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ISOLATION CHARACTERISTICS AND ANTIMICROBIAL RESISTANCE OF COMMON BACTERIAL PATHOGENS IN ICU AND NON-ICU DEPARTMENTS AT TRA VINH GENERAL HOSPITAL IN 2025

Kha Dac Luong[1*], Lam Thi Truc Dao[1], Huynh Trung Hao[1], Thach Thanh Duoc[2]

[1]*Tra Vinh University - 126 Nguyen Thien Thanh, Hoa Thuan Ward, Vinh Long Province, Vietnam*
[2]*Tra Vinh General Hospital - 399 Nguyen Dang, Nguyet Hoa Ward, Vinh Long Province, Vietnam*

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ABSTRACT

Objective: To describe the bacterial isolation characteristics from clinical specimens and to compare the antimicrobial resistance rates of selected common pathogens between the intensive care unit (ICU) and non-ICU departments at Tra Vinh General Hospital in 2025.

Materials and methods: A retrospective cross-sectional descriptive study was conducted on 9,543 clinical specimens and antimicrobial susceptibility testing results of the first bacterial isolates that met the selection criteria at Tra Vinh General Hospital in 2025. Culture results were analyzed, with a focus on several commonly isolated bacterial species.

Results: Among 9,543 clinical specimens, 3,539 yielded positive bacterial cultures. Antimicrobial resistance analysis was performed at the isolate level using eligible first bacterial isolates with available susceptibility testing results. *Escherichia coli* and *Staphylococcus aureus* were the most common Gram-negative and Gram-positive bacteria, respectively. Compared with isolates from non-ICU departments, isolates from the ICU showed higher resistance rates to many clinically important antibiotics. This was particularly evident for *Acinetobacter baumannii* complex, with resistance rates in the ICU ranging from 94.0% to 100% for most of the antibiotics investigated.

Conclusion: Gram-negative bacteria predominated among clinical specimens collected at Tra Vinh General Hospital in 2025. Isolates from the ICU showed higher levels of antimicrobial resistance than those from non-ICU departments, especially *Pseudomonas aeruginosa* and *Acinetobacter baumannii* complex.

Keywords: Bacterial isolates; antimicrobial resistance; ICU; antimicrobial susceptibility testing; Gram-negative bacteria.

1. INTRODUCTION

In the current healthcare context, antimicrobial resistance (AMR) not only reduces the effectiveness of clinical treatment but has also become a major challenge to global public health. According to the World Health Organization (WHO), AMR was directly responsible for approximately 1.27 million deaths in 2019 [1]. In Vietnam, this situation has become increasingly alarming, with high rates of bacterial resistance reported across most levels of healthcare, particularly the rise of multidrug-resistant (MDR), extensively drug-resistant (XDR), and pandrug-resistant (PDR) strains [2]. These trends reduce the effectiveness of empirical therapy, prolong hospital stays, and increase the economic burden on the healthcare system.

Clinical microbiology studies conducted in Vietnam during 2020–2024 have shown considerable changes in bacterial pathogen patterns and antimicrobial resistance profiles. While Gram-positive bacteria such as *Staphylococcus aureus* have continued to show high rates of methicillin resistance (MRSA), ranging from 56% to 85.5% [3,4], Gram-negative bacilli have increasingly predominated in severe infections. In intensive care units (ICUs), Gram-negative bacteria may account for up to 86.6% of isolates [2], with the presence of highly resistant pathogens such as *Acinetobacter baumannii* — with carbapenem resistance exceeding 80% [5] — and extended-spectrum beta-lactamase (ESBL)-producing *Klebsiella pneumoniae* [5].

Notably, microbial patterns and antimicrobial susceptibility profiles continuously vary over time, across geographic regions, and under the selective pressure present in each healthcare setting. At Tra Vinh General Hospital, 2024 data from the ICU showed that *K. pneumoniae* and *A. baumannii* were the two most common pathogens, with very high resistance rates to carbapenems and fluoroquinolones, ranging from over 56% to 90% [6]. However, comprehensive studies describing bacterial isolation patterns at the hospital-wide level remain limited, and direct comparisons of antimicrobial resistance between ICU and non-ICU departments at Tra Vinh General Hospital are still lacking. This gap poses challenges to the development of periodic antibiograms and antimicrobial stewardship policies tailored to specific treatment areas.

Based on these practical needs, the present study was conducted to describe the characteristics of bacterial isolates from clinical specimens at Tra Vinh General Hospital in 2025, to analyze the antimicrobial resistance rates of selected common pathogens, and to compare differences in antimicrobial resistance between isolates recovered from the ICU and those from

*Corresponding author
Email: dacluongkha@gmail.com **Phone:** (+84) 962525161 **Https:**//doi.org/10.52163/yhc.v67iE1.5269

non-ICU departments.

2. MATERIALS AND METHODS

2.1. Study design

This was a retrospective cross-sectional descriptive study using microbiological laboratory data.

2.2. Study setting and period

The study was conducted at Tra Vinh General Hospital. Data were collected from clinical specimens for which bacterial culture, identification, and antimicrobial susceptibility testing were indicated during the period from January 2025 to the end of December 2025.

2.3. Study subjects

The study subjects were clinical specimens collected from patients who were indicated for bacterial culture and identification at Tra Vinh General Hospital during the study period.

- Inclusion criteria

All clinical specimens with culture and bacterial identification results and complete relevant information were included.

- Exclusion criteria

Specimens with missing essential information, suspected contamination/external contamination, no appropriate antimicrobial susceptibility testing results, and repeated specimens from the same patient during the same treatment episode were excluded. For repeated specimens, only the first isolate for each specimen type during the same hospitalization was included.

2.4. Sample size and sampling method

All clinical specimens that met the inclusion criteria and did not meet any exclusion criteria during the study period were included in the analysis. Antimicrobial susceptibility analysis was performed on bacterial isolates that met the selection criteria and had corresponding antimicrobial susceptibility testing results.

For specimens yielding more than one organism, only the first bacterial isolate recorded in the microbiology database and meeting the study criteria was included in the antimicrobial resistance analysis.

2.5. Study variables

The study variables included: department sending the specimen/treating department at the time of specimen collection; ICU and non-ICU groups; type of clinical specimen; culture result; Gram-negative or Gram-positive bacterial group; name of the bacterial isolate; antimicrobial susceptibility testing result for each antibiotic; antimicrobial resistance rate; odds ratio (OR) and 95% confidence interval (95% CI) when comparing resistance rates between ICU and non-ICU groups.

The ICU group was defined as clinical specimens sent from the Department of Intensive Care and Toxicology at the time of specimen collection. The non-ICU group included clinical specimens sent from the remaining clinical departments in the hospital.

2.6. Data collection techniques, tools, and procedures

Data were retrospectively extracted from the microbiological laboratory result archive of the Department of Biochemistry and Microbiology, Tra Vinh General Hospital. Bacterial identification and antimicrobial susceptibility testing were performed using the WalkAway 96 Plus system and/or the VITEK 2 system. Antimicrobial susceptibility testing results were interpreted according to the CLSI standards applied at the time of testing.

Antimicrobial susceptibility results were classified as susceptible, intermediate, or resistant. For statistical analysis, intermediate results were grouped with resistant results to facilitate comparison of resistance rates between groups.

2.7. Data processing and statistical analysis

Data were entered, cleaned, and analyzed using SPSS version 20.0. Categorical variables were presented as frequencies and percentages. Antimicrobial resistance rates between ICU and non-ICU groups were compared using the Chi-square test; Fisher's exact test was used when the expected frequency was less than 5. Crude ORs and 95% CIs were calculated to estimate differences in the odds of antimicrobial resistance between the two groups. A p-value < 0.05 was considered statistically significant.

3. RESULTS

3.1. Distribution of clinical specimens by submitting department, specimen type, and culture result

Table 1. Characteristics of clinical specimens

Characteristic			Number (n = 9 543)	%
Department	ICU		2 512	26,32
	Cardiology		1 083	11,35
	Surgery – Anesthesiology and Resuscitation		954	10,00
	Nephrology – Urology – Artificial Kidney		910	9,54
	General Internal Medicine		734	7,69
	Geriatrics		675	7,07
	General Surgery		684	7,17
	Infectious Diseases		480	5,03
	Others		1 511	15,83
Clinical specimen type	Blood		2 688	28,17
	Sputum		2 607	27,32
	Pus		1 561	16,36
	Peritoneal fluid		1 332	13,96
	Urine		867	9,09
	Others		488	5,11
Culture result	Positive	Gram-positive	946	9,91
		Gram-negative	2 593	27,17
	Negative		6 004	62,92

Comment: Among the 9,543 clinical specimens, the ICU submitted the largest number of specimens, with 2,512 samples, accounting for 26.32%, followed by the Department of Cardiology at 11.35% and the Depart-

ment of Surgery – Anesthesiology and Resuscitation at 10.00%. The two most common specimen types were blood and sputum, accounting for 28.17% and 27.32%, respectively. A total of 3,539 specimens were culture-positive, representing 37.08%; among these, Gram-negative bacteria predominated with 2,593 isolates, while Gram-positive bacteria accounted for 946 isolates.

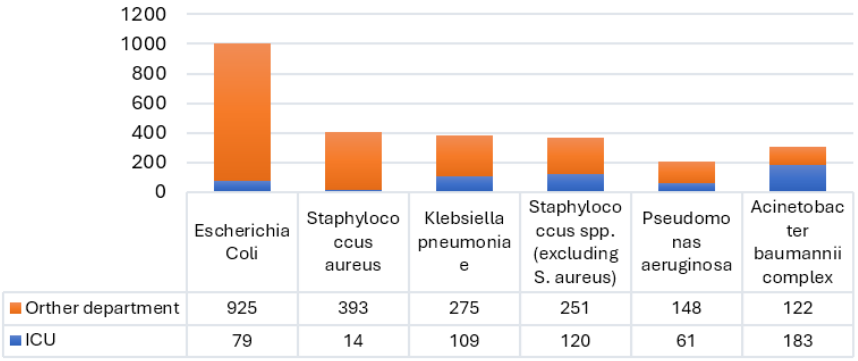


Figure 1. Distribution of common bacteria among culture-positive specimens

Comment: Among all culture-positive specimens, *Staphylococcus aureus* was the predominant Gram-positive bacterium, accounting for 11.5%. Among Gram-negative bacteria, *Escherichia coli* was the most frequently isolated species, accounting for 28.4%, followed by *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*, accounting for 10.9% and 5.9%, respectively.

Table 2. Antimicrobial susceptibility profile of *E. coli*

Antibiotic	Susceptibility category	Non-ICU		ICU		P	OR (95% CI)
		n	(%)	n	(%)		
Piperacillin-tazobactam	Resistant (R)	62	6,7	18	23,1	0,001	4,17 (2,32–7,52)
	Susceptible (S)	862	93,3	60	76,9		
Ceftazidime	Resistant (R)	88	23,3	9	31,0	0,345	1,48 (0,65–3,38)
	Susceptible (S)	290	76,7	20	69,0		
Cefepime	Resistant (R)	603	65,2	65	82,3	0,002	2,48 (1,37–4,48)
	Susceptible (S)	322	34,8	14	17,7		
Gentamicin	Resistant (R)	298	32,2	39	49,4	0,002	2,05 (1,29–3,26)
	Susceptible (S)	627	67,8	40	50,6		
Amikacin	Resistant (R)	13	1,8	7	11,7	0,001*	7,30 (2,80–19,23)
	Susceptible (S)	720	98,2	53	88,3		
Ciprofloxacin	Resistant (R)	561	89,6	59	88,1	0,693	0,85 (0,39–1,87)
	Susceptible (S)	65	10,4	8	11,9		

*Note: The sample size (n) varied for each antibiotic according to the available antimicrobial susceptibility testing results; *: Fisher's exact test.*

Comment: In the ICU, E. coli showed higher resistance rates than those in non-ICU departments for several antibiotics, particularly cefepime (82.3% vs. 65.2%; p = 0.002) and gentamicin (49.4% vs. 32.2%; p = 0.002). In contrast, the difference in resistance to ceftazidime was not statistically significant (31.0% vs. 23.3%; p = 0.345). Notably, ciprofloxacin resistance was very high in both settings (88.1%–89.6%), with no statistically significant difference between ICU and non-ICU isolates (p = 0.693).

Table 3. Antimicrobial susceptibility profile of *K. pneumoniae*

Antibiotic	Susceptibility category	Non-ICU		ICU		P	OR (95% CI)
		n	(%)	n	(%)		
Ceftazidime	Resistant (R)	42	31,8	18	50	0,044	2,14 (1,01–4,52)
	Susceptible (S)	90	68,2	18	50		
Imipenem	Resistant (R)	88	32,0	65	59,6	0,001	3,13 (1,98–4,98)
	Susceptible (S)	187	68,0	44	40,4		
Meropenem	Resistant (R)	70	33,7	55	64,7	0,001	3,61 (2,13–6,13)
	Susceptible (S)	138	66,3	30	35,3		
Amikacin	Resistant (R)	54	26,0	48	56,5	0,001	3,70 (2,18–6,29)
	Susceptible (S)	154	74,0	37	43,5		
Ciprofloxacin	Resistant (R)	162	89,5	86	94,5	0,17	2,02 (0,73–5,59)
	Susceptible (S)	19	10,5	5	5,5		
Colistin	Resistant (R)	36	17,3	25	29,4	0,021	1,99 (1,11–3,58)
	Susceptible (S)	172	82,7	60	70,6		
Tigecycline	Resistant (R)	5	3,1	2	2,8	1*	0,91 (0,17–4,81)
	Susceptible (S)	157	96,9	69	97,2		

*Note: The sample size (n) varied for each antibiotic according to the available antimicrobial susceptibility testing results; *Fisher's exact test.*

Comment: *K. pneumoniae* isolates from the ICU showed markedly higher resistance rates than those from non-ICU departments for several antibiotics, including meropenem (64.7% vs. 33.7%; p = 0.001) and amikacin (56.5% vs. 26.0%; p = 0.001). Ciprofloxacin resistance was very high in both settings (89.5%–94.5%), although the difference was not statistically significant (p = 0.17). Tigecycline was one of the few antibiotics that still maintained very good activity, with very low resistance rates in both non-ICU and ICU isolates (3.1% and 2.8%, respectively).

Table 4. Antimicrobial susceptibility profile of *P. aeruginosa*

Antibiotic	Susceptibility category	Non-ICU		ICU		P	OR (95% CI)
		n	(%)	n	(%)		
Piperacillin-tazobactam	Resistant (R)	33	22,3	43	70,5	0,001	8,33 (4,26–16,39)
	Susceptible (S)	115	77,7	18	29,5		
Ceftazidime	Resistant (R)	37	25,0	44	72,1	0,001	7,75 (3,97–15,15)
	Susceptible (S)	111	75,0	17	27,9		
Cefepime	Resistant (R)	62	41,9	50	82,0	0,001	6,29 (3,04–13,16)
	Susceptible (S)	86	58,1	11	18,0		
Imipenem	Resistant (R)	36	24,3	45	73,8	0,001	8,77 (4,42–17,24)
	Susceptible (S)	112	75,7	16	26,2		
Meropenem	Resistant (R)	25	22,5	31	73,8	0,001	9,71 (4,27–22,22)
	Susceptible (S)	86	77,5	11	26,2		
Amikacin	Resistant (R)	23	20,7	29	69,0	0,001	8,55 (3,83–18,87)
	Susceptible (S)	88	79,3	13	31,0		
Ciprofloxacin	Resistant (R)	38	59,4	47	90,4	0,001	6,45 (2,25–18,18)
	Susceptible (S)	26	40,6	5	9,6		
Colistin	Resistant (R)	42	37,8	9	21,4	0,055	0,45 (0,20–1,03)
	Susceptible (S)	69	62,2	33	78,6		

Note: The sample size (n) varied for each antibiotic according to the available antimicrobial susceptibility testing results.

Comment: *P. aeruginosa* isolates from the ICU showed markedly increased resistance to most key antibiotics. The largest differences in resistance rates were observed for imipenem (73.8% vs. 24.3%) and amikacin (69.0% vs. 20.7%), both of which were statistically significant (p = 0.001). Colistin remained relatively active, with susceptibility rates of 78.6% in ICU isolates and 62.2% in non-ICU isolates; however, this difference did not reach statistical significance (p = 0.055).

Table 5. Antimicrobial susceptibility profile of *A. baumannii* complex

Antibiotic	Susceptibility category	Non-ICU		ICU		P	OR (95% CI)
		n	(%)	n	(%)		
Ampicillin-sulbactam	Resistant (R)	65	78,3	115	94,3	0,001	4,55 (1,81–11,49)
	Susceptible (S)	18	21,7	7	5,7		
Cefepime	Resistant (R)	68	81,9	118	96,7	0,001	6,49 (2,07–20,41)
	Susceptible (S)	15	18,1	4	3,3		
Imipenem	Resistant (R)	62	92,5	120	100	0,005*	Not calculated due to zero cell count
	Susceptible (S)	5	7,5	0	0,0		
Meropenem	Resistant (R)	47	79,7	81	97,6	0,001	10,31 (2,22–47,62)
	Susceptible (S)	12	20,3	2	2,4		
Amikacin	Resistant (R)	34	57,6	78	94,0	0,001	11,49 (4,05–32,26)
	Susceptible (S)	25	42,4	5	6,0		
Levofloxacin	Resistant (R)	39	66,1	79	95,2	0,001	10,10 (3,24–31,25)
	Susceptible (S)	20	33,9	4	4,8		
Ciprofloxacin	Resistant (R)	62	74,7	118	96,7	0,001	10,00 (3,29–30,30)
	Susceptible (S)	21	25,3	4	3,3		

*Note: The sample size (n) varied for each antibiotic according to the available antimicrobial susceptibility testing results; *: Fisher's exact test.*

Comment: In the ICU, resistance rates ranged from 94.0% to 100% for most of the antibiotics investigated, with the highest rates observed for imipenem (100%) and meropenem (97.6%). Compared with non-ICU isolates, these resistance rates were all significantly higher.

4. DISCUSSION

Due to the complex antimicrobial resistance profiles and the distribution of isolates, this study focused on an in-depth analysis of differences in resistance patterns of *Escherichia coli*, *Klebsiella pneumoniae*, Pseudomonas aeruginosa, and *Acinetobacter baumannii* complex between the ICU and other departments.

4.1. General characteristics of bacterial isolation patterns

This study recorded 3,539 culture-positive results among 9,543 clinical specimens, corresponding to approximately 37.1%. Gram-negative bacteria predominated, with 2,593 isolates, accounting for approximately 73.3% of positive cultures. This distribution is consistent with the general trend observed in many hospitals in Vietnam, particularly in intensive care units and hospital-acquired infections, where Gram-negative bacilli commonly predominate. Similarly, at Children's Hospital 2, Gram-negative bacteria accounted for 86.6% of isolates recovered from the ICU [2]. At the Department of Respiratory Medicine, Thong Nhat Hospital, this proportion was 83.6% [7]. In addition, 2024 ICU data from Tra Vinh General Hospital also showed that the most prominent isolates were *K. pneumoniae* and *A. baumannii* [6].

4.2. Discussion on *Escherichia coli*

In the present study, E. coli isolates from the ICU showed higher resistance levels than those from non-ICU departments for several important antibiotics. Not only were resistance rates higher, but the magnitude of these differences was also clearly reflected by the odds ratios. Specifically, the odds of resistance in ICU isolates were 4.17 times higher for piperacillin–tazobactam, 2.48 times higher for cefepime, 2.05 times higher for gentamicin, and most notably, 7.30 times higher for amikacin compared with non-ICU isolates. These findings indicate that even antibiotics that still retain relatively good susceptibility rates, such as amikacin and piperacillin–tazobactam, have been subjected to substantial selective pressure in the ICU setting. In contrast, ciprofloxacin resistance was very high in both settings, and the corresponding OR was not statistically significant.

Compared with a 2020 study conducted at Viet Tiep Friendship Hospital in Hai Phong, E. coli isolates in our study showed more severe resistance patterns, particularly in the ICU. In the Hai Phong study, *E. coli* resistance rates were 22.92% for cefepime and 68.52% for ciprofloxacin, while resistance to amikacin was only 1.69% and carbapenem resistance was below 4% [5]. In the present study, ICU isolates alone showed resistance rates of 82.3% to cefepime, 49.4% to gentamicin, 11.7% to amikacin, and 88.1% to ciprofloxacin. These findings are also consistent with observations from Thong Nhat Hospital, where *E. coli* remained relatively susceptible to some antibiotics such as amikacin and Piperacillin-tazobactam but showed very high resistance to other beta-lactams and fluoroquinolones [7].

4.3. Discussion on *Klebsiella pneumoniae*

For *K. pneumoniae*, ICU isolates not only showed higher resistance rates but also demonstrated substantial differences, as reflected by the ORs. The odds of resistance among ICU isolates were 2.14 times higher for ceftazidime, 3.13 times higher for imipenem, 3.61 times higher for meropenem, 3.70 times higher for amikacin, and 1.99 times higher for colistin compared with non-ICU isolates.

Compared with the study conducted in Hai Phong, where *K. pneumoniae* resistance rates were 27.69% for imipenem, 28.13% for meropenem, 45.0% for Piperacillin-tazobactam, and 57.29% for ciprofloxacin [5], the resistance levels observed in our ICU isolates were markedly higher, particularly for carbapenems and quinolones.

Our findings are consistent with those reported at the Department of Respiratory Medicine, Thong Nhat Hospital, where *K. pneumoniae* showed resistance rates of approximately 60%–70% to third- and fourth-generation cephalosporins, 55.6% to amikacin, 44.1% to Piperacillin-tazobactam, and approximately 45%–60% to imipenem and meropenem [7].

A noteworthy finding is that tigecycline still retained very good activity in both ICU and non-ICU isolates. Therefore, it may be considered as a potential therapeutic option in multidrug-resistant infections, although its use should be carefully evaluated according to the site of infection and clinical indication.

4.4. Discussion on *Pseudomonas aeruginosa*

For P. aeruginosa, ICU isolates showed substantially higher odds of resistance to several key antibiotics, particularly meropenem. However, because of the retrospective cross-sectional design, this finding should be interpreted as an association rather than evidence that ICU admission caused antimicrobial resistance.

Our study showed more severe resistance patterns compared with the study at Viet Tiep Friendship Hospital in Hai Phong, where P. aeruginosa resistance rates were 33.90% for ceftazidime, 35.76% for imipenem, 46.30% for meropenem, and 54.08% for ciprofloxacin [5]. The study conducted at the Department of Respiratory Medicine, Thong Nhat Hospital also reported high carbapenem resistance among P. aeruginosa, ranging from approximately 45% to 70% [7].

Meanwhile, at Children's Hospital 2, colistin remained highly active against P. aeruginosa, with a susceptibility rate of 97.1% [2].

The present findings are consistent with the national trend showing that P. aeruginosa is becoming increasingly resistant to carbapenems.

4.5. Discussion on *Acinetobacter baumannii* complex

Acinetobacter baumannii complex had the most severe resistance profile in this study. ICU isolates showed significantly higher odds of resistance than non-ICU isolates to most tested antibiotics, particularly meropenem, amikacin, levofloxacin, and ciprofloxacin. These findings indicate a markedly resistant local antimicrobial profile of *A. baumannii* complex in the ICU. However, because data on antibiotic exposure, infection control practices, and clonal relatedness were not available, the results should be interpreted as surveillance findings rather than evidence of an outbreak or causal effect of ICU admission.

These findings are consistent with the 2024 ICU study at Tra Vinh General Hospital, in which *A. baumannii* showed resistance rates above 90% to most of the antibiotics investigated, including beta-lactams, fluoroquinolones, and carbapenems [6].

Compared with the study in Hai Phong, where *A. baumannii* resistance rates were 63.91% for ampicillin/sulbactam, 83.57% for cefepime, 83.05% for imipenem, and 84.36% for meropenem [5], *A. baumannii* complex isolates from the ICU in our study showed even more severe resistance, especially to meropenem and quinolones. At Children's Hospital 2, *A. baumannii* was the most common pathogen isolated in the ICU, and colistin remained the antibiotic with the highest susceptibility rate at 80.6%, whereas carbapenem

susceptibility was very low [2]. Thus, a consistent finding across domestic studies is that *A. baumannii* is the most prominent multidrug-resistant pathogen in ICU settings.

4.6. Practical implications for microbiological surveillance and antimicrobial stewardship

Comparing resistance rates and calculating ORs between ICU and non-ICU groups helped to more clearly quantify the differences in antimicrobial resistance between the two treatment settings.

4.7. Study limitations

This study has several limitations. First, because it was a retrospective study based on routine laboratory data, complete clinical information such as infection diagnosis, disease severity, prior antibiotic exposure, length of hospital stay, invasive procedures, and treatment outcomes was not available. Second, the study analyzed microbiological resistance patterns and did not evaluate antimicrobial consumption or antimicrobial stewardship interventions. Third, clonal relatedness, isolate clustering, outbreak events, and infection control practices were not assessed. Therefore, the high resistance rates observed in ICU isolates, particularly *A. baumannii* complex, should be interpreted as surveillance findings rather than evidence of an outbreak or causal effect of ICU admission. Finally, because the analysis was based on available antimicrobial susceptibility testing results, the denominator varied across antibiotics

5. CONCLUSION

In 2025, Gram-negative bacteria predominated among culture-positive clinical specimens at Tra Vinh General Hospital. *Escherichia coli* was the most common Gram-negative pathogen, while *Staphylococcus aureus* was the most frequently isolated Gram-positive bacterium.

Bacterial isolates recovered from the ICU showed higher resistance levels than those from non-ICU departments for many clinically important antibiotics.

These surveillance data may serve as baseline evidence to support future antimicrobial stewardship planning and infection control monitoring. Further studies incorporating antimicrobial consumption, clinical data, and infection control indicators are needed before evaluating the effectiveness of specific stewardship interventions.

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