ANTIMICROBIAL RESISTANCE PATTERNS AND SUSCEPTIBILITY PROFILES OF UROPATHOGENS AT TRA VINH GENERAL HOSPITAL

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ABSTRACT

Urinary tract infections (UTIs) are among the top five most common hospital-acquired infections. Annually, millions of patients are affected by healthcare-associated UTIs, posing a major challenge to medical facilities worldwide.

Objective: To determine the antimicrobial resistance patterns and susceptibility profiles of each uropathogen isolated from inpatients with suspected UTIs who underwent urine culture at Tra Vinh General Hospital.

Materials and Methods: A descriptive, retrospective cross-sectional study was conducted on 132 patients (or episodes). Bacterial strains were identified and antimicrobial susceptibility testing (AST) was performed using the Vitek 2 automated system. Data were recorded from medical records.

Results: *E. coli* exhibited high resistance rates of >80% to Ampicillin, Piperacillin, and Fluoroquinolones (Ciprofloxacin). Bacterial isolates were more frequent than fungi (23.48% vs 8.33%). *K. pneumoniae* demonstrated 100% resistance to Ampicillin, Ampicillin-sulbactam, Cefepime, and Cefoxitin; resistance to Carbapenems, Aminoglycosides, and Fluoroquinolones ranged from 80% to 100%; and resistance to Cephalosporins exceeded 66.67%. *P. aeruginosa* showed a 50% resistance rate to Piperacillin-tazobactam, Piperacillin, Ceftazidime, Imipenem, Meropenem, and Ciprofloxacin. *P. mirabilis* was 100% resistant to Ampicillin, Piperacillin, Ciprofloxacin, and Tigecycline.

Conclusion: It is essential to prioritize urine culture and antimicrobial susceptibility testing before antibiotic administration to guide appropriate treatment regimens, prevent misuse, and mitigate the risk of escalating antimicrobial resistance.

Keywords: Urinary tract infection, *E. coli*, *K. pneumoniae*, *P. aeruginosa*, Tra Vinh.

1. INTRODUCTION

Urinary tract infections (UTIs) are common infections caused by microorganisms, primarily bacteria, that can affect various parts of the urinary system. The estimated global average prevalence of UTIs is 1.60%, with regional variations worldwide, the highest being in Africa at 3.60% [1]. It is projected that by 2050, the incidence of UTIs will increase to as high as 17.04% [2]. A report by Eulambius M. Mlugu et al. (2022) at the Morogoro Regional Hospital in Africa identified the most prevalent UTI-causing bacteria as *E. coli* (47%), followed by *P. aeruginosa* (17%), *K. pneumoniae* (11.40%), and *P. mirabilis* (14.20%). Notably, 51% of all isolated bacterial strains were multidrug-resistant [3]. A study by Tran Quoc Huy et al. (2021) at Kien Giang General Provincial Hospital reported that *E. coli* accounted for the highest proportion at 54.50% among 352 positive urine cultures, followed by *K. pneumoniae* (15.60%), *Pseudomonas* spp. (9.90%), and *Enterococcus faecalis* (6%) [4]. Author Nguyen Ngoc Lan and colleagues at Thong Nhat Hospital conducted a study on 901 positive urine culture samples from April 1, 2023, to April 30, 2024. The results revealed increasingly high antibiotic resistance rates among these bacteria within the hospital setting: *E. coli* resistance to Cephalosporins ranged from 38.90% to 73.40%, with over 75% resistant to fluoroquinilones. *K. pneumoniae* resistance to Beta-lactams ranged from 51.70% to 79.20%, to Carbapenems from 21.80% to 51.10%, and over 65% to fluoroquinilones. The antibiotic resistance rate for *P. aeruginosa* ranged from 50% to 67.70%, although sensitivity to Piperacillin/Tazobactam was 74.20%. Enterococcus spp. demonstrated a 75.60% susceptibility rate to Vancomycin [5].

Based on these studies, it is evident that detecting the antimicrobial resistance (AMR) profiles of uropathogenic bacteria is crucial. This practice enables clinicians to promptly select appropriate antibiotics, reduce treatment costs, and lower mortality rates.

2. MATERIALS AND METHODS

2.1. Study Subjects: Inpatients diagnosed with urinary

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tract infections who had an indication for urine culture at Tra Vinh General Hospital from January to May 2025.

2.2. Study Design and Methdods

Inclusion Criteria:

+ Hospitalized patients diagnosed with a urinary tract infection and with an indication for urine culture.

+ For cases with a positive urine culture, an antimicrobial susceptibility test must have been indicated.

+ The most recent urine culture order during the treatment episode was selected.

+ Medical records contained all required information for data collection.

Exclusion Criteria:

+ Urine culture results indicating contamination or colonization.

+ Cases with a positive urine culture but for which an antimicrobial susceptibility test was not performed.

+ Patients with a UTI whose second urine culture yielded the same bacterial species as the first culture.

+ *Study Design:* A descriptive, retrospective cross-sectional study.

Sample Size:

$$n = Z^2_{1-\alpha/2} \frac{p(1-p)}{d^2}$$

Where: $Z_{1-\alpha/2}$: Confidence coefficient; with α = 0,05, $Z_{1-\alpha/2}$ = 1,96. p = Estimated proportion; p= 0,203 [6] (The proportion of positive bacterial isolates in urine, based on a study by Le Ha Long Hai and Nguyen Van An); d: Margin of error. d= 7% = 0,07. Thus, the minimum required sample size was: n = 127 participants.

The actual sample size collected for the study group was: 132 patients.

Research Methods:

Data were obtained from the medical records of study subjects archived at Tra Vinh General Hospital. Relevant information for the study was collected using a standardized data collection form, which included: personal information, bacterial identification and culture results, antimicrobial susceptibility testing (AST) results, clinical characteristics, laboratory findings, and patient risk factors.

Data Processing:

- Data were entered using Epidata software version 3.1 and analyzed using Stata software version 14.0.

- Descriptive statistics were performed: percentages were calculated for categorical variables; the minimum, maximum, and mean values were calculated for the continuous variable of age.

2.3. Research Ethics: This study was approved by the Biomedical Research Ethics Committee of Tra Vinh University under approval number 94/GCN.ĐC-HĐĐĐ via an expedited review process on April 24, 2025.

3. RESEARCH RESULTS AND DISCUSSION

3.1. Bacterial Pathogens Isolated from the Study Samples

Table 1. Distribution of Isolated Bacterial Pathogens

Bacterial Strain		n=31	%
Gram Negative Bacteria	*Escherichia coli*	16	51,61
	Klebsiella pneumoniae	5	16,12
	Enterobacter cloacae complex	3	9,68
	Pseudomonas aeruginosa	2	6,45
	Proteus mirabilis	2	6,45
	Acinetobacter baumannii complex/haemolyticus	1	3,23
	Klebsiella oxytoca	1	3,23
Gram Positive Bacteria	*Enterococcus faecium*	1	3,23
Total		31	100

Of the 31/132 (23,48%) urine culture samples yielding positive bacterial results, Gram-negative bacteria constituted the majority (30 out of 31 samples). Among these, *E. coli* accounted for the highest proportion at 51.61% (16/31), followed by *K. pneumoniae* at 16.12% (5/31), then Enterobacter cloacae (9.68%), *P. aeruginosa* (6.45%), *P. mirabilis* (6.45%), with the remainder consisting of Acinetobacter baumannii complex/ haemolyticus and Klebsiella oxytoca. The only Gram-positive bacterium recorded was Enterococcus faecium, representing 3.23% (1/31) of isolates.

3.2. Antibiotic Resistance Rates of Bacterial Isolates in the Study

Table 2. Antibiotic Resistance Profile of *Escherichia coli* (*E. coli*)

Antibiotic	n	Susceptible (S) n (%)	Intermediate (I) n (%)	Resistant (R) n (%)
Ampicillin	16	1 (6,25)	1 (6,25)	14 (87,5)
Ampicillin-sulbactam	8	1 (12,5)	3 (37,5)	4 (50,00)
Piperacillin-tazobactam	16	12 (75,00)	1 (6,25)	3 (18,75)
Piperacillin	16	3 (18,75)	-	13 (81,25)
Cefuroxime	16	4 (25,00)	2 (12,5)	10 (62,5)
Cefotaxime	11	6 (54,55)	-	5 (45,45)
Ceftazidime	11	5 (45,45)	3 (27,27)	3 (27,27)
Cefepime	8	4 (50,00)	-	4 (50,00)
Cefoxitin	8	5 (62,50)	-	3 (37,50)

Antibiotic	n	Susceptible (S) n (%)	Intermediate (I) n (%)	Resistant (R) n (%)
Imipenem	16	15 (93,75)	-	1 (6,25)
Meropenem	16	16 (100,00)	-	-
Doripenem	8	8 (100,00)	-	-
Gentamicin	16	12 (75,00)	-	4 (25,00)
Ciprofloxacin	13	-	1 (7,69)	12 (92,31)
Levofloxacin	4	-	-	4 (100,00)
Trimethoprim-sulfamethoxazole	16	9 (56,25)	-	7 (43,75)
Tigecycline	15	15 (100,00)	-	-
Cefuroxime Axetil	8	1 (12,50)	2 (25,00)	5 (62,50)

In our study results presented in Table 3.2, the isolated *E. coli* strains exhibited high resistance to commonly used antibiotics, specifically: Ampicillin (87.50%), Piperacillin (81.25%), Cefuroxime (62.50%), Ciprofloxacin (92.31%), Levofloxacin (100%), and Cefuroxime Axetil (62.50%). This finding signals an alarming trend of antimicrobial resistance, indicating a marked decline in the efficacy of Penicillins, first- and second-generation Cephalosporins, and Fluoroquinolones for treating *E. coli* infections. However, within the scope of our study, *E. coli* remained susceptible to certain other antibiotic classes, such as Carbapenems, Aminoglycosides, and the combination drug Piperacillin-tazobactam (75% susceptibility), which maintained relatively good efficacy.

Table 3. Antibiotic Resistance Profile of *Klebsiella pneumoniae* (*K. pneumoniae*)

Antibiotic	n	Susceptible (S) n (%)	Intermediate(I) n (%)	Resistant (R) n (%)
Ampicillin	5	-	-	5 (100,00)
Ampicillin-sulbactam	2	-	-	2 (100,00)
Piperacillin-tazobactam	5	1 (20,00)	-	4 (80,00)
Piperacillin	3	1 (33,33)	-	2 (66,67)
Cefuroxime	5	1 (20,00)	-	4 (80,00)
Cefotaxime	3	1 (33,33)	-	2 (66,67)
Ceftazidime	3	1 (33,33)	-	2 (66,67)
Cefepime	2	-	-	2 (100,00)
Cefoxitin	2	-	-	2 (100,00)
Imipenem	5	1 (20,00)	-	4 (80,00)
Meropenem	5	1 (20,00)	-	4 (80,00)
Doripenem	2	-	-	2 (100,00)
Gentamicin	5	1 (20,00)	-	4 (80,00)
Ciprofloxacin	5	1 (20,00)	-	4 (80,00)
Levofloxacin	2	-	-	2 (100,00)
Trimetho-prim-sulfame-thoxazole	5	1 (20,00)	-	4 (80,00)
Tigecycline	5	5 (100,00)	-	-
Cefuroxime Axetil	3	1 (33,33)	-	2 (66,67)

The results above indicate that most isolated *K. pneumoniae* strains exhibited very high resistance rates to multiple antibiotic classes. Specifically, Beta-lactam antibiotics such as Ampicillin, Ampicillin-sulbactam, Cefepime, and Cefoxitin all showed 100% resistance. High resistance rates, ranging from 80% to 100%, were recorded for Aminoglycosides, Carbapenems, and Fluoroquinilones. Resistance to Cephalosporins (e.g., Cefuroxime, Cefotaxime, Ceftazidime) exceeded 66.67%.

Table 4. Antibiotic Resistance Profile of Enterobacter cloacae

Antibiotic	n	Susceptible (S) n (%)	Intermediate(I) n (%)	Resistant (R) n (%)
Ampicillin	2	-	-	2 (100,00)
Ampicillin-sulbactam	2	-	-	2 (100,00)
Piperacillin-tazobactam	3	2 (66,67)	-	1 (33,33)
Piperacillin	3	2 (66,67)	-	1 (33,33)
Cefuroxim	3	1 (33,33)	1 (33,33)	1 (33,33)
Cefotaxime	3	2 (66,67)	-	1 (33,33)
Ceftazidime	3	2 (66,67)	-	1 (33,33)
Cefepime	2	1 (50,00)		1 (50,00)
Cefoxitin	2	-	-	2 (100,00)
Ertapenem	1	1 (100,00)	-	-
Imipenem	3	2 (66,67)	-	1 (33,33)
Meropenem	3	2 (66,67)	-	1 (33,33)
Doripenem	2	1 (50,00)	-	1 (50,00)
Gentamicin	3	2 (66,67)	-	1 (33,33)

Antibiotic	n	Susceptible (S) n (%)	Intermediate(I) n (%)	Resistant (R) n (%)
Tobramycin	2	1 (50,00)	-	1 (50,00)
Amikacin	2	1 (50,00)	-	1 (50,00)
Ciprofloxacin	2	1 (50,00)	-	1 (50,00)
Levofloxacin	1	-	-	1 (100,00)
Trimethoprim-sulfamethoxazole	3	2 (66,67)	-	1 (33,33)
Tigecycline	3	2 (66,67)	-	1 (33,33)
Cefuroxime Axetil	1	-	1 (100,00)	-

Enterobacter cloacae isolates exhibited 100% resistance to Ampicillin, Ampicillin-sulbactam, and Cefoxitin. Resistance rates of 50% were observed for Cefepime, Doripenem, Tobramycin, Amikacin, and Ciprofloxacin. In contrast, susceptibility to antibiotics such as Piperacillin-tazobactam, Cefotaxime, Ceftazidime, Trimethoprim-sulfamethoxazole, and Gentamicin was approximately 66.67%.

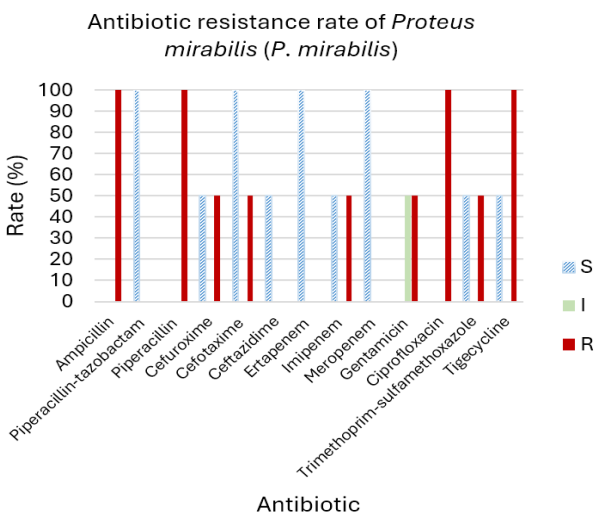

Figure 1. Antimicrobial resistance rate of *P. aeruginosa*

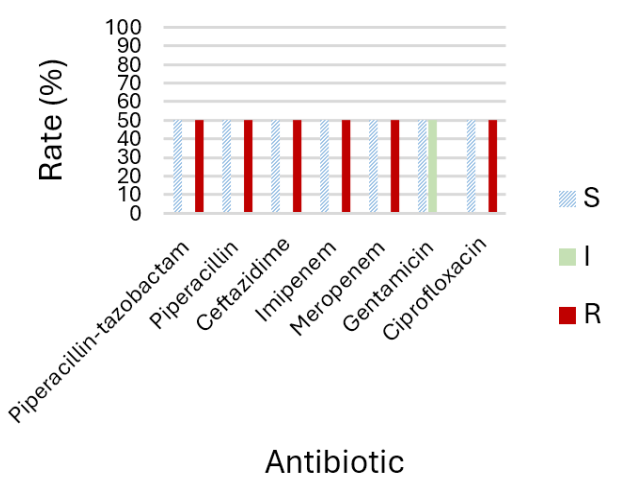

Figure 2. Antimicrobial resistance rate of *P. mirabilis*

As shown in Figure 3.1 and Figure 3.2, *P. aeruginosa* exhibited a resistance (and susceptibility) rate of approximately 50% to the tested antibiotics. *P. mirabilis* demonstrated 100% resistance to Ampicillin, Piperacillin, Ciprofloxacin, and Tigecycline, while maintaining 100% susceptibility to antibiotics such as Piperacillin-tazobactam, Ceftazidime, Ertapenem, and Meropenem. The results indicate that the isolation rates of *P. aeruginosa* and *P. mirabilis* were low, each accounting for only 2 out of 31 samples (similarly to Acinetobacter baumannii and Klebsiella oxytoca, each with 1/31 sample). Consequently, the antimicrobial resistance rates for these specific bacteria may not be representative of the overall resistance prevalence. Further studies with larger sample sizes are required to conduct a more robust analysis of these rates.

4. DISCUSSION

From January to May 2025, the study was conducted using the medical records of 132 inpatients diagnosed with UTIs who had an indication for urine culture. Among the 132 patients, 68.18% were negative and 31.82% were positive. Among the positive samples, , bacterial isolates were more frequent than fungal isolates (23.48% vs. 8.33%). These findings are consistent with a study by Le Ha Long Hai (2023) at Military Hospital 103 (positive rate: 36.35%, bacterial rate: 20.33%) [6], and a study by Jwarchan B. in Nepal (2024), which reported a positive rate of 41.69% [7]. The high proportion of negative results could be attributed to several factors: prior antibiotic use before sample collection, which may inhibit bacterial isolation; the presence of atypical pathogens requiring specialized culture methods; or clinical conditions mimicking UTI symptoms, such as non-infectious inflammation, or irritation due to stones or chemicals.

These results align with a study by Lam Tu Huong (2021) conducted in the Urology Department of Ho Chi Minh City University of Medicine and Pharmacy Hospital, which also reported a predominance of Gram-negative over Gram-positive bacteria (77.30% vs. 22.70%), with *E. coli* being the most prevalent agent at 49.20%, and Klebsiella spp. at 18.10% [8]. Notably, the proportion of Gram-positive bacteria such as Enterococcus spp. in Lam Tu Huong's study was higher (13.10%) compared to our finding of 3.23%. Similarly, a study by Pham Thuy Yen Ha et al. (2022) also identified the two primary agents as *E. coli* (43.40%) and *K. pneumoniae* (18.90%). Furthermore, that study documented the presence of Burkholderia pseudomallei and Stenotrophomonas maltophilia, albeit at low frequencies, which were not isolated in our study. Gram-positive bacteria accounted for a significantly higher proportion (18.90%) in their research, primarily due to Enterococcus spp. (11.30% compared to our 3.23%) [9]. These disparities may be attributed to differences in the study populations.

The observed resistance patterns are consistent with the findings of Que Anh Tram (2023) [10] for Penicillins like Ampicillin (89.50%) and Piperacillin (85.30%); Fluoroquinolones including Ciprofloxacin (68.30%) and Levofloxacin (66.20%); and Cefuroxime (74.80%). Furthermore, our results align with a study by Nguyen Thi Hoa (2022) at the 108 Central Military Hospital [11], which

also reported considerable resistance to Cefotaxime (61.50%), Cefepime (40%), and Fluoroquinilones such as Ciprofloxacin (32%) and Levofloxacin (50%). Concurrently, the high susceptibility rates to Amikacin, Meropenem, Imipenem (all 100%), Ertapenem, and Piperacillin-tazobactam (96.50% and 80%, respectively) in that study are congruent with our findings. In contrast, the study by Le Thi Bao Chi at Hue University of Medicine and Pharmacy Hospital [12] showed a significant discrepancy in the resistance rate to Levofloxacin (58.80% versus 100% in our study). Additionally, our recorded resistance to Trimethoprim-sulfamethoxazole (43.75%) was lower than the 67.30% reported by this author.

Compared to the study by Que Anh Tram (2023) [10], our findings are consistent regarding the highest resistance rates to Ampicillin-sulbactam, Cefuroxime, Ciprofloxacin, and Levofloxacin, although our study documented resistance rates reaching 100%. However, discrepancies were observed for some antibiotics: Piperacillin-tazobactam (46.20%) and Cefepime (66.20%) in their study demonstrated lower resistance compared to our results (80% and 100%, respectively). Our data align with a 2023 Indian study [14] in terms of resistance to Piperacillin-tazobactam, Cefotaxime, Cefepime, Cefoxitin, Imipenem, and Meropenem. When compared to the study by Mays B. Jalil (2022) [15], similarities are noted in resistance to Cefotaxime, Ceftazidime, Gentamicin, Levofloxacin, and Trimethoprim-sulfamethoxazole. Nevertheless, our study revealed higher resistance rates to Ampicillin, Cefepime, Imipenem, and Ciprofloxacin. The variations between our findings and those of other studies may be attributed to differences in sample size, study population, and geographical location.

These results show a close alignment with the study by Bui Thi Hong Thanh et al. (2019-2020), which reported that Enterobacter spp. had the highest resistance rate to amoxicillin/clavulanic acid (100%). Resistance to cephalosporins in that study ranged from 30.0% to 66.7%, and other antibiotics, including ampicillin/sulbactam and levofloxacin, showed resistance rates of 60.0% and 42.9%, respectively [16].

5. CONCLUSION

Among 132 inpatients diagnosed with urinary tract infections (UTIs) who underwent urine culture and were treated at Tra Vinh General Hospital from January to May 2025, the positive urine culture rate was 31.81%. Bacteria were predominant, accounting for 23.48% of positive cultures. The primary isolates were *E. coli* (51.61%) and *K. pneumoniae* (16.13%). Other identified bacteria included Enterobacter cloacae, *P. aeruginosa*, *P. mirabilis*, Acinetobacter baumannii, and Klebsiella oxytoca. The only Gram-positive bacterium isolated was Enterococcus faecium (3.23%).

Escherichia coli (*E. coli*) exhibited high resistance rates (>80%) to Ampicillin, Piperacillin, and Ciprofloxacin. Klebsiella pneumoniae (*K. pneumoniae*) demonstrated very high resistance rates across multiple antibiotic classes: 100% resistance to Beta-lactam; over 80% resistance to Aminoglycosides, Carbapenems, and Fluoroquinolones; and over 60% resistance to Cephalosporins. Enterobacter cloacae showed 100% resistance to Ampicillin, Ampicillin-sulbactam, and Cefoxitin. In contrast, it maintained a susceptibility rate of approximately 66.67% to antibiotics such as Piperacillin-tazobactam, Cefotaxime, Ceftazidime, Trimethoprim-sulfamethoxazole, and Gentamicin.

Our findings may contribute to guiding clinicians in selecting appropriate antibiotics for the treatment of urinary tract infections. However, due to the short study duration and retrospective data collection, we were unable to investigate the antimicrobial resistance genes in these bacterial isolates. Therefore, long-term molec ular epidemiological surveillance studies are necessary to enable early detection of antimicrobial resistance mutations both in vivo and in vitro. This will facilitate the development of timely and appropriate antibiotic stewardship strategies.

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