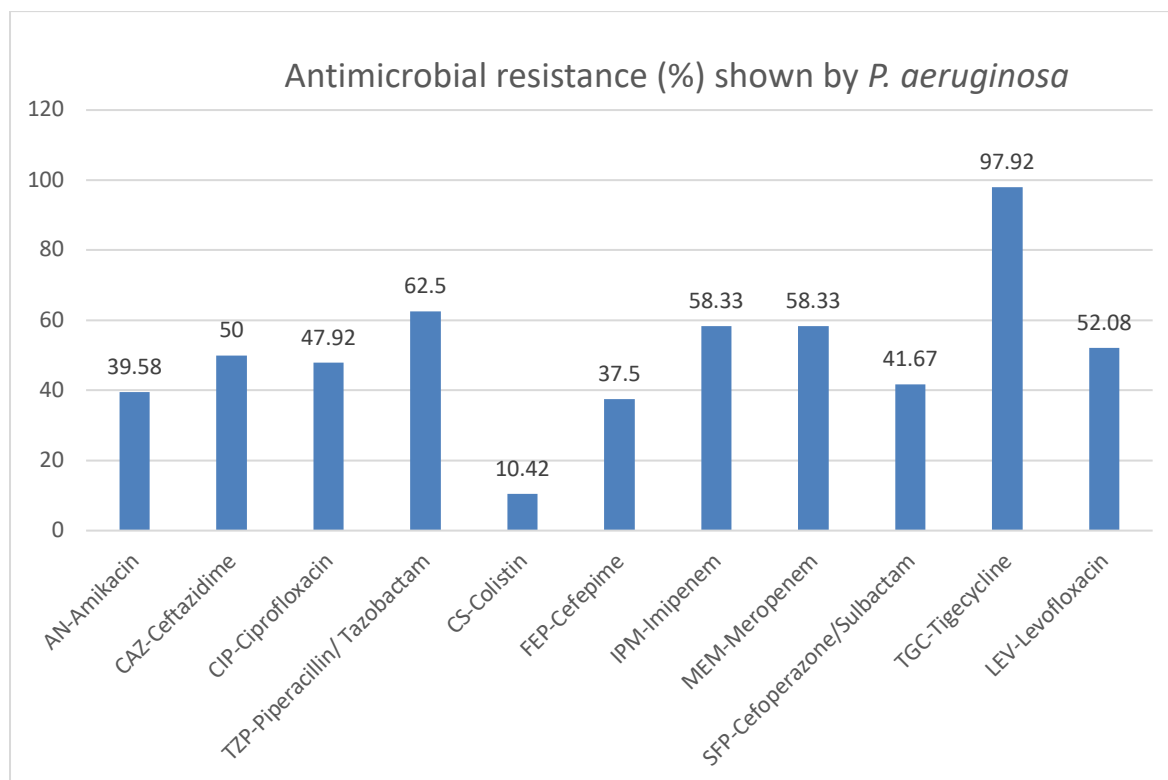
**Figure 4: Antimicrobial resistance (%) shown by *K. pneumoniae***

*P. aeruginosa* presented a varied resistance pattern, with the highest resistance observed for Tigecycline (97.92%), while Colistin resistance remained low (10.42%) as shown in Table 5 and Figure 5.

**Table 5:**

Antimicrobial agent	Antimicrobial resistance (%) shown by <i>P. aeruginosa</i>
AN-Amikacin	39.58
CAZ-Ceftazidime	50
CIP-Ciprofloxacin	47.92
TZP-Piperacillin/ Tazobactam	62.5
CS-Colistin	10.42
FEP-Cefepime	37.5
IPM-Imipenem	58.33
MEM-Meropenem	58.33

SFP-Cefoperazone/Sulbactam	41.67
TGC-Tigecycline	97.92
LEV-Levofloxacin	52.08



**Figure 5: Antimicrobial resistance (%) shown by *P. aeruginosa***

## Discussion

The escalating challenge of antimicrobial resistance (AMR) is a global concern, with significant implications for public health, treatment of infectious diseases, and healthcare costs.

Our study's finding aligns with the growing body of evidence indicating high rates of AMR in rural healthcare settings. Given the role of *E. coli*, *K. pneumoniae*, and *P. aeruginosa* in common and life-threatening infections, resistance patterns observed for them in our study is particularly alarming.

The high resistance rate to first-line antibiotics such as Ampicillin and Cefalotin in *E. coli* mirrors the trends reported by the World Health Organization, which has signalled increasing resistance to antibiotics in bacterial infections based on data from 87 countries [16]. Similarly, the resistance of *K. pneumoniae* to Ceftriaxone and Piperacillin/Tazobactam is consistent with the findings from the China Antimicrobial Surveillance Network (CHINET), which reported stable but high resistance levels in this pathogen.

Our study's observation of low resistance to Fosfomycin in *E. coli* and moderate resistance to Piperacillin/Tazobactam in *P. aeruginosa* offers a glimmer of hope, suggesting that these antibiotics

could be viable options for treating infections caused by these organisms. This is in line with the global efforts to identify alternative therapeutic options in the face of rising AMR, as highlighted in a comprehensive overview of AMR profiles by CHINET [14]. The resistance pattern for *P. aeruginosa*, particularly high resistance to Tigecycline, is a cause for concern and underscores the need for novel antimicrobial agents. The near-universal resistance of *P. aeruginosa* to Tigecycline in our study is a stark contrast to the lower resistance rates reported in other regions, emphasizing the variability of AMR across different geographical locations and healthcare settings [17].

The findings from our study emphasize the critical need for antimicrobial stewardship programme, especially in rural healthcare setting where resources may be limited. Such programmes are essential for optimizing the use of antimicrobials, improving patient outcomes and reducing the spread of AMR. Additionally, our study supports the call for continuous surveillance of AMR trends, as advocated by WHO. [16,18].

## Conclusion

Findings from our retrospective observational study in a rural tertiary care teaching hospital emphasize

the persistent and escalating challenges of antimicrobial resistance (AMR). High resistance rates observed in *E. coli*, *K. pneumoniae*, and *P. aeruginosa* to commonly used antibiotics are indicative of a broader global health crisis that threatens the efficacy of our current antimicrobial arsenal.

Our study contributes to the mounting evidence that AMR is not confined to urban healthcare settings but is also prevalent in rural areas, which often faces unique challenges such as limited access to healthcare resources and a lack of robust antimicrobial stewardship programme. Data presented in our study highlights urgent need for comprehensive surveillance programmes to monitor AMR trends and guide empirical therapy, particularly in resource-limited settings.

Moreover, the study emphasizes the importance of judicious antibiotic use and the implementation of targeted interventions to curb the spread of resistant pathogens. It is imperative that healthcare providers, policymakers and the scientific community collaborate to address the AMR threat through education, research and the development of novel therapeutic strategies.

To conclude, our study serves as a call to action for the global health community to intensify efforts in combating AMR. Only through a concerted and multidisciplinary approach can we hope to preserve the effectiveness of antibiotics for future generations and avert a return to the pre-antibiotic era.

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